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The Role of Artificial Intelligence in Supporting Development in Emerging Markets

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Artificial Intelligence has enormous potential to augment human intelligence and to radically alter how we access products and services, gather information, make products, and interact. In emerging markets, AI offers an opportunity to lower costs and barriers to entry for businesses and deliver innovative business models that can leapfrog traditional solutions and reach the underserved. With technology-based solutions increasingly important to economic development in many nations, the goals of ending poverty and boosting shared prosperity may become dependent on harnessing the power of AI. While emerging markets are already using basic AI technologies to solve critical development challenges, much more can be done, and private sector solutions will be critical to scaling new business models, developing new ways of delivering services, and increasing local markets' competitiveness. All of these solutions require innovative approaches to expand opportunities and mitigate risks associated with this new technology.

Artificial Intelligence (AI) designates "the science and engineering of making machines intelligent, especially intelligent computer programs,"[1] with intelligence defined by the AI100 Panel at Stanford University as "that quality that enables an entity to function appropriately and with foresight in its environment."[2] Other experts define AI as a computerized system that can think and act like humans. More comprehensive definitions consider AI to mean all computer systems that can continuously scan their environment, learn from it, and take action in response to what they sense, as well as to human-defined objectives.[3]

AI combines large volumes of data with computing power to simulate human cognitive abilities such as reasoning, language, perception, vision, and spatial processing. Three types of AI applications can be identified based on which cognitive abilities are simulated and automated:

Basic AI imbeds cognitive abilities such as memory, attention and language, as well as some executive functions like anticipation and decision-making with limited reference to the past. It is typically used to enhance the performance of business analytics solutions and to improve the functioning of digital platforms. Examples include credit scoring, online matching, chatbots, and smart speakers. In emerging markets, existing services include AI-enabled credit scoring in Madagascar (M-Kajy), Kenya (M-Shwari), Egypt (ValU, Fawry Plus), and India (Aye Finance).

Advanced AI goes further in the simulation of human cognitive abilities such as perception, vision, and spatial processing. It closely mimics the human mind and enables the analysis of unstructured data such as texts, images, and audio data. Immediate application domains include facial

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and speech recognition, medical diagnoses, transportation, and urban planning, as well as logistics, security, and safety. Outside of China, advanced AI applications are not yet widely adopted in emerging markets. In China, Yitu Technology, a startup founded in 2012 and valued at $1 billion in 2017, provides facial recognition technology. Infervision uses AI to provide medical diagnosis solutions to more than 280 hospitals, 20 of which are outside China. In the transportation and automotive industry, NIO develops autonomous vehicle solutions.

Autonomous AI is expected to become self-aware with the ability to interact with human beings and learn on its own, thereby augmenting humans at home, outside the home, or in work environments. Autonomous AI is still far from widespread commercial use due to limitations in handling irregular objects, biased decision-making involving value judgment, and an inability to learn from a few examples. Prototypes from Fetch Robotics, Boston Dynamics, and Hanson Robotics are early examples of autonomous AI.

AI performance has been enhanced by a new generation of algorithms labelled machine learning, or ML. Unlike standard rules-based approaches, ML algorithms are automatically built from data, and the richer the dataset, the better they perform. Rules-based approaches tell the algorithm what to do in each state of the world. As a result, they are limited to predictable outcomes and perform poorly out of sample. ML, by contrast, involves the use of algorithms to parse data, learn from it, and make a determination or prediction as a result. By learning patterns from the data—including unpredictable ones—ML algorithms generally outperform rules-based approaches. They can be classified into two broad categories according to the number of stages involved in the learning process:

Basic learning algorithms involve only one stage of learning and are suitable for analyzing structured data like price, quantity, or time; for predicting an outcome given a set of inputs; or for clustering items according to their characteristics. Examples include the prediction of a customer's churn, probability of default (credit scoring), and fraud detection in financial transactions. **Deep learning algorithms**, on the contrary, involve several learning stages organized similar to the structure of the brain. They are suitable for analyzing unstructured data such as images, audio recordings, or texts, and can be useful for face recognition, speech-to-text transcription, or text reconstitution. Unlike basic learning algorithms, deep learning algorithms radically open new avenues for data-driven decision-making, as few alternative methodologies exist to process unstructured data.

Why is AI Gaining Prominence Now?

Adoption of AI has significantly accelerated over the last five years due the diffusion of digital technologies and major breakthroughs in algorithmic capabilities, access to richer data, and increasing computing power. According to a Gartner global survey, 14 percent of large companies used AI in 2019, up from 3 percent in 2018, and that is expected to increase to 23 percent in 2020. The most popular AI applications include chatbots, process optimization, and fraud analysis on transactional

Box 1: Differences between AI and other disruptive technologies

Standard inference and data mining techniques differ greatly from AI and machine learning. For instance, to predict whether a customer is likely to churn, a statistical approach would assemble data on the characteristics of all customers, including whether they have churn or not, specify a statistical relationship between customers' statuses and their characteristics, estimate parameters, and use this relationship to infer the probability that a customer will churn given his or her characteristics. An ML approach would first train an algorithm linking customers' churning statuses with their characteristics on a subset of data (training dataset), use another subset of data to validate the construction of the algorithm (validation dataset), further test the predicting power of the final algorithm on another subset of data (testing dataset), all before predicting the probability of churn. Deep learning algorithms involve several iterations of this process after partitioning the unstructured dataset.

Cloud Computing, the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer, is often used to implement AI, but it remains distinct. Cloud computing can be used for non-AI related purposes such as data sharing and securing. Likewise, **Blockchain,** a decentralized data sharing architecture, can also be used to store and process data, but does not include an automated and data-driven learning process like AI. In addition, while several **digital platforms** imbed AI technology into their functioning, others do not. Digital platforms that match users from different sides of the platform, recommend contents, or use targeted advertising typically use an AI technology. However, peer-to-peer platforms or job boards, for instance, do not use AI, although they could eventually upgrade.

Opportunities	Risks
• New products and business models—including leapfrogging solutions, solutions for bottom of pyramid individuals, and easier access to credit • Automation of core business processes—leading to lower product costs • Human capital development • Innovation in government services	• Obsolescence of traditional export-led path to economic growth • Increased digital and technological divide • Transformation of job requirements and disruption of traditional job functions • Privacy, security, and public trust

FIGURE 1 Selected development opportunities and risks from AI in emerging markets

Source: IFC

data. Emerging applications include consumer and market segmentation, computer-assisted diagnostics, call center virtual assistants, sentiment analysis and opinion mining, face detection and recognition, and human resources applications such as resume screening. These applications are most common in insurance, software and IT services, telecom, and retail. AI companies tend to have higher valuations and raised more investment rounds than equivalent non-AI startups since 2015.[4]

Companies and users are now creating an unprecedented amount of data. In 2017, the amount of digital data created was more than eight times that of 2009. Progress in telecommunications networks, the ongoing deployment of the Internet of Things, and the upcoming large-scale deployment of 5G networks will all enable even greater data generation. In 2022, Internet data traffic is projected to be three times that of 2017, and the share of licensed IoT devices is predicted to rise from 13 percent in 2018 to 28 percent in 2025. Because AI needs data to learn, these trends are set to supercharge the development of more powerful AI technologies.

Vast improvements in computing power and capacity to store data have supported this growth in data. For example, Google recently introduced its Tensor Processing Unit, which has a processing power of 15 to 30 times that of a Graphical Processing Unit, a key computer element that was central to the implementation of deep learning algorithms.

The rising importance of AI is also driven by demand-side effects such as **the deployment of digital platforms and the emergence of other disruptive applications such as blockchain and cloud computing**. The digital platform business model hinges on the successful targeting of users for marketing purposes and the provision of personalized Internet content to catalyze usage. These functions are essential to the ability of digital platforms to reach the minimum number of users necessary for profitability. Thus, online platforms like Google and Amazon rely on AI to attract both users and advertisers.

Furthermore, the wide range of sectors that AI can transform has attracted **significant venture capital investment**. AI-related VC deals rose from 150 in 2012 to 698 in 2017, with 90 percent annual growth in the volume of investment, from just $0.6 billion in 2012 to $14 billion in 2017.[5]

Reducing Poverty and Boosting Shared Prosperity

Traditional pathways to a country's economic development are increasingly subject to technology-based disruptions. AI is highly disruptive in that it can result in a step change in the cost of or access to products or services, or can dramatically change how we gather information, make products, or interact. As development challenges become more and more intertwined with technology-based disruptions, the twin goals of ending poverty and boosting shared prosperity become critically dependent on harnessing the power of technologies such as AI, while at the same time seeking to limit the associated risks.[6]

Emerging markets, including some of the world's poorest countries, are already using basic AI to solve critical development challenges, particularly in the provision of financial services to unserved and underserved populations. Early progress in basic machine learning algorithms, combined with the limited burden of legacy technologies and a growing mass of technology users, have enabled emerging markets to implement basic AI solutions such as credit scoring and targeted advertising. Ant Financial in East Asia, M-Shwari in East Africa, M-Kajy in Madagascar, and MoMo Kash in Cote d'Ivoire are early examples of AI delivering financial services to the poorest. M-Shwari uses machine learning to predict the probability of default of potential borrowers, which allowed it to deliver small loans to 21 million Kenyans by the end of 2017.

AI applications have the potential to address challenges faced by individuals at the bottom of the income distribution, particularly the bottom 40 percent. While these individuals lack the means to purchase AI-

technologies or AI-enabled equipment, they can benefit from AI-as-a-service solutions through their mobile devices. Recent examples include a machine learning app, Nuru, that has been used on farms in Kenya, Mozambique, and Tanzania to identify leaf damage in photos taken by farmers and to send information to authorities to help monitor the presence of an invasive pest that threatens farm revenue and food security across East Africa.

Data generated through mobile phones can be highly correlated with financial status, educational attainment, and health status and therefore can enable mobile AI apps to deliver microlending, personalized tutoring, health diagnoses, and medication advice. In addition, AI's speech recognition and speech-to-text functionalities remove literacy barriers typically encountered by the poorest individuals when accessing text-based applications. And image recognition can be used to assess microinsurance claims of farmers in distant rural communities.

AI technologies can enable new approaches to the monitoring and evaluation of development interventions to target those most in need.[7] Emerging countries often lack the data necessary to fine-tune development interventions. AI's ability to tackle unstructured data such as text, images, and audio can be useful for extracting the information needed to improve development outcomes. For instance, an experiment in rural India relies on textual transcription of village assemblies to identify the topics discussed and how the flow of conversation varies with the gender and status of the speaker, thereby shedding light on the functioning of these deliberative bodies, an important aspect of political accountability.[8] Other experiments include the use of machine learning on VAT tax data in India to better target firms for audits and to predict travel demand patterns after hurricanes[9] as well as where food insecurity will occur to help target aid interventions.[10]

Despite the potential risks of AI, failing to take advantage of the opportunities it offers could be even more costly. The economic and societal transformations brought about by disruptive technologies can be accelerated with AI and can dramatically speed up progress toward the Sustainable Development Goals and the twin goals. Yet if countries cannot compete in the future global economy, they will be left behind. To harness the potential of new business models, new ways of delivering services, and shifting sources of competitiveness, countries and companies in the private sector will need to implement innovative approaches to expand AI's opportunities and mitigate its risks.

Identifying the Development Opportunities of AI

AI can expand and increase development opportunities in emerging markets in several ways. **Improved business productivity** stemming from automation of core business processes and human capital development can significantly lower production costs. These improvements are already used by many companies in developed markets. AI-enabled productivity growth directly raises output and employment, and also does so indirectly through increased consumption.

Cost reductions stemming from automation of certain functions can combine with increased access to credit—a critical advantage AI technologies are already delivering—to reduce overall business costs. This can increase both the volume of bankable business opportunities and the level of competition within markets and industries. AI solutions can also help overcome the lack of infrastructure and large information asymmetries in emerging markets by supporting product innovation in the form of new business models and leapfrogging solutions tailored to serve previously unserved and underserved populations.

AI has the potential to deliver significant productivity gains for businesses. This includes the combination of the accelerated pace of technology diffusion, the convergence of multiple technologies, and the emergence of digital platforms. Through automation, AI is set to bring significant cost reductions across all core business functions, including human resources management, marketing, accounting, and inventory. For instance, employee recruitment often involves the costly review of dozens of candidate profiles, a process that can be automated using AI solutions. Automation of the recruitment process typically curbs time-to-hire from 10 weeks to 2 weeks, and the time to shortlist candidates from 2–3 weeks to almost instantaneous. Also, repetitive human review of accounting documents or inventory can instead be performed by AI, generating significant cost savings. For instance, automation of accounting services in Brazil is set to alleviate the cost of bureaucracy—tax filing is an example—incurred by medium-sized enterprises. These improvements are likely to drive the growth of informal businesses, which make up to two-thirds of GDP in some lower-income countries.[11]

Productivity improvements also stem from more efficient investment in human capital thanks to automation. AI can reshape high-quality education and learning through precisely targeted and individually customized human capital investments. The integration of online courses with AI offers the opportunity to improve access to affordable education and raise learning and employment in emerging markets. Edtech companies like Coursera, Andela, and Udemy are generating data on student performance across emerging markets and are poised to leverage this data to deliver upskilling recommendations. In India, UpGrad has enrolled 2,000 students in entrepreneurship, digital marketing, data analytics, and product management courses, whereas Edutel uses two-way satellite technology to deliver live lessons by specialist teachers in science, math, and English to about 2,000 primary and secondary schools in the southern state of Karnataka. Other companies are combining data from online education and job platforms to deliver automatic upskilling recommendations with the goal

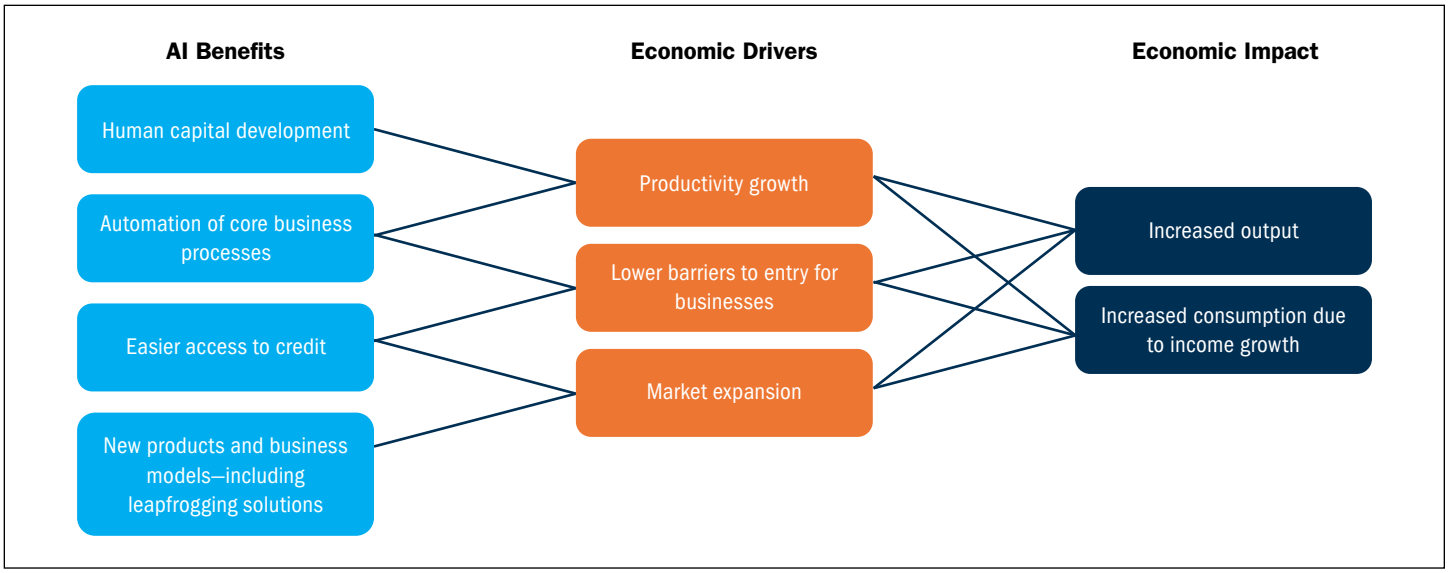

FIGURE 2 Channels to economic development supported by AI technologies

Source: IFC

of improving employability. Examples include 51job.com in China and Revelo in Brazil.

AI is driving innovation in financial services through better data processing, increasing access to credit. By relying on nontraditional data such as mobile phone call records, mobile-money transaction data, text messages, and address books, AI can reduce information asymmetry in contexts where borrowers lack credit history, enabling access to financial services for first-time borrowers and the unbanked. AI has the potential to make financial services more affordable thanks to the automation of credit scoring, a process that requires human resources in traditional financial institutions. Machine learning algorithms can parse large amount of mobile phone data to deliver instantaneous credit scores to users in developing countries. Once a user is offered a loan, the scoring algorithm continues to improve by absorbing credit history data. An example of this approach is Branch, a fintech company that offers microloans to first-time borrowers and customers without banking accounts in Africa (Kenya and Nigeria), India, and Mexico.

AI's capacity to handle unstructured data has the potential to enable product innovation in sectors such as pharmaceuticals, transportation, and logistics. Because of limited statistical capacity, emerging markets often lack the structured data needed to power business analytics solutions. AI, however, can handle unstructured data such as audio recordings or videos largely available in emerging markets to discover new ways of servicing customers, new drugs, and new predictive healthcare solutions. Drug discovery, for instance, involves searching through an almost infinite set of molecular combinations, a task for which AI is far more efficient than medicinal chemists.

AI is also driving innovations in business models through automation that delivers more affordable services, thereby expanding the market to underserved consumers. For instance, TaxiJet, a ride-hailing company with a business model similar to Uber, uses AI to match users with taxi drivers in Cote d'Ivoire at lower cost than traditional taxis.

AI can also alleviate constraints from poor infrastructure in emerging markets by providing alternatives and cost-effective solutions to deliver social services to those who need them most, including remote communities. Taking advantage of the widespread coverage of mobile networks, AI is being used in telemedicine for early diagnosis of disease, thereby saving costs associated with maintaining an extensive network of community health workers. Likewise, education resources planning often fails to account for the geographical distribution of learning outcomes due to poor data, which leads to an unequal distribution of resources. Automated processing of student performance can help target areas with the greatest challenges. AI-enabled matching of students with teachers can also improve access to higher quality education.

Productivity growth, lower barriers to entry, and market creation and expansion have the potential to raise consumption and ultimately output. Creating and expanding markets can help create jobs and raise consumption to the benefit of the wider economy. For instance, online marketplaces that rely on AI solutions across Africa are expected to create around 3 million jobs by 2025 by expanding the supply of goods and services, making assets more productive, and unlocking demand in remote locations.[12] Productivity growth of informal businesses and market expansion are more critical in emerging markets, suggesting a higher economic potential

for AI in these countries than in developed markets. China offers an example of the size of the opportunities AI holds for emerging markets: It is estimated that AI could boost China's GDP by 26 percent by 2030, compared with 14 percent in the United States.[13]

These gains could be further reinforced by AI-driven efficiencies in the delivery of public services. Governments in emerging markets could benefit from AI due to potentially significant cost-savings, improved delivery of social services, and better risk management. While few studies have investigated the gains from automation for governments in emerging economies, estimates from advanced economies suggest that it could be substantial. In the United States, estimates suggest that the federal government could save up to $41 billion through AI-enabled automation.[14] Potential government services that could be automated include data entry with automated handwriting recognition, planning and optimization algorithms, and customer service using speech recognition and natural language processing. For instance, electronic document discovery locates 95 percent of relevant documents in the discovery phase of legal cases, compared to an average of 50 percent for humans, in a fraction of the time.[15]

Other opportunities include risk management—disease prevention, natural disaster management, humanitarian crisis management—and citizen engagement through automated and real-time analysis of online activities, including social network and telecommunications metadata.

Managing the Risks that AI Poses

Disruptive technologies including AI pose new risks to economic and societal inclusion. Technologies are reshaping the nature of work and could exacerbate inequality within countries.[16] Shifts in the demand for labor and the skills that complement technology can reward those with access to new technologies and skills—at the expense of those who lack them. With advances in AI and ML, highly-skilled routine tasks may be disrupted. There will thus be a premium on skills that complement technology—not only technical skills but also socio-behavioral and creative skills for greater adaptability and lifelong learning.

One concern is whether AI will disrupt the potential for emerging economies to catch up through traditional export-led manufacturing. Emerging countries have been able to take advantage of an abundant skilled but low-wage labor to attract foreign manufacturing firms and outsourced services and gain global competitiveness in export-oriented sectors. Countries like China today, or South Korea and Japan yesterday, have succeeded by relying on this model. However, AI, more than other disruptive technologies, embeds the cognitive abilities mobilized by this labor force, which might make it more difficult for emerging countries to exploit this important traditional development ladder.

For instance, advanced AI applications such as natural language processing could replace outsourced customer care services, an industry which employ thousands of workers in countries like Vietnam, South Africa, and Morocco. Likewise, autonomous AI, enabling robots to sew, could replace hundreds of thousands of workers in Bangladesh and Ethiopia. Job displacement, accentuated by the decreasing importance of cross-country labor cost arbitrage and combined with slower output growth, could further widen the gap between advanced and emerging countries, as well as increase inequality within countries, and thereby limit upside opportunities for nascent middle classes. This risk is more acute in the medium term for countries that have already developed these types of jobs, while for the poorest countries these jobs may not be there to lose.

AI may challenge existing local businesses that fail to catch up with the latest technologies. A key element of AI performance is access to large volumes of data, and this tends to increase the initial advantage of a successful first mover. Such a trend has the potential to create 'winner takes all' outcomes. Successful AI-enabled businesses are more competitive and therefore attract more customers and accumulate more data, which further improves their AI algorithm and reinforces their initial competitive advantage. This is often the case with mobile operators that offer electronic financial services and employ AI to optimize their distribution networks. If the enabling environment to be competitive does not adapt, firms will not be able to pursue new opportunities, widening productivity differences, creating larger first-mover advantages, and fostering growth accelerations only in certain sectors and locations.

Acute societal challenges include privacy, security, public trust, algorithmic biases, and ethical use of AI. Survey results suggest that these issues are more severe in emerging markets. For instance, only 20 to 21 percent of businesses leaders in the Asia-Pacific and Europe, the Middle East and Africa regions provide their boards with adequate reporting metrics for cyber and privacy risk management, compared to 35 percent in North America.[17] Because they are often trained on imperfect data, AI applications in real world settings like job screening, insurance approval, and policing tend to reproduce social biases typically related to gender and race. Policy makers are taking steps to mitigate these risks, with member states of the OECD and some emerging countries like Brazil and Peru having recently endorsed a set of principles to promote responsible stewardship of AI.

On top of these challenges, there are **risks that AI may widen gaps between countries, reinforcing the current digital divide.**[18] AI leaders (mostly in developed countries) could increase their lead in AI adoption over developing countries. Many developed countries may have no choice but to develop local AI industry to capture higher productivity growth as their GDP growth momentum

slows, a phenomenon often related to aging populations. Moreover, wage rates in these economies are high, providing more incentive than in low-wage developing countries to substitute labor with machines.

Developing countries tend to have other ways to improve their productivity, including catching up with best practices and restructuring their industries, and may therefore have less incentive to develop local AI industry. This does not mean that developed economies will reap the biggest gains from AI and that developing economies are destined to lose the AI race. Countries can choose to strengthen their digital economy foundations and develop the supporting capabilities needed to reap the potential of AI. While China has become the second largest AI powerhouse, paths remain open to other economies, and support from the private sector will be critical to accelerating adoption and dissemination.

Supporting Private Sector-led AI Solutions in EMs

The private sector is well positioned to harness the opportunities AI offers in emerging markets because of the significant need for innovation and the potential gains in productivity, market expansion, and business opportunities in the public sector. However, aside from China, private sector involvement in the diffusion of AI in emerging markets has been limited so far. India, the second largest emerging market nation, remains a significant laggard, with just 152 AI startups as of 2018, compared with 1011 in China.[19]

Most private sector initiatives are focused on microlending and use machine learning algorithms in conjunction with mobile phone data to predict the probability of default by potential borrowers, with fintech companies and mobile operators leading the race. AI applications in promising sectors such as transportation, education, health, and agribusiness are rarely available in most emerging markets.

Critical constraints to the adoption of AI solutions include the lack of a developed digital economy and a supporting entrepreneurial ecosystem capable of driving innovation and attracting financing; a scarcity of local AI expertise; and a lack of government support in key areas such as open access to data, system interoperability, trust, and acceptance of trial and error.

While basic AI applications such as credit scoring and online platforms (mobile-based or fixed) can rely on traditional connectivity like 2G, advanced AI applications such as facial and speech recognition require broadband connection to transmit bandwidth-consuming files such as images and audio. Likewise, the smooth functioning of autonomous vehicles requires a web of connected objects and a network architecture closer to 5G.[20] Data centers are critical infrastructure for data storage and high-speed computation and parallel computing, yet they remain deficient in many emerging markets, particularly in Africa.

In terms of entrepreneurial ecosystems, few emerging markets have AI startups. As of 2018, 20 countries hosted 95 percent of worldwide AI enterprises, only three of them are emerging markets. China is second with 1011 AI enterprises, India is 5th with 152, and Russia is 20th with 17.[21] A lack of access to expertise and data often discourage private investors from pursuing AI projects in emerging markets. Scarce AI expertise in low-income countries increases the cost of implementing any AI project. Recent initiatives tackling this issue in Africa include Andela (Nigeria, Kenya, Rwanda, and Uganda), a Google AI Lab in Accra (Ghana) and the creation of a Master in Machine Intelligence at the African Institute of Mathematical Science in Kigali (Rwanda).

Looking Forward

Development Finance Institutions including IFC are pursuing a broad range of strategies to help private companies and governments across emerging markets implement AI solutions.[22] VC investment as well as investment in funds is enabling the growth of AI startups. Further investment in online educational platforms that offer machine learning and programming courses are building local expertise across emerging markets. However, private sector investment in AI projects in emerging markets remains limited to a few countries, partly due to uncertainty about consumer interest in AI products.

The private sector alone cannot make AI succeed in emerging markets. Governments must level the playing field by providing open access to big data; by catalyzing network effects through standards setting and interoperability enforcement; and by supporting trial-and-error phases, including potentially through public subsidies to AI incubators.

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Please see the following additional reports and EM Compass Notes about technology and its role in emerging markets: *Reinventing Business Through Disruptive Technologies—Sector Trends and Investment Opportunities for Firms in Emerging Markets* (March 2019); *Blockchain:*

Opportunities for Private Enterprises in Emerging Markets (January 2019); *How Technology Creates Markets—Trends and Examples for Investors in Emerging Markets* (March 2018); *Basic Business Models for Banks Providing Digital Financial Services in Africa* (Note 68); *The Case for Responsible Investing in Digital Financial Services* (Note 67); *Natural Gas and the Clean Energy Transition* (Note 65); *How a Know-Your-Customer Utility Could Increase Access to Financial Services in Emerging Markets* (Note 59); *Modelo Peru: A Mobile Money Platform Offering Interoperability Towards Financial Inclusion* (Note 54); *Precision Farming Enables Climate-Smart Agribusiness* (Note 46); *Digital Financial Services: Challenges and Opportunities for Emerging Market Banks* (Note 42); *How Fintech is Reaching the Poor in Africa and Asia: A Start-Up Perspective* (Note 34).

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[1] Definition attributed to Professor John McCarthy in 1956. Quoted in Moor, James. 2006. "The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years." *AI Magazine*, Volume 27 Number 4, pp 87–91. https://pdfs.semanticscholar.org/d486/9863b5da0fa4ff5707fa972c6e1dc92474f6.pdf.

[2] See One Hundred Year Study on Artificial Intelligence (AI100). "Defining AI". Stanford University. https://ai100.stanford.edu/2016-report/section-i-what-artificial-intelligence/defining-ai

[3] Broader definitions of artificial intelligence are drawn from the following sources: Nilsson, Nils. 2010. "The Quest for Artificial Intelligence: A History of Ideas and Achievements." Cambridge University Press; Russell, Stuart and Peter Norvig. 2009. "Artificial Intelligence: A Modern Approach." Pearson 3rd Edition; OECD. 2019. OECD. 2019. "Recommendation of the Council on Artificial Intelligence." OECD Legal 0449 as adopted on May 21, 2019. https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449; PwC. 2018. "The Macroeconomic Impact of Artificial Intelligence." February 2018. https://www.pwc.co.uk/economic-services/assets/macroeconomic-impact-of-ai-technical-report-feb-18.pdf.

[4] MMC Ventures. 2019. "The State of AI 2019: Divergence." MMC Ventures Report in Partnership with Barclays. https://www.stateofai2019.com/.

[5] CB Insights, 2019. "Artificial Intelligence Deals Tracker." https://app.cbinsights.com/research/artificial-intelligence-deals-tracker-heatmap/

[6] For examples about the human development opportunities that AI offers, see the following World Bank Blog: Osornprasop, Sutayut. 2018. "Artificial Intelligence, Big Data: Opportunities for Enhancing Human Development in Thailand and Beyond." World Bank Blogs, December 18, 2018. https://blogs.worldbank.org/eastasiapacific/artificial-intelligence-big-data-opportunities-enhancing-human-development-thailand-and-beyond

[7] Blumenstock, Joshua Evan, 2016. "Fighting Poverty with Data: Machine Learning Algorithms Measure and Target Poverty." Science Magazine, Volume 353, Issue 6301, pp. 753–754. http://www.jblumenstock.com/files/papers/jblumenstock_2016_science.pdf.

[8] Parthasarathy, Ramya, Vijayendra Rao and Nethra Palaniswamy. 2017. "Deliberative Inequality: A Text-as-Data Study of Tamil Nadu's Village Assemblies." World Bank Group Policy Research, Working Paper WPS 8119. http://documents.worldbank.org/curated/en/582551498568606865/Deliberative-inequality-a-text-as-data-study-of-Tamil-Nadus-village-assemblies.

[9] Farley, Scott. 2017. "Tracing Hurricane Maria's Wake." Blog, October 25, 2017. https://blog.mapbox.com/tracing-hurricane-marias-wake-7217a7d08380.

[10] Knippenberg, Erwin, Nathan Jensen and Mark Constas. 2018. "Resilience, Shocks, and the Dynamics of Food Insecurity: Evidence from Malawi." Working Paper, March 2018. https://static1.squarespace.com/static/59c807a890bade1b5925f72e/t/5a9ef2b253450a57bf5f6a7c/1520366270740/Resilience%2C+Shocks+and+the+Dynamics+of+Food+Insecurity+%28JMP%29.pdf

[11] Leandro, Medina and Friedrich Schneider. 2018. "Shadow Economies Around the World: What Did We Learn Over the Last 20 years?" IMF Working Paper WP/18/17. https://www.imf.org/en/Publications/WP/Issues/2018/01/25/Shadow-Economies-Around-the-World-What-Did-We-Learn-Over-the-Last-20-Years-45583.

[12] Boston Consulting Group (BCG). 2019. "How Online Marketplaces Can Power Employment in Africa." https://www.bcg.com/publications/2019/how-online-marketplaces-can-power-employment-africa.aspx.

[13] PwC. 2017. "Sizing the Prize: What's the Real Value of AI for Your Business and How Can You Capitalize?" https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf.

[14] Eggers, William, David Schatsky and Peter Viechnicki. 2017. "AI-Augmented Government: Using Cognitive Technologies to Redesign Public Sector Work." Deloitte Center for Government Insights. https://www2.deloitte.com/content/dam/insights/us/articles/3832_AI-augmented-government/DUP_AI-augmented-government.pdf.

[15] Kershaw, Anne. 2005. "Automated Document Review Proves its Reliability." *Digital Discovery & e-Evidence*, Talking Tech Note Volume 5, Number 11, November 2005, pp 1–4. www.akershaw.com/Documents/2004AEKDocReviewArticle.pdf.

[16] World Bank Group. 2019. "World Development Report 2019: The Changing Nature of Work." http://documents.worldbank.org/curated/en/816281518818814423/pdf/2019-WDR-Report.pdf.

[17] PwC. 2018. "Digital Trust Insights." PwC 2018 Digital Trust Insights Survey. https://www.pwc.com/us/en/services/consulting/cybersecurity/digital-trust/2018-insights.html

[18] World Bank Group. 2016. "World Development Report 2016: Digital Dividends." https://openknowledge.worldbank.org/bitstream/handle/10986/23347/9781464806711.pdf

[19] China Institute for Science and Technology Policy at Tsinghua University (CISTP). 2018. "China AI Development Report 2018." CISTP, July 2018. http://www.sppm.tsinghua.edu.cn/eWebEditor/UploadFile/China_AI_development_report_2018.pdf

[20] Forecast of 12% 5G penetration rate in developing countries by 2025, compared to 48% in developed countries according to projections by GSMA Intelligence. GSMA Intelligence, 2018. "Market Penetration: 5G." https://www.gsmaintelligence.com/metrics/44/1529/data/?report=5d26d871dd310

[21] China Institute for Science and Technology Policy at Tsinghua University (CISTP). 2018. "China AI Development Report 2018." CISTP, July 2018.

[22] These strategies are complemented by investment in digital infrastructure such as Helios Towers Africa and a 10,000 km sub-marine cable system in East Africa. See Chapter 6 of "Reinventing Business Through Disruptive - Sector Trends and Investment Opportunities for Firms in Emerging Markets." IFC Report, March 2019. https://www.ifc.org/wps/wcm/connect/8c67719a-2816-4694-9187-7de2ef5075bc/Reinventing-business-through-Disruptive-Tech-v1.pdf?MOD=AJPERES