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Bridging the AI Divide: Empowering Developing Countries through Manufacturing

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Abstract [1]

Artificial intelligence (AI) is reshaping global manufacturing by integrating with advanced digital production technologies (ADPTs) and driving significant changes in production and innovation[2]. The disparity in AI development between advanced and developing countries threatens to widen the technological gap, with the latter frequently relegated to being mere consumers (i.e. becoming 'technological colonies') rather than becoming innovators and producers in this rapidly evolving field. This article presents a comprehensive review of the current state of AI innovation and distribution, which highlights the concentration of capabilities and resources in a handful of advanced economies. It provides strategic recommendations for developing countries to narrow the technological divide by developing their AI capabilities, fostering innovation, and creating an enabling environment for AI adoption.

Key Messages

1. Artificial intelligence (AI) is a catalyst for technological advancement in manufacturing, and significantly enhances decision-making, prediction, and cause-effect inference in several sectors, including automotive, industrial automation and energy.

2. The current global distribution of AI technologies reveals a stark disparity, with developed countries leading in innovation and infrastructure and developing countries relegated as users of these technologies. This calls for targeted efforts in developing countries to bridge this gap.

3. Developing countries must prioritize and pursue the establishment of robust AI ecosystems, skill development and international collaboration to effectively integrate AI into their industrial strategies.

4. UNIDO can play a crucial role in helping developing countries develop the necessary capabilities to leverage AI technologies to achieve long-term benefits.

Introduction

Artificial intelligence (AI) marks a crucial step in the ongoing evolution of technological innovations in hardware, software and connectivity within manufacturing and production, collectively referred to as advanced digital production technologies (ADPTs). AI is broadly defined as a machine-based system which—for a given set of human-defined explicit or implicit objectives—infers from the inputs it receives (e.g. data or rules) to generate outputs such as predictions, recommendations or decisions.[3]

The focus on AI within policy, industry and academia has increased due to its potential to enhance synergies between existing ADPTs (e.g. sensors, industrial robots, additive manufacturing and the Internet of Things), and its growing ability to make decisions, predict outcomes, and infer results in both the physical and virtual worlds. Recent developments in AI, including generative AI and large-language models (LLMs) such as ChatGPT, Gemini and DALL-E, highlight the significant potential of AI applications in reshaping economic and social landscapes. These advancements reinforce the need for investments in and continued development of AI technologies. Investments are necessary in both the infrastructure and algorithmic layers. At the level of the infrastructure layer, these investments include the manufacturing and assembly of advanced AI chips, as well as the construction of server farms and data centres, enabling fast access to large volumes of stored data. At the level of the algorithmic layer, efforts are focused on efficiently harnessing available computational power to produce intelligent computations. Advancements in generative AI are anticipated to spill over into other AI applications in the manufacturing sector. These applications include predictive and diagnostic AI applications, which have the potential to enhance autonomy and revolutionize production processes. Despite this potential, a recent study suggests that the use of AI in manufacturing is still limited. There is a notable prevalence of AI in specific sectors, however, such as automotive, industrial automation and machinery, energy, utilities, renewables and agriculture, indicating a high level of heterogeneity.[4]

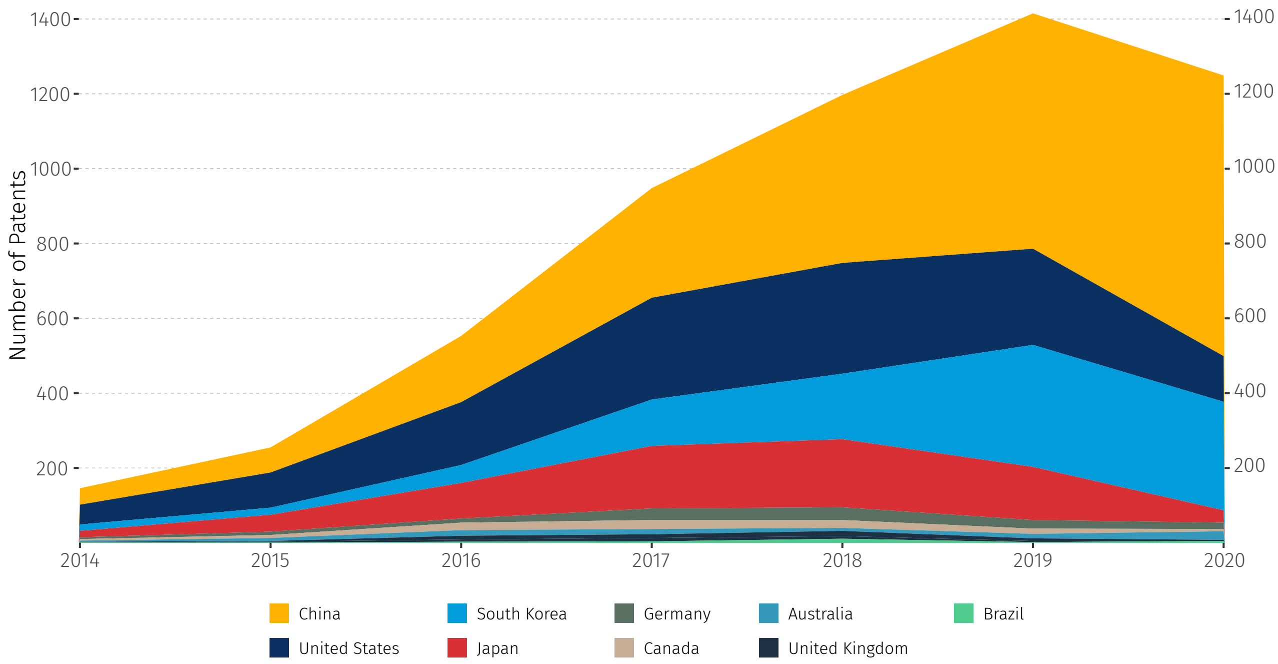
While opportunities and risks exist in the development and diffusion of AI technologies for both advanced and developing economies, the balance is far more uneven for the latter. The deployment of digital technologies and AI can only be effective when they are integrated into an already well-developed ecosystem of production technologies, equipped with the necessary capabilities to absorb and adapt to these new technologies.

The focus on AI at the level of policy, industry and academia has increased, given the potential of AI technologies to enhance synergies between existing ADPTs, and its growing ability to make decisions, predict outcomes and infer results.

Current state and distribution of AI technologies across countries

The distribution of production and innovation in AI technologies is currently highly uneven in terms of both infrastructure and algorithmic layers. Advanced economies, including the United States, China, and a handful of Asian and European countries, dominate advancements in these two crucial components of AI technology. For instance, the United States, China, Japan and the Republic of Korea lead in the design and production of advanced AI-tailored chips. These chips incorporate technologies such as mixed-precision computing, which accelerates computations by reducing the precision of numerical formats. They also incorporate tensor cores, which are designed to handle the computational patterns found in neural networks. Emerging economies such as Malaysia participate in the AI supply chain, but primarily in lower value-added phases such as assembly and testing. However, they only hold a small percentage of the market share. The absence of these economies in the manufacturing of chips can be attributed to the high costs and initial investment required. This is due to the complexity of the production process and the need for sophisticated capital equipment and related capabilities. As regards the algorithmic layers and AI-related advancements in software, China stands out as the only emerging country with a significant share in AI applications. Figure 1 illustrates the number of AI patent applications granted in industry and manufacturing, with China and the United States leading in AI innovations.

FIGURE 1: AI PATENT APPLICATION GRANTED IN INDUSTRY AND MANUFACTURING



Source: Authors based on data from OurWorldinData.org

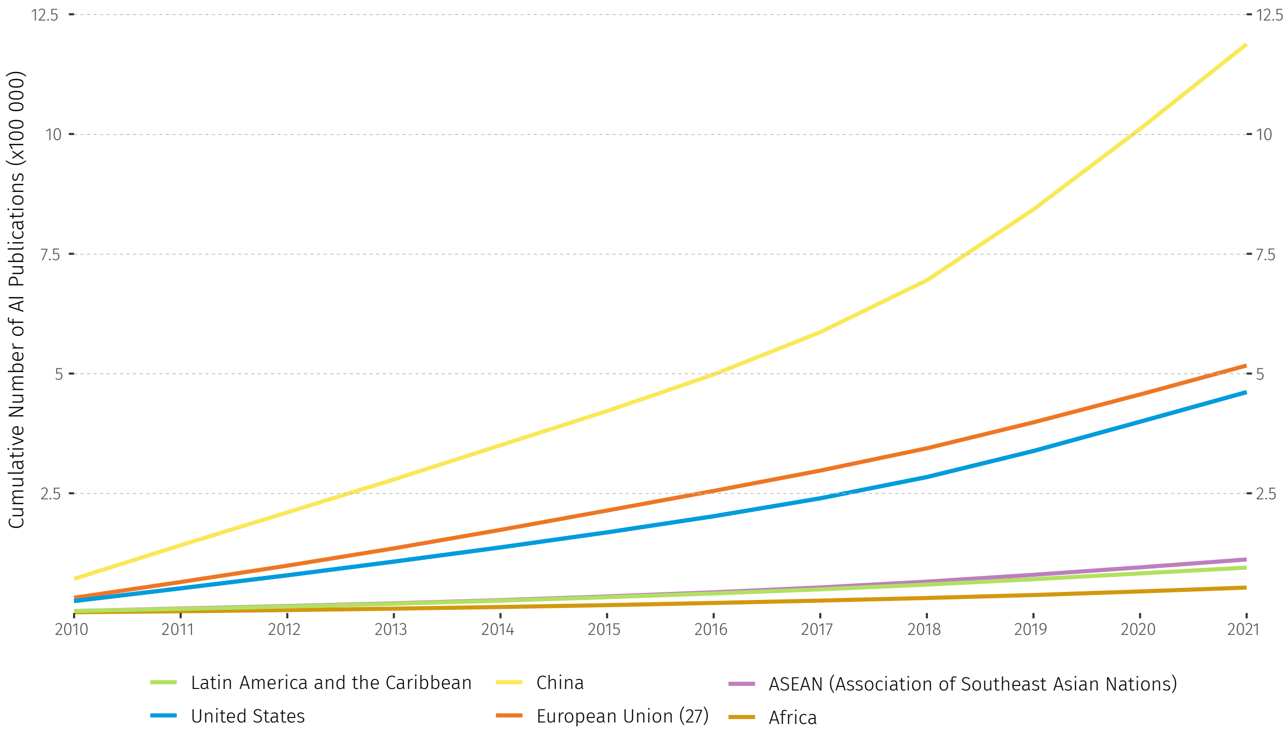
Patents are not the only source for understanding innovative developments in AI - scientific publications often provide better insights into the dynamic aspects of the multi-level process of AI innovation. Figure 2 presents the distribution of scholarly publications on AI, further highlighting the concentration of AI expertise and research in a few advanced economies only. On a more positive note, there is potential for development in the academic sector of several emerging economies. India, Brazil, Iran, Pakistan and Malaysia are among the top 15 countries for AI/ML publications.

Lagging behind in AI innovation also has consequences for AI adoption and diffusion into production systems. Countries that innovate tend to be early adopters of technologies.[5] In terms of AI investments, three sectors dominate: (i) medical and healthcare; (ii) data management, and (iii) industrial automation.

The objective is to create opportunities for local value creation, while also providing support for the adoption of digital technologies and AI, such as the development of the AI infrastructure layer.

These sectors, along with their supply chains, are more developed in advanced economies. A direct consequence of the concentration of both innovation and production/investment in AI technologies is that emerging economies (excluding China) are mostly importers of digital production technology systems[6] produced in the Global North. This not only exacerbates some countries'

FIGURE 2: SCHOLARLY PUBLICATIONS ON ARTIFICIAL INTELLIGENCE (CUMULATIVE VALUES)



Source: Authors based on OurWorldinData

trade deficit, which export low value-added goods and services while importing high value-added ones, such as ADPTs, but also widens the existing gap in technological capabilities. Developing countries are thus relegated to being users of ADPTs, preventing learning, accumulation, and innovation around new technologies.

The path forward: AI for industrial development in developing countries

This uneven distribution between producers and users of AI poses a risk for developing countries, potentially deepening existing technological gaps. If developing countries fail to keep pace with AI advancements, they risk falling further behind in industrial development. The concentration of AI technologies in a few advanced economies means developing countries are consumers rather than producers of AI innovations. As a result, developing countries may become increasingly dependent on advanced economies for AI technologies, which can further entrench economic disparities. To mitigate these risks, developing countries need to focus on building their AI capabilities, fostering innovation, and creating an enabling environment for AI adoption.

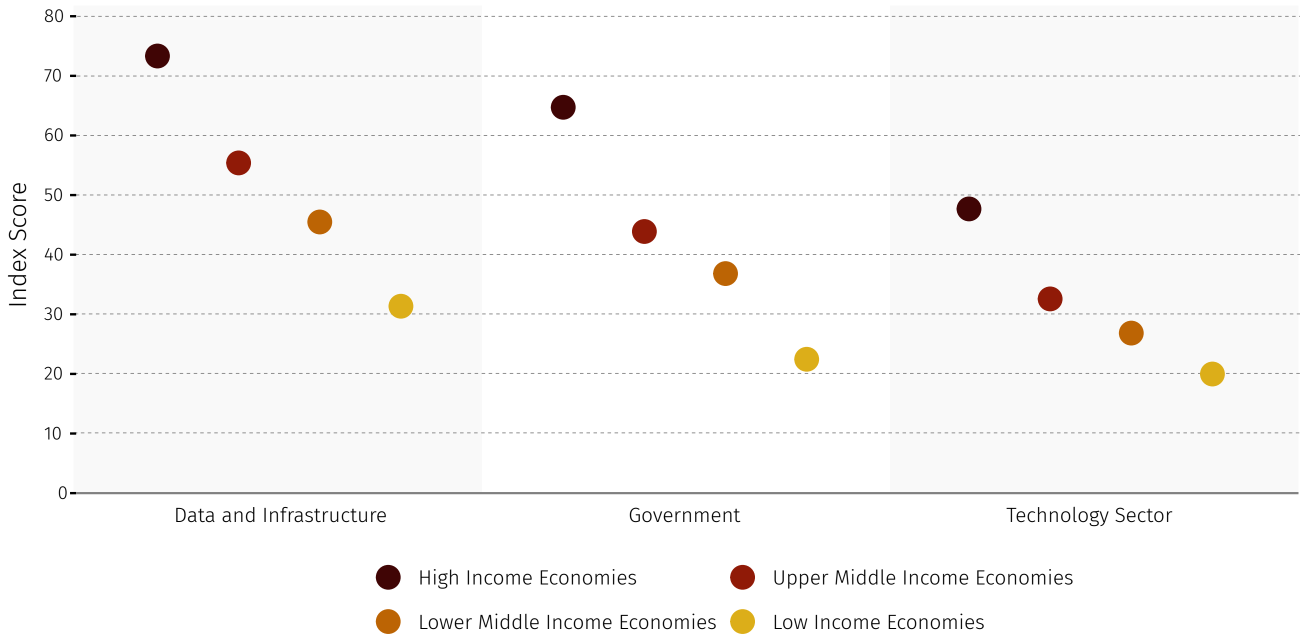
The industrial development of developing countries hinges on their ability to effectively adopt and integrate AI technologies into their production systems. Narrowing the existing gap is crucial to keep pace with technological advances and to ensure participation in international trade, which remains an important avenue for learning and upgrading for firms in developing countries.

Initiatives in developing countries should focus on improving (i) AI readiness, which involves targeting business entities (multinational corporations (MNCs) and local companies) as well as government, and (ii) how governments deal with the integration of AI into public services and its adoption/ use for the public good. MNCs are usually early adopters of ADPTs and AI systems due to their financial resources, allowing them to upgrade existing technologies[7] [8]. Governments should collaborate with MNCs and develop industrial policies that facilitate MNCs' activities, while also implementing strict conditionalities to benefit the local economy.

Such conditionalities depend on the negotiating power of the respective developing country. The objective is to create opportunities for local value creation, while also providing support for the adoption of digital technologies and AI, such as the development of the AI infrastructure layer. Additionally, efforts to assist small and medium sized enterprises (SMEs) should focus on addressing gaps in the adoption of ADPT and AI in production and supply chains. The main challenges include limited financial resources, lack of human resources and absorptive capabilities, and a scarcity of technologies and regulations to ensure the proper functioning of new technologies.[9] While SMEs in advanced economies face greater obstacles than MNCs, their challenges are even more acute in developing countries. SMEs in developing countries have fewer opportunities to either specialize in a specific niche with a competitive advantage or participate in supply chains that involve high precision components, where learning mechanisms flow in both directions between SMEs and large corporations. It is therefore essential, especially in developing countries, to expand the knowledge frontier on the potential of ADPT and AI development. This can be achieved through various means, such as showcasing demonstrations between government agencies and technology providers, conducting ad hoc demonstrations on the shop floor, and providing training courses and facilities. The rapid evolution of AI poses a significant threat to the adoption and implementation of basic research and science in developing countries, which deal with significant hurdles due to the absence of a robust ecosystem and appropriate innovation and industrial policies.

The Government AI Readiness Index[10] should be used to target specific bottlenecks that cause structural lags in AI adoption in developing countries. The index includes 193 countries and builds on three pillars, each comprising multiple indicators: (i) the government pillar, which refers to public sector capabilities in terms of regulation and adaptability, (ii) the technology sector pillar, which refers to how the high innovation sector can support business and promote a research and development (R&D) focus, and (iii) the data and infrastructure pillar which refers to the critical infrastructure required for digitalization and the effective use of AI.[11]

FIGURE 3: GOVERNMENT AI READINESS INDEX - PILLAR SCORES



Source: Authors based on "Government AI Readiness Index 2023" by Oxford Insights

The scatter plot in Figure 3 provides the AI readiness index scores across different income levels in the three pillars. This analysis reveals several important insights that can inform policy decisions and strategic investments in AI readiness.

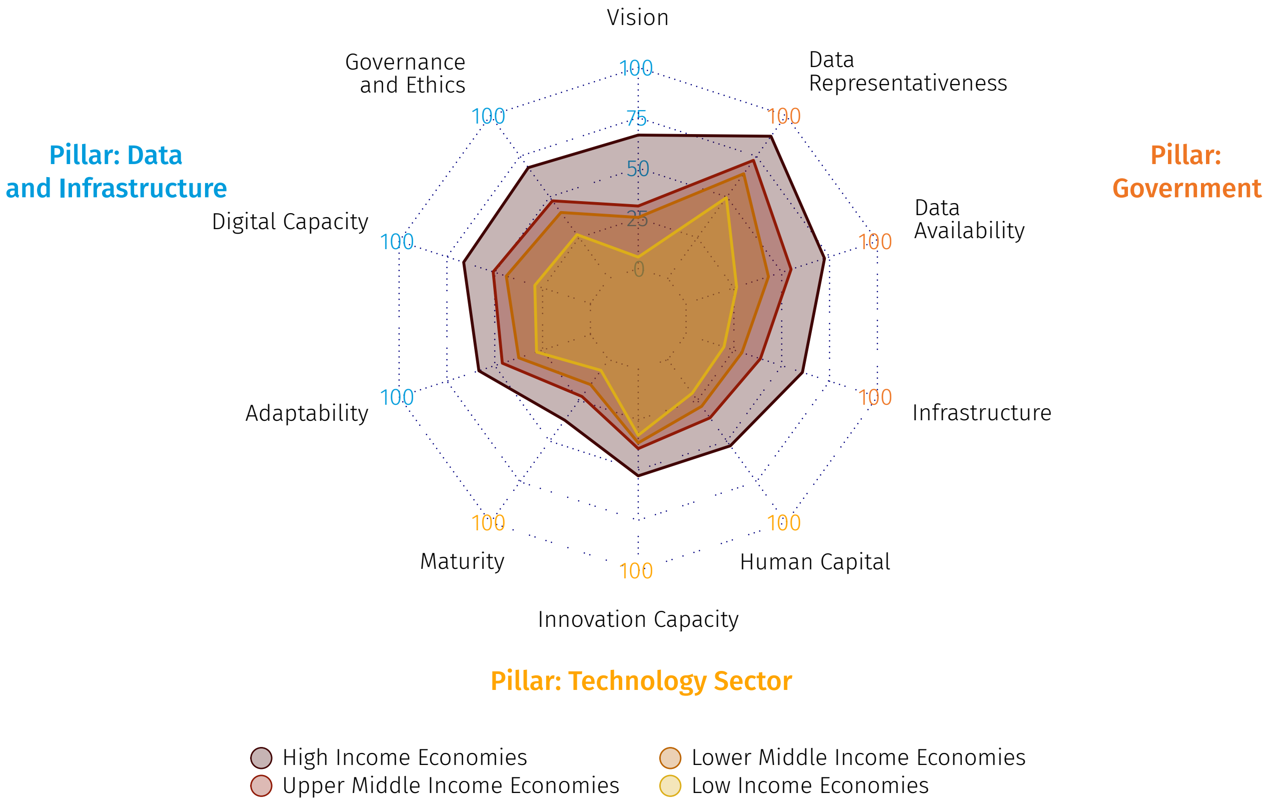
The figure shows a wide range of scores across all pillars and income levels, indicating a diverse global landscape of AI readiness. The "Data and Infrastructure" pillar consistently achieves the highest values across all income levels, but also indicates significant disparities between income groups. This disparity highlights the need for developing countries to increase their investment in data and infrastructure to improve their AI readiness and narrow the gap with more developed nations.

In the "Government" pillar, the scores increase significantly as economies transition from low-income to lower middle-income. This suggests that implementing targeted policies and strategic measures could yield substantial benefits for low-income countries. By prioritizing specific improvements in governance, these countries could make significant strides in their AI readiness.

One intriguing finding is that all country groups attain their lowest index scores in the "Technology Sector" pillar. The differences across income groups are less pronounced, especially when excluding high-income countries. This implies that there is a significant potential for countries to catch up and improve their scores in this pillar, regardless of their income level. Consistent and coherent efforts towards technological development, guided by a national strategy, could thus enhance countries' AI readiness.

Figure 3 obscures the considerable heterogeneity in the reasons for these disparities. While we observe major differences in the "Data and Infrastructure" and "Government" pillars among high-, medium- and low-income countries, the analysis does not explain the underlying reasons for these divergences. To gain a better understanding, we need to explore the different dimensions that make up each pillar.

FIGURE 4: GOVERNMENT AI READINESS INDEX - DIMENSIONS SCORES



Source: Authors based on "Government AI Readiness Index 2023" by Oxford Insights

The spider chart shown in Figure 4 presents the distribution of scores for the dimensions across four income categories. While there are notable variations among income groups in the different pillars, these disparities are more pronounced within specific dimensions within each pillar, rather than being consistent across all dimensions.

The AI Readiness Index reveals an important trend: all dimensions of the index improve as income levels rise. Low-income countries have the lowest readiness to use and benefit from AI, followed by lower middle-income-, upper middle-income- and high-income economies. This correlation between income and AI readiness is consistent across the board. The most significant jump in AI readiness occurs when a country transitions from being an upper middle-income- to becoming a high-income economy, rather than when transitioning from being a low-income- to becoming a lower middle-income economy. This highlights the need for substantial investments in infrastructure, institutions and knowledge to develop AI capabilities. It also suggests that developing countries should focus their limited resources on the most promising sectors or firms to enhance their AI capabilities, ensuring that the benefits spill over to all segments of society.

The starkest differences among high-, middle- and low-income countries are evident in the "Data and Infrastructure" pillar. The "Vision" dimension is the driving force behind these disparities. It is measured by the presence of national AI strategies and captures whether governments have a clear vision for implementing AI (Annex I). Our results suggest that middle-income and even

> While the number of national AI strategies published by global governments has been decreasing, a remarkable rise in strategies published in Latin America, Africa and the Middle East has been observed.

more so low-income countries should prioritize the development of their AI implementation strategies. This entails pursuing specific practices and activities, governance frameworks, and the creation of targeted structures to build and implement these strategies.

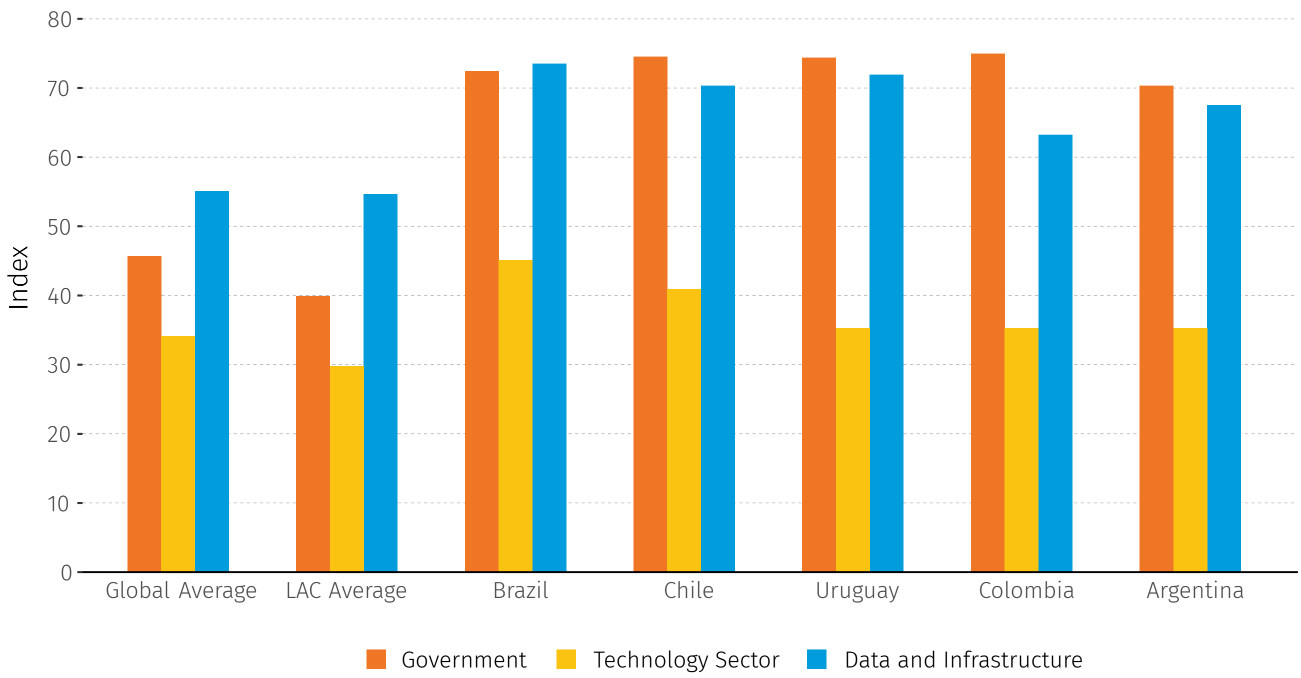
The poor performance of low- and middle-income countries in the “Maturity” dimension—which measures the capacity of a country’s technology sector to supply government with AI technologies—is equally concerning. This weakness is prevalent across all income groups, with high-income countries also achieving their lowest scores in this dimension.

Conversely, the "Technology Sector" pillar's "Innovation Capacity" dimension demonstrates more homogeneity across income groups, particularly between middle-income and low-income countries. This dimension assesses whether the conditions of the country's technology sector are suitable for supporting innovation, including R&D spending, venture capital availability and research activities (Annex I). This homogeneity observed is due to higher income groups performing relatively worse rather than low-income countries performing particularly well. Nevertheless, it presents an opportunity for a more collaborative approach given the similar baselines of these different groups.

Nonetheless, there are significant differences among developing countries, even within the same income group and region. Some developing countries have made promising strides in terms of their AI readiness. For instance, Rwanda, a low-income country, became the first to publish an AI strategy in 2023 under the first pillar (“Government”). While the number of strategies published by governments around the world has been decreasing, a remarkable rise in strategies published in Latin America, Africa and the Middle East has been observed.

Figures 5, 6 and 7 provide an overview of how countries are performing in relation to world and regional averages. In Latin America, five countries (Brazil, Chile, Uruguay, Colombia and Argentina) perform better than other countries in the region. Most of these countries perform well in the “Government” pillar, but lag behind in the other two, especially in the “Technology Sector” pillar. This suggests a lack of innovation and industrial capabilities in high-tech sectors.

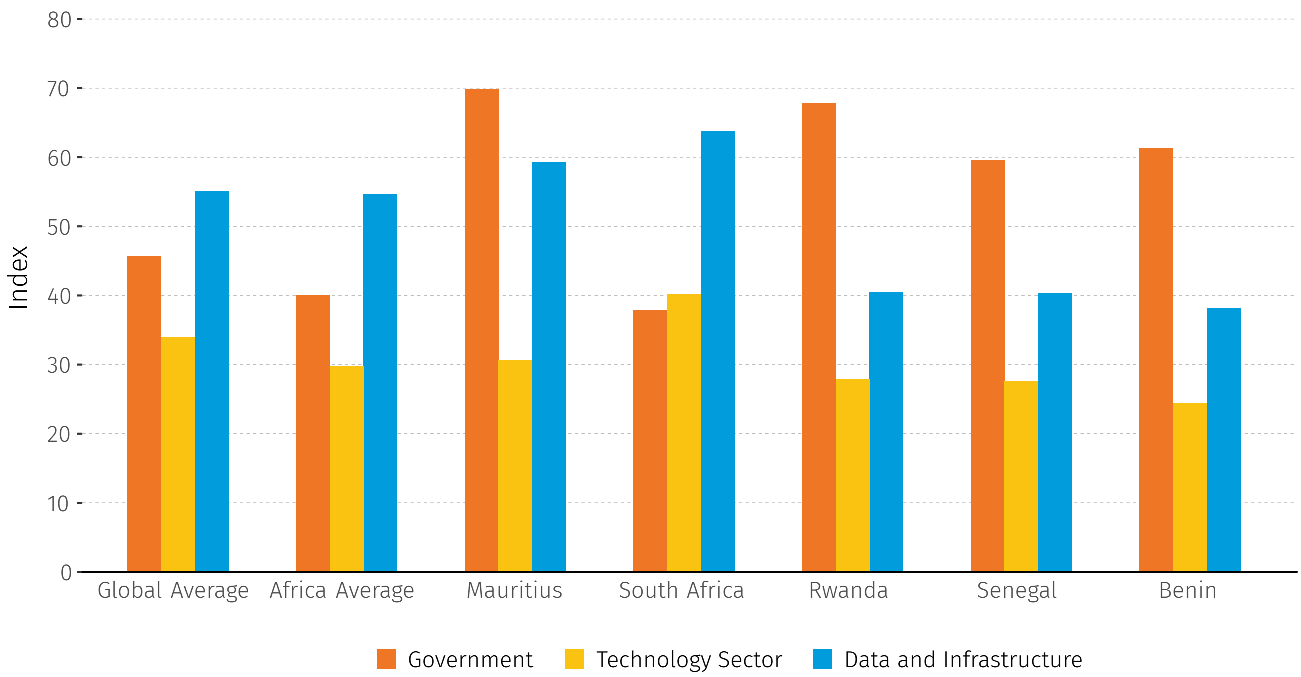
FIGURE 5: LATIN AMERICA: GOVERNMENT AI READINESS INDEX - PILLAR SCORES



Source: Authors based on "Government AI Readiness Index 2023" by Oxford Insights

In sub-Saharan Africa (SSA), Mauritius, South Africa, Rwanda, Senegal and Benin stand out. These countries perform well in the "Government" pillar. South Africa also shows strong performance in the "Data and Infrastructure" and especially in the "Technology Sector" pillar.

FIGURE 6: SUB-SAHARAN AFRICA: GOVERNMENT AI READINESS INDEX - PILLAR SCORES

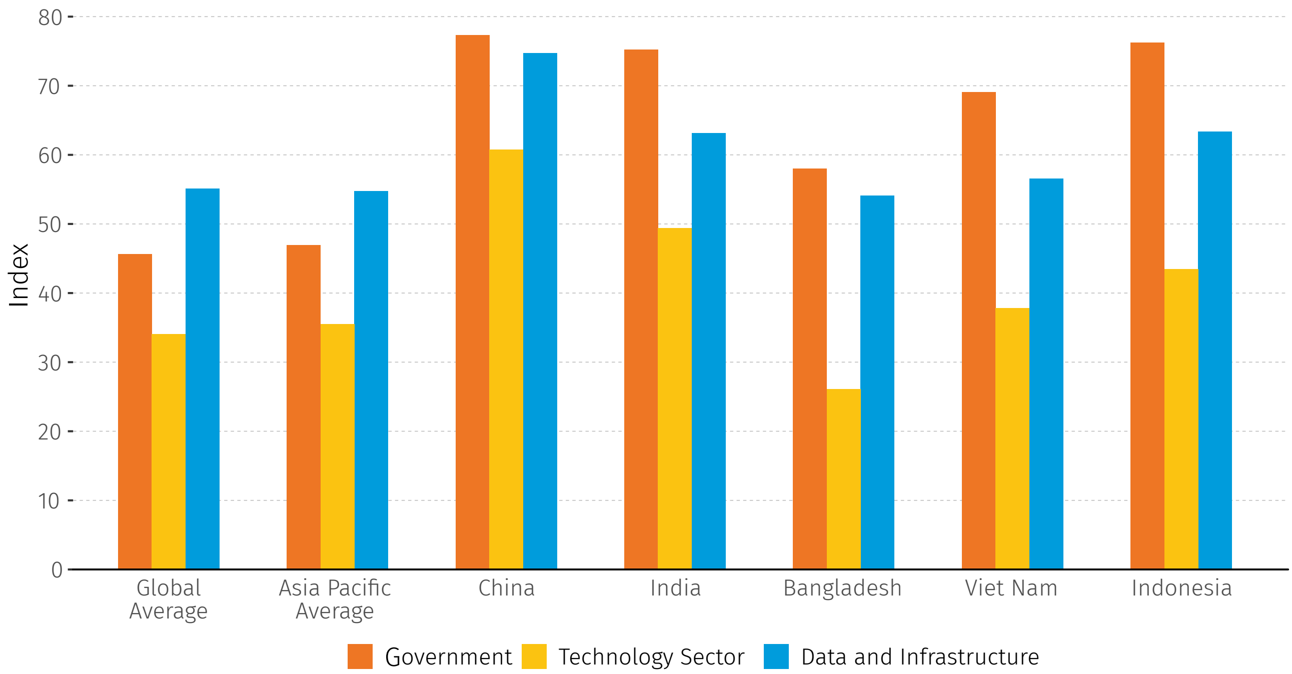


Source: Authors based on "Government AI Readiness Index 2023" by Oxford Insights

The trends in AI readiness across the Asia Pacific region mirror global patterns. AI readiness improves as income levels increase. Lower middle-income countries such as Bangladesh record a lower AI readiness, while countries such as China demonstrate high AI readiness across all pillars. Despite some deep disparities, the region has generally made significant progress. The region's average AI readiness aligns with the global average (which includes high-income countries), slightly surpassing the global average in the "Government" and "Technology Sector" pillars, and slightly lagging in "Data and Infrastructure". However, these differences are negligible.

The selected countries include one upper middle-income country, China, and four lower middle-income countries. All of them perform above the global average, with the exception of Bangladesh, which falls below the global average in the "Technology Sector" pillar.

FIGURE 7: ASIA PACIFIC: GOVERNMENT AI READINESS INDEX - PILLAR SCORES



Source: Authors based on "Government AI Readiness Index 2023" by Oxford Insights

China's performance reflects that of a high-income country in every pillar, while India, Viet Nam and Indonesia show strong performances in the "Government" pillar. These countries fall short of China's performance in the other two pillars, especially Viet Nam and Indonesia.

Our assessment based on the data reveals that the key factors of effective implementation of AI in developing countries are: (i) government efforts to regulate and provide incentives, (ii) infrastructure to support AI development, and (iii) the integration and development of AI technologies at the local level. Engaging with the private sector, particularly in sectors with room for technological upgrading, is crucial to ensuring that the "Technology Sector" pillar (i.e. building productive and innovation capabilities) lies at the core of developing countries' strategies.

Endnotes

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[11] The pillars have different indicators: Government (vision, governance and ethics, digital capacity and adaptability; Data and infrastructure (data representativeness, data availability and infrastructure); Technology sector (human capital, innovation capacity, maturity).

Annex

Government Pillar		
Dimensions	Description	Indicator
Vision	Does the government have a vision for implementing AI?	National AI strategy (Y/N)
Governance and Ethics	Are appropriate regulations and ethical frameworks in place to implement AI in a way that builds trust and legitimacy?	Data protection and privacy legislation
		Cybersecurity
		Regulatory quality
		National ethics framework (Y/N)
		Accountability
Digital Capacity	What is the current digital capacity within government?	Online services
		Foundational IT infrastructure
		Government promotion of investment in emerging technologies
Adaptability	Can the government change and innovate effectively?	Government effectiveness
		Government's responsiveness to change
		Procurement data

Technology Sector Pillar		
Dimensions	Description	Indicator
Maturity	Does the country have a technology sector that is capable of supplying government with AI technologies?	Number of AI unicorns
		Number of non-AI technology unicorns
		Value of trade in ICT services (per capita)
		Value of trade in ICT goods (per capita)
		Computer software spending
Innovation Capacity	Does the technology sector have the right conditions to foster innovation?	Time spent dealing with government regulations
		VC availability
		R&D spending
		Company investment in emerging technology
		Research papers published on AI
Human Capital	Does the population possess the necessary skills to support the technology sector?	Graduates in STEM
		GitHub users per thousand population
		Female STEM graduates
		Quality of engineering and technology in higher education
		ICT skills

Data and Infrastructure Pillar		
Dimensions	Description	Indicator
Infrastructure	Does the country have proper technological infrastructure to support AI technologies?	Telecommunications infrastructure
		Supercomputers
		Broadband quality
		5G infrastructure
		Adoption of emerging technologies
Data Availability	Is sufficient data available to effectively train AI models?	Open data
		Data governance
		Mobile-cellular telephone subscriptions
		Households with internet access
		Statistical capacity
Data Representativeness	Is the available data likely to be representative of the population as a whole?	Gender gap in internet access
		Cost of internet-enabled device relative to GDP per capita

Source: "Government AI Readiness Index 2023" by Oxford Insights

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