WORLD BANK GROUP

Accelerating Artificial Intelligence Investment *in* Emerging Markets

Handbook

May 2026

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Accelerating Artificial Intelligence Investment *in* Emerging Markets

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Foreword

The rapid advance of artificial intelligence (AI) presents emerging markets with a generational opportunity and poses serious development risks if countries are left behind. For countries that can build the right conditions, AI offers a chance to accelerate development, improve business productivity and expand access to education and health services. But for those that cannot, there is a risk of the digital divide growing ever larger, driven by the fact that AI technology is faster-moving, more technically complex, and potentially more disruptive than previous technological advances.

The question this raises for governments, investors, and entrepreneurs in emerging markets is whether they can adapt and leapfrog. The experience in mobile money and off-grid solar shows that developing countries need not replicate every stage of a frontier technology path to capture its benefits. Leapfrogging remains possible, but is neither automatic nor guaranteed. It requires deliberate action, well-sequenced investment, and clear understanding of technological, policy, and human constraints.

Constraints differ significantly by context. Some countries will become sophisticated adopters and adapters of AI solutions. Others, with stronger preexisting infrastructure, will be positioned to develop and scale AI domestically and through international trade. There is no single pathway. This handbook offers a framework to help navigate this complexity, building on two proposed lenses. The Ecosystem Lens maps the necessary components to develop a thriving AI ecosystem, including hard and soft infrastructure, AI building blocks such as foundational models, and vertical applications across sectors. The Structural Elements Lens compliments this by articulating broader enablers, such as energy and data, that sustain the ecosystem over time. Together, they give stakeholders a practical basis for diagnosing where a given market stands and where intervention can create the necessary circumstances for growth.

We offer this framework as a call to action: for governments on policy and infrastructure, investors on where to deploy capital, and entrepreneurs on which problems to tackle. The window for emerging markets to shape their position in the global AI landscape is open and decisions made today will define their trajectory for years. The World Bank Group is committed to supporting those decisions with the best available evidence and tools.

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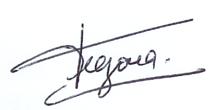

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Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
CaaS	Compute-as-a-Service
DPI	Digital Public Infrastructure
GPT	General-Purpose Technology
GPU	Graphics Processing Unit
HPC	High-Performance Computing
LLM	Large Language Model
MCP	Model Context Protocol
ML	Machine Learning
MLOps	Machine Learning Operations
TPU	Tensor Processing Unit

Executive Summary

Artificial intelligence (AI) has the potential to become a powerful force in emerging markets for shaping products, production, and service delivery. Yet, media headlines often conflate short-term experiments with long-term impact, and the race toward building the most advanced AI models can drown out practical challenges on computing power, data quality, and institutional readiness.

This handbook proposes two complementary lenses to cut through the increasing AI noise.

The Ecosystem lens looks at who builds and enables AI solutions, and the Structural Elements lens looks at the preconditions needed to make scaling AI sustainable. Taken together, these two lenses offer a pragmatic approach to evaluate where value will concentrate, how quickly AI adoption can compound, and which foundations are needed for outcomes to sustain.

In emerging markets, using both lenses together helps avoid the common pitfalls of overestimating momentum from isolated successes or underestimating the adaptability that can overcome systemic gaps. The Ecosystem lens surfaces actors, capabilities, and adjacent elements that can enable early value. Viewed alone, however, it can overstate traction by mistaking short-term ingenuity for structural, long-term readiness. The Structural Elements lens shows where certain elements—like energy and cooling needs, data governance, and construction timelines—need to be ready to support widespread AI use. Viewed alone, it can become fatalistic, that is, correct on constraints but blind to the creativity of teams that find ways around them. The complementarity of the lenses is designed to help investors and policymakers see the feedback loop: early ecosystem wins justify infrastructure bets, and infrastructure upgrades unlock the next wave of AI solutions.

The lenses also help to clarify what gives the edge in a fast-moving and competitive AI-driven environment. As models and tools become easier to access, long-term advantages will shift to proprietary data, verified performance in compliance-heavy workflows, and supply-chain positioning in energy and construction. In emerging markets in particular, the ability to work with trusted local data, connect with small business networks, integrate with national payment and identification systems, and operate reliably at low bandwidth can make or break a firm's success. The Ecosystem lens highlights where firms can own workflow, distribution, or regulated integration, while the Structural lens tests whether those competitive advantages deepen or erode as energy prices move, cooling tech evolves, or data access rules tighten.

The report also addresses how AI's impact evolves over time. In the near term, AI helps firms and government agencies reduce costs, quicken turnaround times, and improve accuracy. It augments individual and small business productivity, typically through tools that do not require deep technical skills and lower entry barriers. As these gains accumulate, it can lead to deeper changes within the domestic ecosystem: linkages grow among research hubs, startups, and infrastructure providers; supply chains become more sophisticated for compute, storage, and cybersecurity; export capacity expands for AI-enabled services; and government systems strengthen for procurement, regulatory frameworks, and data governance. In the longer run, global spillovers—new diagnostics and medicines, safer materials, and more efficient logistics—diffuse across borders, raising the quality and variety of goods and services and supporting skills upgrading and job creation.

Against this backdrop, the report stays focused on practical evaluation for developing and diffusing AI in emerging markets. The Ecosystem lens shows who builds what and the early value AI can bring, including foundational models and tooling, data and orchestration layers, and vertical AI where local advantage compounds. The Structural Elements lens maps prerequisites—energy, cooling and materials, data regimes, and digitization—that convert pilot wins into lasting capacity. When read together, they let us separate near-term utility from long-term inevitabilities.

The result is an optimistic but candid picture for AI investment. There is an opportunity for AI firms to succeed on workflow, data rights, and trust, especially when supported by steady improvements in grids, buildings, and public data systems. But there are also clear risks, like focusing too much on pilots, underestimating power demands and construction timelines, or assuming that simply having access to a powerful AI model is enough to compete. Looking through both lenses does not prescribe a single strategy; rather, it will help equip decision-makers with better tools to understand what is working, what is missing, and how to create momentum from early gains as core systems and infrastructure improve over time.

1

Introduction

AI technologies are rapidly evolving, increasingly taking on non-routine and cognitive tasks. As AI develops more capabilities, this could enable individuals, businesses, and institutions to address increasingly complex challenges, particularly in areas with clearly defined tasks and access to large volumes of high-quality data (box 1.1). AI therefore has the potential to fundamentally change production, economies (The Economist 2025a), and support further technological advancements, influencing how productivity and economic growth are generated in the long term (Amodei 2024).

However, the development, adoption, and diffusion of AI is highly uneven across countries. Most AI development and value chain components are concentrated in a few high-income economies. Meanwhile, adoption of AI by businesses and individuals is spreading worldwide-faster than previous waves of disruptive technologies-signaling a strong demand for AI integration (Hu and Chmielewski 2024; Liu and Wang 2024). In emerging markets, AI offers new opportunities to leapfrog longstanding development constraints, particularly in sectors like education, healthcare, and finance. Realizing this potential depends on having the right foundations, such as strong digital infrastructure, robust data sources, and AI tools suited to local needs and capacities.

To fully benefit from AI, emerging markets must consider how to develop sustainable AI ecosystems. This report is intended for investors, policymakers, and AI ecosystem builders seeking a practical way to assess where AI investment in emerging markets can compound and where constraints can slow or block scaling. It addresses a gap between broad, model-centric AI narratives and the on-the-ground investment questions that determine adoption and durability, emphasizing the role of both AI technologies and the enabling operating environment in accelerating diffusion. To support decision-making and planning in this context, the authors propose a cohesive, structured approach for investing in AI in emerging markets. This approach leverages IFC's years of experience funding disruptive technologies in emerging markets and offers lessons learned in appraising investments across the AI value chain—from data centers and data generation to the AI orchestration layer and vertical AI[1] as well as expertise from the Digital Knowledge Bank in collaboration with governments and operational teams on the ground. This handbook centers on investment considerations and enabling conditions. It does not aim to provide a comprehensive treatment of AI risks or policy and regulatory responses; these topics are explored in depth in the forthcoming *World Development Report 2026*.

The proposed approach offers a way for the investment community to assess a country's AI ecosystem and identify what might be needed to support AI deployment in low-resource contexts. It clarifies possible roles of different ecosystem participants, identifies potential gaps, and explores ways to support AI development and adoption in emerging markets. A major emphasis is that sustainable AI ecosystems depend upon both technological deployment and local adaptation, as well as coordination across governments, businesses, communities, investors, and entrepreneurs.

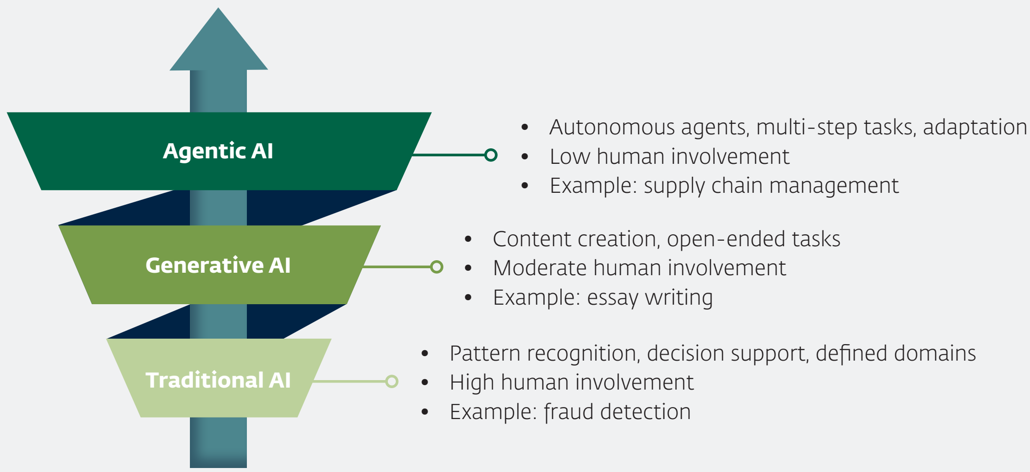
1. Vertical AI refers to specialized AI systems designed for specific industries or use cases. This concept is explained further in chapter 4.

BOX 1.1.

The Evolution of Artificial Intelligence

AI refers to machine-based systems that, based on a set of human-defined objectives, can make predictions, recommendations, or decisions influencing real or virtual environments (NIST 2024). Over the past few decades, AI and its applications have gradually advanced and transformed a wide range of industries, and this progress continues to accelerate at remarkable speed (figure B1.1).

FIGURE B1.1. Progression of Artificial Intelligence: From Traditional Model to Agentic System



Traditional AI was designed to analyze data, recognize patterns, and make predictions or decisions within narrowly defined domains. These systems included classic rule-based programs and early machine learning models. From expert systems that provided supportive tools for doctors that diagnose diseases, to algorithms that detected fraud in banking or forecast crop yields, these AI applications steadily expanded automation and decision support across the economy. However, their capabilities remain limited and often require human expertise to design, curate, or interpret outputs.

Generative AI represents a significant step in AI capabilities. Whereas earlier AI mostly analyzed existing data, generative models can create new content-writing in natural language, producing images and designs, and even composing music. Thanks to advances in underlying technologies, generative AI can now handle more complex and open-ended tasks, such as writing essays, designing product prototypes, or answering complex questions. These tools have rapidly moved from research labs to real-world use, making knowledge and creativity more accessible (Meeker et al. 2025). For example, a small business can use an AI assistant to generate marketing content or customer support scripts, or a student in a remote village can interact with an AI tutor in their native language.

Agentic AI systems go a step further: they not only generate content but also take actions on their own to pursue goals (Wiesinger et al. 2024). Unlike traditional and generative AI, which respond with single outputs, AI agents can complete multi-step tasks with little human help. These systems use sophisticated planning and reasoning to break down complex problems, act in digital or physical environments, and adapt based on feedback. For example, an AI agent in customer service might converse with a user, independently check account records, perform a transaction, resolve an issue related to that transaction, and adjust its actions based on feedback. Though still emerging, agentic AI is advancing rapidly, with pilot uses for debugging software, analyzing medical data, and managing supply chains from start to finish.

SOURCE: Authors.

Taking this approach could help emerging markets navigate the AI era in line with their development goals and varying levels of preparedness. Some countries have already built strong foundations by investing in digital infrastructure, innovation ecosystems, data sources, and talent. Others are still in the process of laying these foundations. Regardless of a country's maturity level, emerging markets can participate in or leverage AI to further their economic and social development. Advances in AI deployment, open-source tools, and flexible computing models are opening up new possibilities for emerging markets. The authors' suggestions aim to help emerging markets develop tailored, investable strategies that harness AI as a technology that serves for long-term economic transformation.

2

Investing in Artificial Intelligence *in* Emerging Markets

2.1. Rationale for Investing in Artificial Intelligence in Emerging Markets

AI is increasingly recognized as a General-Purpose Technology (GPT),[2] that is, a foundational type of technology that improves over time and can be widely applied across the economy (Bresnahan and Trajtenberg 1995; Lipsey et al. 2005). Like past GPTs, such as computers and the internet, AI is expected to drive profound, economy-wide transformations by reshaping how goods and services are produced, enabling complementary innovations, and creating spillover effects across economic sectors (Eloundou et al. 2023). Historically, the timely adoption and diffusion of GPTs were associated with accelerated productivity growth, albeit typically with a time lag (Solow 1987; Brynjolfsson, Rock, and Syverson 2021; Comin and Hobijn 2010). Investing in AI, therefore, is about seizing a broader, strategic opportunity for countries to leapfrog stages of development and shape their growth and development trajectories.

That said, predicting the realm, direction, and magnitude of the impact of AI, especially in emerging markets, is difficult. The technology is still evolving, which affects the predictability of the full range of outcomes (Acemoglu 2024). The commercialization of AI models and applications that support AI adoption and diffusion is still in progress. The cost structures and viable business models for AI deployment also remain under formation, particularly in emerging markets. Historically, GPTs take time to show results: the literature typically identifies a delay between recognition of a new technology's potential and its measurable effects in the economy. This is mainly due to the time it takes to build and scale the technology, the necessity of complementary innovations to obtain the full benefit of a new GPT (Brynjolfsson, Rock and Syverson 2017; Solow 1987), and the time required for businesses and populations to develop the skills to use it.

Currently, limited research exists on the AI economy in emerging markets. Impacts could differ between developed and emerging markets given their varying economic structures, social and cultural factors, infrastructure, and institutions. For example, given the large informality in emerging labor markets, AI's impact on task automation and augmentation may be different (Cazzaniga et al. 2024; Demombynes et al. 2025). Similarly, effects may be uneven across socioeconomic groups, business sizes, and other dichotomies within

2. General-Purpose Technology (GPT), as used in this report, should not be confused with Generative Pre-trained Transformer (GPT), as in ChatGPT.

countries. Understanding these differences is critical to designing effective strategies for AI adoption in specific contexts.

The authors consider three rationales for investing in AI development and adoption in emerging markets.

- *Economic rationale:* Embracing AI and integrating into global AI value chains can enhance national competitiveness, boost productivity, foster innovation, and create new industries and markets. AI can also support the development of human capital, ensuring workers gain skills for the future of work.
- *Developmental rationale:* AI is increasingly contributing to the achievement of development outcomes by improving quality, accessibility, and affordability of products and services (Strusani and Houngbonon 2019). For example, in healthcare, AI can improve diagnostic accuracy and personalize treatments, and could be especially relevant given the limited availability of doctors and medical specialists. In education, AI can enable adaptive learning, which is especially valuable in emerging markets where there are shortages of trained teachers and educational materials (De Simone et al. 2024).
- *Sovereignty rationale:* Developing a strong AI ecosystem covering research, development, widespread use, and infrastructure (such as computing power and data) has the potential to strengthen a country's strategic autonomy, technological sovereignty, and national security. A strong ecosystem also can enable countries to participate in shaping global AI governance and standards.

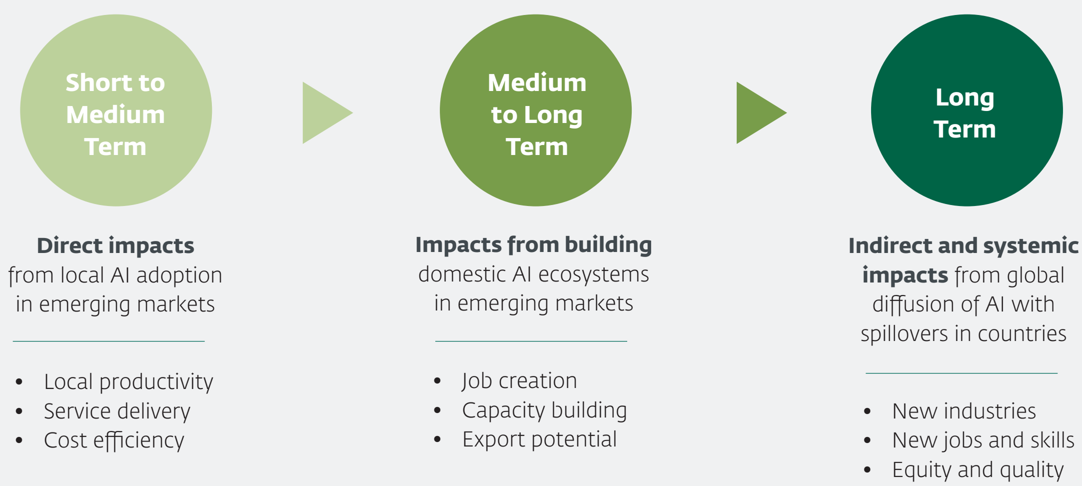
2.2. Anticipated Impacts of Investing in Artificial Intelligence in Emerging Markets

The economic, developmental, and sovereignty rationales can provide overarching motivation for stakeholders to invest in AI development and diffusion in emerging markets. The authors suggest the expected impacts of such investments in the AI ecosystem can be grouped into three categories: (i) those emerging directly from local AI adoption, (ii) those generated by building domestic AI ecosystems, and (iii) those resulting from the global diffusion of AI innovations (figure 2.1). This structure aims to help client countries clarify which

FIGURE 2.1

Expected Impacts of Artificial Intelligence Investment in Emerging Markets

Investing in AI development and diffusion in emerging markets could lead to impacts in the short to long term.



SOURCE: Authors.

impacts are country-specific and which emerge systemically, including those in countries with limited AI capabilities.

(i) Direct impacts of AI adoption in emerging markets (short to medium term)

In the short to medium term, the direct impacts of AI adoption in emerging markets stem from the adoption of AI by firms, governments, and individuals. AI has started to reshape how businesses operate, how services are delivered, and how individuals work, learn, and access products and services.

For workers, AI can both augment and substitute tasks within occupations and for personal reasons. The nature and extent of this support depends on how complex the task is and how advanced the AI technology is. Some routine tasks may be fully automated, while others may be performed more effectively or efficiently as a result of human-AI collaboration. Occupations in which tasks are prone to be supported by AI include software development and copywriting. Outside of work, individuals use AI for academic assistance, financial planning, and personal support.

At the firm-level AI adoption can ultimately help reduce costs, boost revenue, and improve productivity. Businesses are increasingly using AI adoption among workers to streamline workflows, increase efficiency, and develop better products and services.[3] In addition, entrepreneurs, developers, and businesses often use tools like Application Programming Interfaces (APIs)[4] with Large Language Models (LLMs); low-code or no-code tools; and open source AI[5] to build applications faster and with fewer requirements for proprietary infrastructure and models.

As AI becomes embedded across the private and public sectors, access to high-quality and affordable services for individuals is expected to improve. For example, AI can enhance medical diagnostics, personalize education, and optimize public services, which are especially critical in the emerging market context, where AI-tools help overcome the low penetration of doctors, radiologists, and teachers. In financial services, AI-powered credit scoring and customer analytics can enable underserved individuals and small businesses to gain access to credit without traditional collateral or credit histories (Handa et al. 2025, February and April; IFC 2020a).

(ii) Impacts of building domestic AI ecosystems in emerging markets (medium to long term)

In the medium to long term, building a strong domestic AI ecosystem can generate a range of benefits, particularly for countries seeking to enhance their global competitiveness and development trajectories. Benefits include direct, indirect, and induced economic value addition through job creation, skills development, innovation, entrepreneurship, improved market competitiveness and export potential, and help induce the modernization of institutional capacity of governments.

A successful AI ecosystem typically encompasses a diverse array of participants collaborating to develop AI solutions. These participants include research institutions and academic hubs, AI labs, infrastructure and platform providers, large companies and startups, investors and entrepreneurs, accelerators and incubators, and AI communities. Their production not only contributes directly to gross domestic product (GDP) but also indirectly stimulates growth in other parts of the economy by driving demand for supporting infrastructure and services, such as computing power, data storage, data centers, cybersecurity systems, and other components of the AI value chain (PwC 2017). A vibrant AI ecosystem also improves a country's export potential by attracting foreign investment, promoting trade in AI-enabled products and services, and strengthening participation in global value chains.

Developing a sustainable domestic AI ecosystem supports the development of a skilled workforce and job creation. AI

3. Stripe (2025b) finds that revenue milestones are reached faster by AI-first companies than previous generations of tech startups, including Software as a Service (SaaS) companies that provide applications over the internet. Also see Heim (2025) and Tania et al. (2024).

4. APIs are tools that let different software programs communicate and work together.

5. A growing number of developers and companies in emerging markets are exploring open-source or locally hosted models as alternatives. Though these models may lag cutting-edge proprietary offerings in performance, they offer greater control over data and reduce reliance on APIs.

requires a highly educated and specialized labor force-including researchers, engineers, and entrepreneurs-especially in AI research labs at the forefront of technology and vertical AI companies, the latter of which tend to operate with leaner teams (Tong 2023). Economic ecosystems also benefit from innovation spillovers, for instance, strong collaboration between academia, industry, and government enhances knowledge transfer and accelerates the emergence of new innovations.

Building domestic AI ecosystems can spur governments to modernize their own institutional capacity to regulate AI responsibly and proactively shape frontier digital markets. This may include equipping government tax and procurement systems to embed AI-enabled solutions, enabling the state to serve as early adopters of AI tools, or effectively convening stakeholders across sectors. As governments become more capable of managing and supporting AI they can play a pivotal role in coordinating actors, de-risking investment, and fostering trust. Over time, this creates a more predictable, innovation-friendly environment that attracts investment and amplifies the broader impact of AI ecosystem development.

(iii) Indirect and systemic global impacts of AI with spillovers across countries (long term)

Over the long term, emerging markets may benefit from AI even in the absence of widespread local AI adoption. These impacts occur through the global diffusion of AI-enabled innovations and restructuring of global value chains, driving long-term productivity and economic growth.

AI capabilities are increasingly being extended to support scientific discovery, with the potential to result in improved access to new or enhanced products. For example, AI can be leveraged to discover new medicines, materials, and novel technologies. In turn, these new innovations can lead to the emergence of new industries and increased business creation and growth (Acemoglu 2024; The Economist 2025b; Zhang et al. 2025). The development and diffusion of these innovations may help address persistent developmental challenges in sectors like healthcare, education, agriculture, and financial services, where AI support can improve accessibility, affordability, and quality.

Over time, the advancement of AI and complementary innovations could lead to the emergence of new occupations and skill demands. Historically, waves of technological innovation often result in the creation of entirely new jobs. For example, approximately 60 percent of occupations in the United States in 2018 did not exist in the 1940s, a transformation driven in part by technological revolutions like computers and the internet (Autor et al. 2022). A similar pattern is likely to occur with AI as technologies mature and scientific discoveries scale up, as already evidenced by new roles like prompt engineers (Capps 2025).

2.3. Challenges of Investing in Artificial Intelligence in Emerging Markets

Investing in AI presents challenges that tend to be more pronounced in emerging markets. Monetization and commercial sustainability may be more challenging to anticipate due to fragmented consumer bases, lower purchasing power, and limited digital readiness, including gaps in infrastructure, digitization, and literacy. These factors can constrain market size, making it harder to predict demand and generate revenue. At the same time, AI ventures globally face inherent difficulties establishing sustainable revenue streams due to high upfront investment requirements, long return on investment timelines, and complex demonstrations of value. To reduce risk in this context, investors must consistently encourage AI startups in emerging markets to validate product-market fit and help them identify clear, quantifiable value propositions early on. This is further addressed in section 5.3.

The global AI landscape is trending toward high market concentration, with a few dominant, well-capitalized international players that disproportionately capture economic benefits. In emerging markets, this global dynamic restricts competitive opportunities for smaller, local AI innovators, limiting their growth and discouraging broader innovation. Local startups may struggle to compete against incumbents leveraging established network effects, proprietary datasets, and resource advantages. Addressing this imbalance necessitates interventions and strategic investment by regulators and policymakers, and startups must invest heavily in local adaptation and customization. This is also further addressed in section 5.3.

Rapid commoditization of parts of the AI value chain presents another challenge for AI startups to capture long-term economic value. As foundational AI models, infrastructure, and capabilities become increasingly accessible via open-source platforms and cloud providers, it becomes harder for individual firms to differentiate themselves or maintain strong profit margins. This pressures startups to continually innovate or risk losing market relevance, thereby heightening investor risk. To counteract commoditization, emerging AI companies can consider strategies like vertical integration, investing in proprietary datasets, and focusing on local adaptation and customization.

3

Proposed Approach *to* Artificial Intelligence Investment *in* Emerging Markets

To fully realize the benefits of AI, emerging markets must build sustainable AI ecosystems. This requires more than access to cutting-edge technologies—it demands a clear understanding of how AI fits within local infrastructure, policy, and economic contexts. To support this effort, the authors propose a structured, practical approach for strategic investments that unlocks the potential of AI in both low-resource and high-resource settings. This aims to help client countries better understand, evaluate, and support AI ecosystems, tailored to the distinct challenges and opportunities in emerging economies.

This set of ideas is intended to help emerging markets think through how to navigate the evolving AI landscape in line with their development objectives and varying levels of preparedness. Emerging markets are well positioned to engage in the AI revolution and explore its potential to accelerate economic growth and social development. The suggestions outlined here may offer value to a wide range of stakeholders: investors can use it to evaluate viability and risks; governments and policymakers can shape enabling environments and regulatory strategies; development partners can integrate AI into broader development priorities; and businesses and entrepreneurs can gain insights into AI market and ecosystem dynamics, helping them to adapt and scale solutions and attract investment.

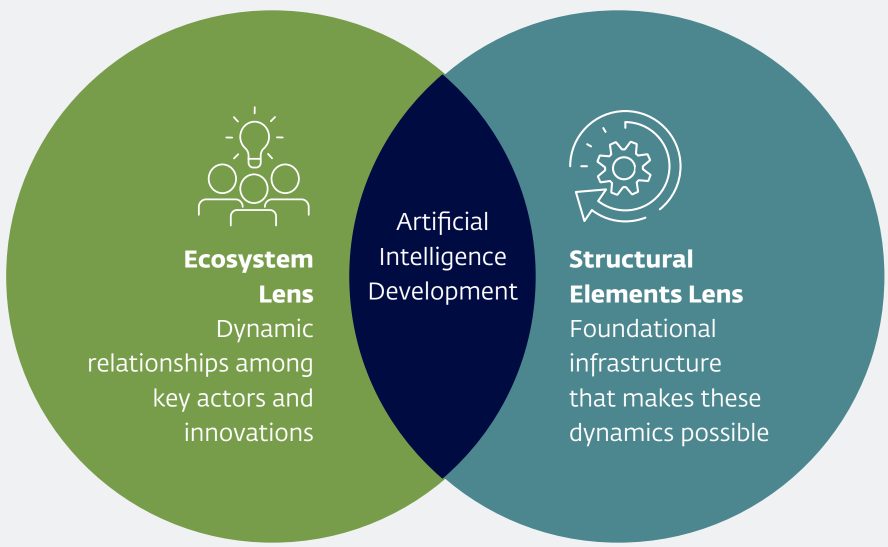
To structure this approach, the authors propose two complementary perspectives of examining investment in integrated AI: the Ecosystem Lens and the Structural Elements Lens. These interlocking views focus on different but connected dimensions of AI development (figure 3.1). The Ecosystem Lens looks at the dynamics among key actors and innovations, while the Structural Elements Lens emphasizes the foundations that make those dynamics possible. This framework to AI investments has been adopted by the World Bank Group Knowledge Bank. Together, these lenses offer a flexible yet coherent structure for analyzing and supporting AI ecosystems in emerging markets. The next two chapters explore them in greater detail.

Two cross-cutting elements underpin both lenses: policy and regulation, and the availability and maturity of private capital instruments. These elements are closely interlinked and reinforce one another. Well-designed policy frameworks provide clarity, reduce uncertainty, and establish the structural foundations of the ecosystem, which enables more confident and sophisticated deployment of private capital. As capital instruments mature and scale, they in turn accelerate the development, commercialization, and adoption of AI solutions, strengthening the overall ecosystem.

These dimensions are critical to long-term ecosystem development and require coordinated attention. A detailed treatment of these elements falls outside the scope of this report, but they are addressed extensively across a range of World Bank and IFC publications.

FIGURE 3.1

Structural Elements Lens



SOURCE: Authors.

4

The Ecosystem Lens

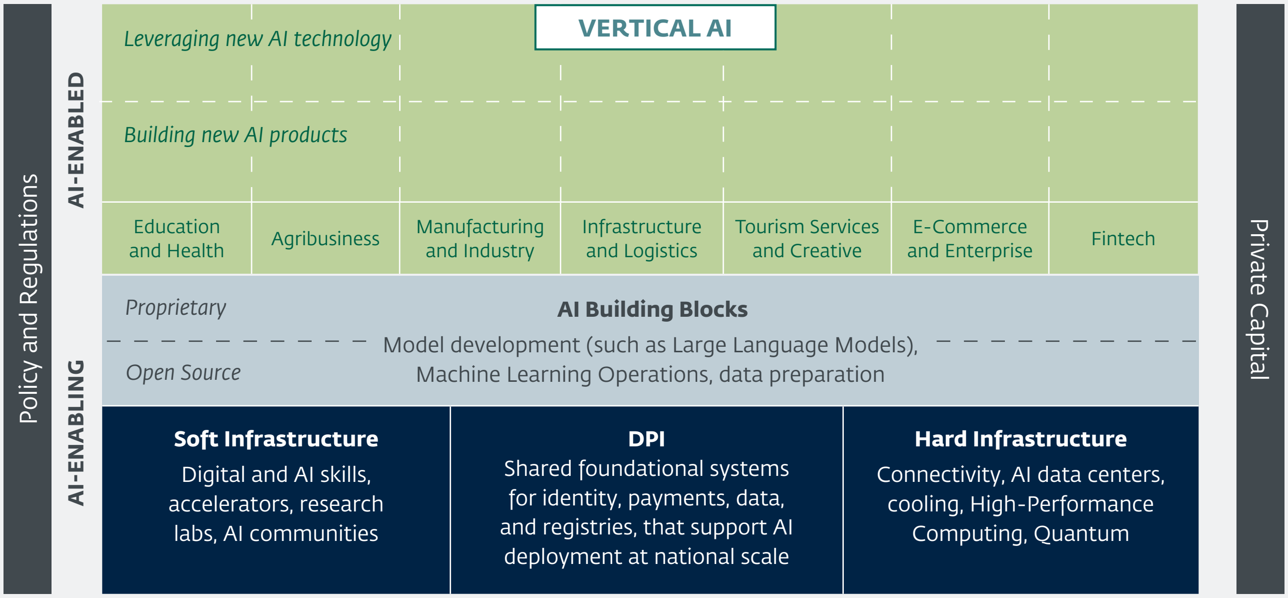
The Ecosystem Lens examines how AI-enabling and AI-enabled elements interact in the ecosystem. It centers on individual actors, such as AI labs, infrastructure providers, and platform developers, and the links between them. These actors either build and deploy AI solutions or enable others to do so (figure 4.1). This lens can be helpful for identifying emerging opportunities, market gaps, and critical connections within the AI innovation pipeline. Mapping actor-level actions and relationships could be especially useful for firms, investors, and entrepreneurs seeking to build competitive advantage or address under-represented market segments.

4.1. AI-Enabling Elements

AI-enabling elements consist of hard and soft infrastructure and building blocks that support the development of AI technologies and represent significant investment opportunities. These include products, applications, infrastructure

FIGURE 4.1

AI Investment World Bank Group Knowledge Bank Framework



SOURCE: Authors.

providers, and startups that form the backbone of the AI ecosystem.

4.1.1. Hard Infrastructure

Hard infrastructure encompasses the physical and hardware systems that support AI applications, such as data centers, chips, and networking equipment. These components enable the storage, transmission, and processing of vast amounts of data and model workloads. Investing in hard infrastructure is foundational to scaling AI technologies and ensuring their efficient, widespread adoption and integration.

At the core of hard infrastructure is connectivity, particularly high-speed internet, which enables reliable access to cloud platforms. This is critical for moving, storing, and processing the large volumes of data required for AI systems, and it plays a key role in lowering barriers to AI adoption. Cloud services can democratize access to computing power resources by removing the need for costly local infrastructure, significantly lowering entry barriers. This enables businesses of all sizes to affordably leverage AI technologies and supports collaboration across different locations for scalable innovation.

Data centers house the physical servers and storage systems needed to run large-scale AI operations. The "interior" of data centers enables everything—from training and fine-tuning to extensive data processing and AI model training—and is essential to national AI capacity and access. However, data centers' growing energy demand and environmental impact are a concern. In the United States alone, data centers are projected to account for 6 percent of total electricity consumption by 2026 (IEA 2024). Investing in energy-efficient data centers and high-performance compute clusters, ideally powered by renewable energy sources, is vital to minimizing their carbon footprint. Accelerating advancements in complementary sectors, such as construction and energy infrastructure, is also crucial. This includes innovative cooling and localized networking solutions, which are the largest energy consumers after computing.

INVESTING IN HARD INFRASTRUCTURE can deliver substantial financial and development impact by (i) accelerating technological advancements, (ii) improving operational efficiencies, and (iii) driving economic growth through the creation of new markets and job opportunities. These investments could be especially important for emerging economies seeking to build resilient and competitive AI ecosystems.

Data centers often host high-performance computing (HPC) systems, including specialized processors like Graphics Processing Units (GPUs) and Tensor Processing Units (TPUs), commonly referred to as AI chips. These chips are essential for performing the intensive computations required by the latest AI models, including training complex algorithms, processing large datasets, and running inferences at scale. HPC systems are developed and manufactured along the semiconductor value chain, involving chip designers, manufacturers, and other stakeholders.[6] They are often made available to end-users through cloud service providers like AWS, Microsoft Azure, or CoreWeave.

Investing in HPCs stimulates growth in the tech sector and affects global supply chains. Ongoing innovation in chip design continues to advance computing power, in support of AI capabilities and more powerful models. However, access to state-of-the-art chips remains a constraint in emerging markets, where high costs and the global supply chain concentration limit their availability (Lehdonvirta et al. 2024; Satariano et al. 2025).

Compute-as-a-service (CaaS) platforms—offering bundled access to models, computing power, storage, and user support—function as virtual hard infrastructure. By

6. For example, the semiconductor value chain includes software tools for chip design (such as those from Synopsys), manufacturers of chip-making equipment (like ASML for lithography), providers of packaging and testing solutions, distribution and supply chain services, and wafer suppliers

eliminating the need for local infrastructure, they provide scalable, cost-effective computing resources that are otherwise unavailable for many users. This significantly lowers barriers to entry for entrepreneurs, researchers, and small businesses, particularly in emerging markets where high-quality computing infrastructure is often expensive and difficult to establish locally. Further, by reducing technical complexity and infrastructure-related overhead, CaaS platforms enable local innovators to focus on solving practical problems rather than managing computational resources. This inclusive approach can democratize AI capabilities, foster diverse innovation ecosystems, and accelerate sustainable economic development.

Specialized hardware, such as edge computing devices, help AI systems process data locally or closer to the source of data generation, such as sensors, cameras, or mobile devices. This reduces latency,[7] lowers bandwidth requirements,[8] and enables real-time data analysis and decision-making at the point of use. Edge computing is particularly viable in emerging markets where there are limited data centers, cloud computing services, and communication infrastructure. By enabling localized AI adoption in low-resource environments, edge infrastructure can support applications like diagnostic tools in clinics, adaptive learning systems in schools, and intelligent supply chain systems for small local businesses, even in remote areas. It allows these AI-powered services to function without constant internet access or connection to remote servers, helping extend the reach of AI to underserved communities.

4.1.2. Soft Infrastructure

Soft infrastructure refers to the human, institutional, and social components that support the development, adoption, and use of AI technologies. It encompasses education, innovation support, research, and community-building, all of which are essential for a thriving AI ecosystem.

Building human capital through educational programs is essential for widespread participation in the AI economy.

INVESTING IN SOFT INFRASTRUCTURE can yield financial and development benefits by (i) strengthening technological capabilities, (ii) fostering innovation, and (iii) stimulating economic growth through entrepreneurship and job creation. Though outcomes may take time and be harder to quantify, the potential impact is substantial.

These programs equip individuals with foundational skills, such as data labeling and annotation, and advanced skills for research work, such as machine learning, model development, and AI research. For example, Data Science Nigeria and Fusemachines in Nepal offer training for AI and data science skills, ranging from basic digital literacy to advanced AI research. Investing in educational initiatives expands the talent pool and bolsters national competitiveness and adaptability.

Accelerators and incubators support early-stage AI companies with funding, mentorship, and networking opportunities. They help startups navigate commercialization and scale of AI innovations in local markets. Local general partners, who lead regional accelerators and venture funds, help identify context-appropriate solutions, de-risk early-stage capital, and guide founders through operational and regulatory complexity. For example, the C4IR Rwanda Accelerator supports AI-driven startups in Africa with mentorship, access to funding, and industry connections.

Academic hubs, such as university-affiliated labs and research centers, help translate scientific advances into real-world applications. By fostering industry–academia collaboration and supporting spinoffs and startups, they align innovation with local development needs and drive sector-specific economic growth. For example, The Dot in Tunisia is a national center for digital innovation. In partnership with InstaDeep and the German Agency for

7. Latency is the delay between when a request is made and when a response is received, that is, how long it takes for data to travel from one point to another.

8. Bandwidth usage refers to the amount of data transmitted over a network in a given amount of time.

International Cooperation (GIZ), The Dot hosts an AI hub with a world-class supercomputing server. Similarly, France has established four Interdisciplinary Institutes for Artificial Intelligence (known as 3IA) in different parts of the country to advance AI research and education through industry–academia collaboration. Partnering with academic institutions can ensure sustained access to cutting-edge AI and support market-driven solutions.

AI communities and networks—often informal and formed around open-source platforms or local developer meetups—facilitate collaboration, co-creation, peer learning, and knowledge sharing. Their accessibility fosters strong community ties and sustainable growth. Examples include the EdgeAI global community, which focuses on ultra low-power machine learning for embedded and edge devices; the EleutherAI open-source community, which develops LLMs; and the Masakhane NLP Pan-African open-source initiative, which creates smaller natural language processing models for African languages. These communities can be especially valuable in emerging markets with limited formal training channels. Strengthening AI communities can offer a cost-effective opportunity to expedite AI across diverse social groups and sectors.

4.1.3. Digital Public Infrastructure

Digital public infrastructure (DPI) is an approach to digitalization centered on developing foundational digital systems or public benefit. These systems provide core functionalities at population scale—such as identity verification, payments, and data exchange—that can be reused across sectors by public and private actors. By standardizing and scaling these building blocks, DPI improves the efficiency and speed of service delivery and lowers barriers to innovation.

DPI components typically include digital identity systems, electronic signatures, real time payment systems, and interoperable data-sharing frameworks. To function effectively and deliver equitable outcomes, DPI systems should be designed around core principles: openness, interoperability, modularity, inclusion, user-centricity, privacy by design, and robust governance. For further detail, see *Digital Public Infrastructure and Development: A World Bank Group Approach* (Clark et al. 2025).

4.1.4 AI Building Blocks

AI building blocks are modular software tools that support the development, deployment, and scaling of AI technologies. While soft and hard infrastructure companies provide the foundational support and resources that enable AI ecosystems to scale and thrive, AI building blocks help organizations build, customize, and operationalize AI systems efficiently and effectively. In doing so, they drive technological advancement and enable the foundation upon which new AI-enabled products are brought to market.

A key AI building block is foundational models—large-scale, general-purpose, or specialized models trained using vast compute resources and data. General-purpose LLMs like OpenAI's GPT-4o can understand and generate text, audio, and images. Other models are designed for specific tasks like recognizing objects in images (computer vision), predicting the 3D structure of proteins (such as AlphaFold), or helping vehicles navigate on their own (autonomous navigation). Foundational AI models can operate independently or serve as advanced building blocks for vertical AI solutions built by third-party developers connected through LLMs. The models can be proprietary or open-source (box 4.1).

Machine learning operations (MLOps) platforms make it easier to develop and deploy models, allowing developers to focus on advanced functionalities and innovations.

INVESTING IN AI BUILDING BLOCKS
particularly when localized and made accessible, can (i) expand innovation and support technical problem-solving, (ii) reduce digital divides among non-technical users, and (iii) drive productivity growth across industries. Their development and adoption are essential for building scalable, adaptable, and inclusive AI ecosystems.

BOX 4.1.

Open-Source AI Approach: Opportunities, Benefits, and Tradeoffs

Open-source AI building blocks refer to models, platforms, and software tools developed, distributed, and maintained under open-source licenses. In AI, "open-source" generally means the code for software's structure is accessible and modifiable. In contrast, "open-weight" specifically pertains to when the trained model parameters (weights) are openly accessible, allowing users to use pre-trained model capabilities without training it from scratch. Thus, while open-source ensures transparency of design and implementation, open-weight provides direct access to a ready-to-use, fully trained model, significantly lowering the barrier to adoption.

AI building blocks often leverage these models and tools to provide cost-effective and collaborative ways to advance AI systems. They enable developers, researchers, and startups to build and customize powerful AI systems without needing to license proprietary technologies. This collaborative approach can support rapid experimentation, cost-effective deployment, and localized innovation, yet it typically requires a higher level of technical knowledge and resources to maintain a deployed model. These factors are especially relevant in emerging markets, where access to proprietary tools may be constrained by the upfront costs of customization.

Investing in open-source AI offers several potential advantages:

- Enables rapid innovation by allowing researchers and developers worldwide to build upon each other's work.
- Opens access to frontier AI models (like the open-weight approach by Meta) promotes decentralized value creation, lowers costs and increases transparency.
- Empowers individuals and businesses to download and deploy an AI model locally, eliminating the need to share sensitive data with model developers or cloud service providers.

The open-source approach counters regulatory capture, competition suppression, and market monopolization by making powerful tools accessible to a broader AI ecosystem. By supporting open-source initiatives and investing in such platforms and tools within emerging markets, stakeholders in emerging markets can encourage broader participation and collaboration from different sectors and geographies, leading to a wider range of solutions tailored to country-specific needs and challenges.

However, there are trade-offs to leveraging this approach. Open-source tools can be difficult to monetize, performance may lag behind proprietary solutions, and long-term support and maintenance often shift to the user. Organizations using open-source components must weigh these risks, especially when building mission-critical systems or seeking to scale. In addition, though open access to model weights increases transparency, it can also increases exposure to risks, such as the manipulation or corruption of training data (data poisoning), exploitation of inputs to cause unintended responses (prompt injection), or repurposing of models for malicious use (Kosinski and Forrest 2024; Krantz and Jonker 2024).

BENEFITS OF OPEN-SOURCE APPROACH	TRADEOFFS OF OPEN-SOURCE APPROACH
Lower cost, local deployment	Requires high technical expertise
Promotes innovation and transparency	Difficult to monetize and maintain
Reduces reliance on proprietary systems	Potential security risks
Fosters decentralized AI ecosystems	Risk of legal/regulatory uncertainty

For emerging markets, the risks highlight the need for robust national or regional governance structures. Whether through regulatory bodies, standards-setting institutions, or community-led consortia, these structures can monitor local deployments, assess harm, and assign liability. Without such safeguards, open access can unintentionally lead to opaque accountability, reduced trust, or even legal uncertainty.

These elements may play an important role not only for the effective deployment of open-source AI in emerging markets but also for supporting its long-term maintenance. Investing in this approach can contribute to more fair, inclusive, and resilient AI ecosystems.

SOURCE: Authors.

NOTE: Notable examples include open-source AI frameworks TensorFlow, PyTorch and Langchain; open-source AI models EleutherAI's GPT-J and Stability AI's Stable Diffusion; and open-weight AI models Meta's Llama and Llama-2.

Integrated environments like Hugging Face and Google's TensorFlow offer end-to-end platforms for model development, testing, deployment, and maintenance, supporting interoperability between models and data pockets. They typically offer pre-built modules, scalable infrastructure, and comprehensive support tools to manage the entire AI model lifecycle. No-code platforms, a significant subset within MLOps, can further democratize AI by enabling users lacking deep technical expertise to create, deploy, and manage AI solutions.

By providing pre-trained models and diverse datasets, MLOps platforms accelerate AI adoption across various sectors. They can enable startups and small businesses to implement advanced AI solutions that were once exclusive to larger corporations, helping drive economic growth and innovation.

Data preparation and deployment tools reduce complexity and manual effort, enabling organizations to rapidly build robust, accurate, and tailored AI solutions. These tools enhance efficiency in data pre-processing, model training, and performance monitoring. Specialized software and applications simplify and automate various aspects of AI development. Examples include AutoML frameworks (such as Google AutoML, DataRobot), data labeling platforms (such as Labelbox, Scale AI), and data orchestration solutions (such as Apache Airflow, Prefect).

These tools improve the reliability, scalability, and security of AI applications and are essential for enterprise use, impacting productivity and economic outcomes. Investments in them in sectors like manufacturing, healthcare, and logistics can yield cost savings, better resource allocation, and improved service delivery, contributing to overall socioeconomic development.

The Model Context Protocol (MCP) introduces a standardized way for AI models to access external data and services. It is an open integration protocol that provides generative AI models with structured access to external contextual data and services. MCP clients request and use this contextual information to enhance AI capabilities, while MCP servers supply and manage it, together creating an interoperable ecosystem. This can enable generative AI models to autonomously and dynamically interact with APIs, databases, payment systems, and other digital or physical services in real time.

MCP enables the creation of AI agents capable of performing complex tasks with minimal human intervention. These tasks include automating customer support, optimizing supply chains, and managing financial transactions. By bridging resource gaps like limited skilled labor or fragmented service delivery, AI agents boost productivity and unlock economic opportunities. Consequently, strategic investment in companies and infrastructure that facilitate, host, or leverage MCP can help organizations of all sizes adopt AI agents for practical applications, driving automation and efficiency.

AI building blocks follow diverse business models. Foundational model providers commonly offer API-based pricing, charging per request or token (such as OpenAI, Cohere). MLOps platforms often offer SaaS solutions, bundling their services into subscription-based platforms with enterprise-grade features, customization, and support (such as Hugging Face Hub, Google Vertex AI). Some vendors provide on-premise or private cloud licensing to meet regulatory, security, or performance requirements, particularly for government, healthcare, and finance clients.

4.2. AI-Enabled Solutions: Vertical AI

AI-enabled solutions and applications, also known as vertical AI, leverage these foundational technologies to bring AI to individuals, businesses, and institutions across key sectors. These solutions address defined challenges, often within specific sectors, such as finance, education, healthcare, agriculture, and government. In many cases, AI is just one component of solving a complex equation.

4.2.1. AI-Enabled Digital Solutions

Vertical AI spans a wide range of industry-specific solutions, driving innovation across business-to-business (B2B), business-to-consumer (B2C), and business-to-government (B2G) market segments. Consumer-focused AI (B2C) startups often adopt freemium pricing strategies that allow users initial access at no cost with opportunities for upselling premium features later. In contrast, enterprise-focused

INVESTING IN VERTICAL AI
can make advanced technologies more accessible and inclusive by addressing real-world challenges across key sectors, especially in emerging markets where domain-specific solutions can deliver meaningful impact. A key caveat in investment is the growing trend of companies rebranding themselves as AI firms regardless of how central AI is to their offering. Fintech, healthtech, and edtech startups increasingly adopt AI labels to tap into investor interest, which can blur the line between genuine AI-native innovation and opportunistic marketing. Investors will need to look beyond company labels to evaluate whether AI is core to value creation, deeply integrated, and delivering measurable performance gains.

solutions (B2B), usually emphasize short-term value propositions, such as cost reductions or efficiency gains through automation. Successful commercialization frequently depends on targeted product customization, strategic relationships, and a focus on industry verticals where economic benefits can be measured. For solutions aimed at governments (B2G), commercial pathways are often shaped by complex procurement processes and heightened regulatory oversight, but they may offer significant scale and impact. These applications can range from enhancing traditional software products to enabling new AI-native solutions built from the ground up.

Many emerging vertical AI applications are established software products with an existing use and user base that seek to leverage new AI functions that can improve user experience and efficiency. These traditional software applications incorporate AI as an additive feature, often improving speed, accuracy, personalization, or automation. For example, graphic design platforms like Canva incorporate AI capabilities like automatic layout adjustments, background removal, and image enhancement to streamline the creative process. In the education sector, AI is being used to personalize learning experiences. UpGrad, an India-based edtech company, developed AI tools for interviews and coaching, powered by LLMs to tailor interactions based on learner performance. Similarly, Amity University Online introduced an AI assistant to personalize student learning experiences and increase engagement.

4.2.2. AI-Native Solutions: Built from the Ground Up

In contrast to AI-enhanced platforms, dynamic AI-native solutions are built entirely around new AI capabilities from the outset and represent a rapidly expanding category. Rather than merely embedding AI into existing software products and systems, AI-native solutions rethink how tasks and processes are performed within industries, often pioneering new approaches, particularly in regions with unique needs and constraints. In financial services, for example, African fintech companies are using AI to generate alternative credit scores for individuals without access to formal banking, expanding financial inclusion. In South America, agricultural technology platforms are applying AI to monitor crops and predict yields, improving existing agricultural practices and creating new ways to improve productivity and respond to environmental conditions in real time.

A fast-growing subset of AI-native solutions is AI wrappers, user-friendly interfaces or applications that simplify access to complex underlying technologies. That is, they make it easier for non-experts to interact with advanced tools by hiding the technical complexity behind interfaces. Many AI wrappers are built on top of third-party foundational models, whether open-source or proprietary, and serve as productivity assistants, code generators, or customer service bots. While some compete on the strength of their underlying technology, many differentiate themselves through interface design, workflow integration, and feature bundling. Though investment opportunities in AI wrappers are currently uncertain, some companies may offer compelling prospects if they identify viable business models.

5

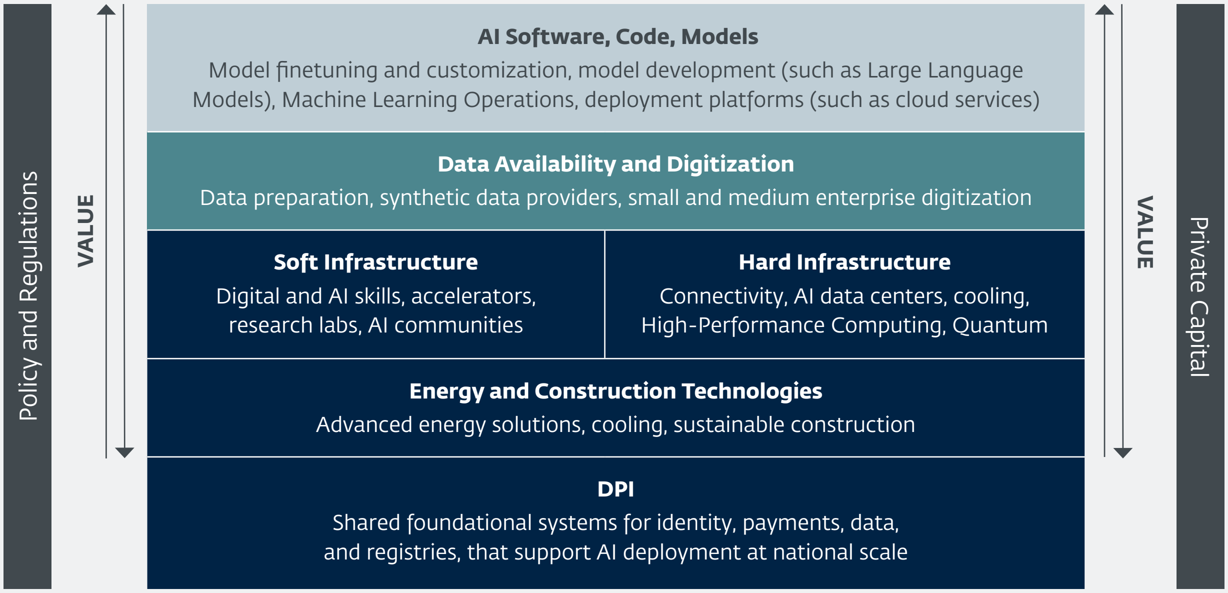
The Structural Elements Lens

The Structural Elements Lens takes a complementary perspective, emphasizing the system-level conditions required to make AI development sustainable (figure 5.1). It could be particularly relevant for stakeholders shaping AI's long-term trajectory at scale, such as the policymakers, public institutions, sovereign wealth funds, and institutional investors responsible for building a broader enabling environment for the long term. By identifying the

FIGURE 5.1

Structural Elements Lens

The diagram visualizes a proposed AI value chain: the top levels show where people directly interact with AI, while the lower levels are shared infrastructure and technologies that support everything above.



SOURCE: Authors.

prerequisites for ecosystem-wide progress, this lens could help client countries ensure that AI growth is not only rapid but resilient, secure, socially beneficial, and aligned with the public interest. It aims to balance technological progress with ethical considerations and risks of bias, misuse, or exclusion.

While this lens introduces distinct system-level foundations, it also incorporates elements in the Ecosystem Lens, namely, hard and soft infrastructure and AI software, code, and building blocks. This chapter focuses on the elements unique to the Structural Elements Lens: "data availability and digitization" and "energy and construction technologies".[9]

5.1. Data Availability and Digitization

Data is fundamental to the AI economy. In the context of AI, it refers to the vast amounts of information used to train, validate, and improve AI models. This can take many forms, including real data, which is derived from text, images, audio, video content, or 3D sources, and synthetic data, which is generated through algorithms rather than recorded from real-world events.

Real data can be structured (like databases), unstructured (like text and voice recordings), or semi-structured, enabling AI systems to recognize patterns and make accurate predictions. Access to large volumes of high-quality real data is a prerequisite for building capable AI models. However, obtaining such data remains challenging in many emerging markets (Heikkila and Arnett 2024). While economic activities in developed countries often generate vast digital datasets due to widespread automation and digitization, processes in emerging markets frequently remain manual and analog, particularly in the large informal sector. Consequently, large volumes of information in emerging markets still need to be digitized and remain inaccessible for AI applications.

Even when digital services exist in emerging markets, they are often operated by global companies based in developed countries. In these cases, data generated by local users is frequently extracted and monetized abroad, becoming an asset of international firms and limiting the capacity of local firms or public institutions to leverage their own data for context-specific AI solutions. Without access to locally generated data, developing vertical AI finetuned to the economic, cultural, and social nuances of individual markets becomes much more challenging. For example, a credit-scoring model trained on data from a developed economy might yield inaccurate or inappropriate results when applied directly to an emerging market.

INVESTING IN DATA COLLECTION AND DIGITIZATION
alongside data infrastructure and local data governance helps AI development support long-term, equitable growth. Increased access to high-quality, inclusive, and context-sensitive data assets could help emerging markets fully benefit from AI's potential.

It is important to consider how emerging market actors can prevent locally generated proprietary data from being passively extracted into frontier model training pipelines, while still benefiting from AI innovation. The objective is twofold: (i) protect privacy and sensitive commercial or public-interest information, and (ii) ensure fair value capture when that data contributes to AI system development. Several approaches can be pursued, ideally as a combination of mutually reinforcing efforts.

First, emerging market data holders can assert greater control through standardized licensing terms. Access can be monetized based on use (such as for research, commercial applications, or model training), through tiered API pricing. Sectoral data trusts or cooperatives can help smaller actors aggregate leverage and negotiate fair value-sharing with

9. The elements "AI global policy and local regulations" and "government/development finance institutions" are addressed in World Bank publications on these topics and therefore considered outside the scope of this report.

frontier AI companies. Recent moves by digital platforms to restrict and license AI training access to proprietary datasets illustrate this principle, such as Reddit's shift from open API access to paid data licensing.

Where privacy risks are high, technical architectures can allow computation on data without exposing raw datasets. Secure clean rooms, controlled research environments, or on-premise or federated training approaches allow computation to occur where the data resides. This reduces exfiltration risk while still enabling model improvement and evaluation, especially when paired with safeguards like de-identification, query logging, and strict rate limits.

Governments and regulators can define the market baseline by specifying permissible downstream uses of sensitive data. This includes limits or licensing conditions for AI training, alongside requirements on data residency, cross-border transfers, and transparency. Public procurement can reinforce these norms by requiring benefit-sharing when AI systems rely on local data, for example through local hosting, local fine-tuning rights, royalties, revenue-sharing, or capacity-building commitments. Embedding value capture and privacy protections into national rules and purchasing power scales leverage beyond individual firms.

Geographic and cultural biases inherent in many large-scale AI models exacerbates the challenge of limited local data. Open-source and proprietary models are often trained on data from North America and parts of Europe, leading to built-in assumptions, linguistic biases, and socioeconomic patterns that may not reflect emerging market realities. Fine-tuning these models for local contexts requires large, high-quality datasets and compute capacity that many emerging markets do not yet have. This reinforces a structural imbalance, where models exported to emerging markets may perform poorly, unintentionally exclude users, or replicate harmful assumptions. New solutions are beginning to address this gap: platforms like Amini are building geospatial and climate-relevant datasets in data-scarce regions, while "unlearning" startups like Hirundo aim to remove or reduce the influence of unwanted training data, making AI models more adaptable to local contexts.

However, some sectors in emerging markets are already generating large volumes of usable data. For example, large-scale customer support services are often localized, generating vast datasets through calls, messages, and interactions. AI advancements in speech recognition and synthesis are opening new avenues for accelerating digitization of communications. Audio interactions can now be recorded, transcribed, structured, and analyzed by LLMs, converting previously analog workflows into machine-readable datasets. This process also creates a feedback loop where AI accelerates further digitization.

In these sectors, data-driven companies are harnessing extensive datasets to improve services and foster innovation. These include fintech startups, digital agriculture platforms, and healthtech innovators. Investing in data-rich, digitally native companies can support broader Bank Group objectives, especially in accelerating the digitization of various industries.

Synthetic data is particularly useful for training and testing AI models when real data is scarce, sensitive, or expensive. It can help expose models to rare or unusual scenarios ("edge cases") and make them perform better on new, unseen data. As model size and data requirements continue to grow, frontier AI developers have begun using synthetic data generated by existing models to train new ones. In some cases, this approach now supplements or even exceeds the volume of available real-world data (Gartner 2023). Epoch AI estimates that the stock of high-quality, human-generated public text data could be fully used between 2026 and 2032 if current trends continue (Villalobos et al. 2024).

In emerging markets, synthetic data could provide a way to leapfrog some infrastructure constraints by helping develop sophisticated AI models and applications without extensive data collection infrastructure. However, overreliance on synthetic inputs, especially when derived from models trained on earlier AI outputs, can introduce distortions and reinforce model biases. These risks underscore the need for a careful balance between synthetic and real data, along with transparent practices for validating model performance. As AI systems increasingly move into physical environments through robotics, drones, smart sensors, and autonomous vehicles, real-world, high-dimensional data (such as video, 3D, geospatial, or tactile) is becoming a critical asset to shape the next generation of embodied and multimodal AI applications.

Finally, effective governance of data collection and usage is critical. Robust regulatory frameworks for data privacy, residency, and protection are crucial, particularly given the underdeveloped regulatory landscapes in many emerging markets. Approaches to regulations will need to strike a balance between privacy and innovation, facilitating secure and responsible use of sensitive data.

INVESTING IN ENERGY AND CONSTRUCTION TECHNOLOGIES within emerging markets are a potential opportunity to develop modern, energy-efficient infrastructure attractive to AI development. Markets could leverage green construction for global climate goals, reduce their dependency on imported fuels, and position themselves as sustainable, responsible innovation hubs.

5.2. Energy and Construction Technologies

As the AI economy rapidly expands, the energy and material demands of large-scale infrastructure and data centers and their associated environmental impacts are becoming increasingly important (IEA 2025b). Data centers consume vast amounts of energy, both to power computers and to keep them cool. Construction of facilities requires carbon-intensive materials like cement and steel. Meeting the growing demand for AI infrastructure while minimizing its environmental footprint relies on advancements in energy production, cooling efficiency, and on-premises networking technologies supporting AI workloads. These infrastructure layers also shape who can deploy and iterate on AI locally, and therefore become a core component of technology transfer for emerging markets.

Clean and Resilient Energy Supply

Solar, wind, and nuclear. New energy supply solutions are key to powering data centers in a world where reducing carbon emissions is essential in the medium and long term. In the near-term, solar power generation has emerged as an affordable and scalable option, often cheaper than traditional fossil fuel sources in many regions (IEA 2025b). Innovations in nuclear energy can offer additional opportunities. In the near term, nuclear fission with small modular reactors promise safer, more flexible, and cost-effective ways to generate power. Fusion energy generation also holds promise for abundant, clean, and nearly unlimited power (O'Donnell and Crownhart 2025). Private companies like Commonwealth Fusion and Helion Energy are building the first practical fusion reactors.

Energy Efficiency and Optimization

Energy storage. As AI data centers grow, the decreasing cost of energy storage systems is crucial to their sustainable operation. Utility-scale battery systems, particularly lithium-ion technologies, are increasingly becoming integral to regional power grids, data center infrastructures, and onsite operations, enhancing energy management and reliability. Emerging alternative chemistries, such as flow batteries, sodium-ion, and solid-state batteries, are gaining attention for their potential to be safer, easier to scale, and more sustainable. As utility-scale battery storage systems improve and become more affordable, it is becoming more practical to integrate these systems within data centers' internal power infrastructure to improve reliability and efficiency.

Cooling systems. Cooling is one of the biggest energy demands in AI data centers. Modern data centers often consume tens or even hundreds of megawatts of electricity; nearly half is consumed by the computing hardware, with the processing units emitting almost all of it in the form of heat. The cooling system then uses another 40 percent to dissipate this heat (McKinsey & Company 2023). Advanced thermal management solutions and cooling technologies, such as liquid cooling, immersion cooling, direct-to-chip cooling, and innovative heat reuse systems, can further support AI infrastructure's energy efficiency and sustainability. For example, Google uses liquid cooling in its data centers, Microsoft deploys immersion cooling technology, and Equinix is repurposing heat from its data centers for community use.

Networking equipment. Making networking equipment more energy-efficient is key to minimize the energy footprint of AI data centers. Networking equipment consumes 5–15 percent of the total power in data centers. Optical and photonic data transfer technologies, which use light to transfer data instead of traditional copper cables, offer a promising alternative. These technologies significantly lower energy consumption compared to traditional copper-based systems while enabling higher bandwidth and lower delays.

Sustainable Materials and Green Construction

Carbon footprint. The environmental impact of data centers goes beyond electricity use. Building them requires large amounts of metal and cement, both of which produce substantial carbon emissions. Traditional steel production methods rely heavily on fossil fuels, and as steel production grows, so does greenhouse gas emissions. Steel and cement are among the hardest industries to decarbonize due to technological and financial challenges. However, emerging technologies in green materials (metal and cement production) offer promising pathways to decarbonize this segment. Some companies are developing low-emission steel production methods, while others are pioneering greener alternatives to traditional cement. These innovations can help to significantly reduce the carbon footprint of AI data center construction.

Energy grids. Beyond optimizing energy use within data centers, it is also important to consider the impact of AI infrastructure on national and regional energy grids. The rapid expansion of hyperscale data centers can significantly strain existing energy systems, sometimes competing with essential public services like schools and hospitals. These tensions may be even more acute in emerging markets, where grid capacity is often limited or unreliable. Potential ways to manage these challenges include investing in better energy monitoring, smart metering, and tools to predict future energy needs.

Taken together, these layers point to a broader challenge with the transfer of technology: ensuring that AI innovation in emerging markets is matched by the operational capacity to deploy, maintain, and improve systems locally. Access to models alone is insufficient without reliable compute, adequate cooling and energy systems, and networking that allow institutions and firms to run workloads, iterate, and scale deployments over time. Investing in this enabling layer turns adoption into durable productive capability, reducing dependence on offshore compute and cloud services while enabling local actors to capture a larger share of AI-driven productivity gains. Recent investments in data centers that depend on reliable power and modern cooling illustrate how tech transfer is being operationalized through the build-out of AI-ready physical capacity.

6

Adoption *and* Diffusion *of* Artificial Intelligence *in* Emerging Markets

For AI ecosystems to mature in emerging markets, it will be important to unlock demand for AI solutions developed by local suppliers. This involves reaching customers who are willing and able to adopt these technologies: individuals, businesses, governments, and other organizations based locally (in emerging markets) and/or internationally (in other emerging markets or developed markets). Adoption and diffusion depend on both hard and soft infrastructure, which may take different forms in emerging markets compared to developed markets.

In terms of hard infrastructure, two types of internet connectivity and device options are relevant to inclusive AI adoption in areas with bandwidth constraints. High-bandwidth access through smartphones, laptops, or connected personal computers allows users to access advanced, cloud-based AI services, including generative AI tools and real-time applications. Low or intermittent connectivity using basic mobile phones or Internet of Things sensors enables a parallel layer of simpler AI deployment, which supports, for example, SMS-based credit scoring, offline health diagnostics, and sensor-driven agriculture tools.

In terms of soft infrastructure, countries with English as their national language may adopt AI tools more easily compared with non-English speakers. Most AI foundational models, applications, and training materials are currently in English. Expanding and leveraging DPI, including digital ID systems, real-time payments, and interoperable data exchanges, can accelerate adoption by making it easier to develop large-scale services for broader market entry. For example, platforms like India Stack or Mojaloop in East Africa allow startups to build trusted, compliant services at scale, especially in sectors like fintech, healthtech, and agriculture.

At the product level, solutions will need to offer material outcomes at good value-for-money, while being mindful of absorption and implementation costs. The economic structure, informality, and relative costs of labor and capital in business models across emerging markets could also affect adoption pathways. Pay-as-you-go strategies or freemium platforms like OpenAI's ChatGPT application and AI-as-a-Service platforms like Microsoft Copilot for businesses can help lower the barriers to entry and support scalable experimentation with AI technologies.

In markets where the local demand for AI solutions remains nascent but where AI suppliers are present, local AI developers may find opportunities in international markets. This is especially true in developed countries where AI ecosystem components are growing rapidly. Yet, tapping into this demand often requires AI solution providers to meet high standards and navigate complexity. For example, addressing enterprise and government clients requires firms to integrate into existing supply chains, often by partnering with established contractors. A local presence, including sales and support teams, is typically needed to establish client relationships and credibility. Further, AI solution providers must comply with stringent standards around data protection, cybersecurity, and AI governance.

In addition to exporting AI solutions, emerging markets are increasingly attracting large-scale foreign direct investment to build AI-enabling infrastructure, such as data centers, compute clusters, and cloud connectivity. Countries like Uzbekistan have secured major AI-related infrastructure investments, reportedly receiving over US$3 billion from Saudi Arabia and US$2 billion from China to develop advanced computing facilities. Such investments can catalyze local AI ecosystems by expanding access to compute, enabling sovereign cloud strategies, and attracting regional AI startups or global partners. However, they also raise concerns around data governance, energy use, and national technology strategies that will need careful management.

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