Technology and Innovation Report 2025

Chapter I

AI at the technology frontier

Frontier technologies are advancing rapidly, with a market size projected to grow sixfold by 2033, to $16.4 trillion. Market power, research and development (R&D) investment, knowledge creation and the development and deployment of these technologies are dominated by technology giants from developed countries. Only 100 companies account for over 40 per cent of the world's business investment in R&D.

China and the United States of America dominate knowledge generation in frontier technologies, with around one third of peer-reviewed articles and two thirds of patents. Similarly, there is a significant AI-related divide between developed and developing countries. This could widen existing inequalities and hinder efforts by developing countries to catch up.

As a general-purpose technology, AI can enhance other technologies and enable effective human-machine collaboration. The use of AI offers significant opportunities for businesses and countries to grow and to progress towards the achievement of the Sustainable Development Goals. However, it also presents various risks and ethical concerns. Decision makers need to know more about AI if they are to navigate its promises and perils, for sustainable and inclusive development.

United Nations

Key policy takeaways

- **Leading technology companies are gaining control over the technology's future, and their commercial motives do not always align with the public interest.** Governments need to explore policies and regulations that can incentivize and guide technological development along a path that promotes inclusivity and benefits everyone.
- **Frontier technologies are capital intensive and could be labour-saving.** In many developing countries, this could erode the comparative advantage of low labour costs, putting at risk the gains of recent decades. When properly directed, AI could help reverse this trend by augmenting rather than substituting for human capabilities.
- **The rapid progress of AI involves three key leverage points that could trigger transformational cascades: infrastructure, data and skills.** These provide a framework to assess a country's preparedness for AI, develop effective industrial and innovation policies and strengthen global AI governance and collaboration.

Frontier technologies, and AI in particular, are having a profound impact, reshaping not just production processes and labour markets but also the structure of societies. Their rapid and widespread diffusion has outpaced the ability of Governments to respond effectively. The present report aims to guide policymakers through the complex AI landscape and help them design science, technology and innovation (STI) policies that foster inclusive technological progress.

The rapid diffusion of frontier technologies makes it difficult for Governments to keep up

This chapter presents the current state of frontier technologies and the global AI landscape, revealing significant disparities in countries' capacity to adopt, adapt and develop AI. This sets the stage for the rest of the report, which delves into the impact of AI on productivity and the workforce, and examines the promises and perils of AI applications for developing countries, through case studies in different sectors.

For a new technology to reach its full potential, a number of conditions must be fulfilled. The spread of electricity, for example, relied on national power grids, and the success of the Internet depended on fibre-optic networks with cables crossing continents and ocean beds. The transformations brought by new technologies also depend on the willingness and capacity to redesign factories and business processes worldwide.

Catching up requires aligning industrial and STI policies to keep pace with rapidly evolving digital technologies

Taking advantage of AI systems requires even more robust broadband infrastructure that can carry massive flows of data, and building essential programming and other skills. This report assesses national AI readiness and capacity based on the three critical leverage points: infrastructure, data and skills.

With regard to AI adoption and development, many developing countries are still in the early stages and lack dedicated strategies or instruments to address AI-specific needs. The report shows how Governments can strengthen their AI capabilities, steer AI adoption and development and seize opportunities, by presenting good practices and lessons learned of national efforts. Catching up requires the alignment of industrial and STI policies, to keep pace with the constant redefinition of competitiveness due to digital technologies and innovation.

AI also poses challenges at the transnational level, with the potential to exacerbate existing inequalities between and within countries and to undermine global efforts towards achieving the Sustainable Development Goals. As this report shows, international governance of AI is still fragmented. Strengthening and harmonizing it requires deeper international cooperation. Working together, Governments can co-create an inclusive global framework that fosters accountability, international collaboration and capacity-building. Only an inclusive approach to AI governance can ensure shared prosperity.

A. Rapid expansion of frontier technologies

Frontier technologies are those advanced and emerging technologies – from AI to green hydrogen and gene editing – that have strong transformative potential and offer new opportunities for economic development, sustainability and governance (UNCTAD, 2018). These technologies help solve complex problems, allow time-consuming undertakings to be carried out more efficiently and offer potential for scalability and fast diffusion. In this way, frontier technologies play a key role in creating and implementing global solutions to address the challenges of the twenty-first century.

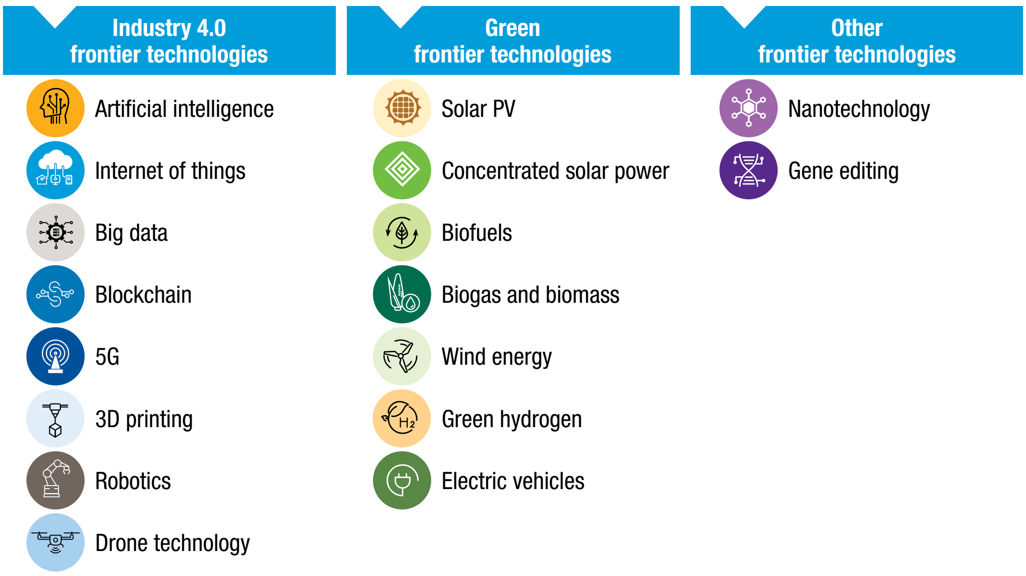
This section provides an update of the status of 17 frontier technologies presented in the previous edition of the *Technology and Innovation Report* (UNCTAD, 2023). As in that report, they can be divided into three broad categories: industry 4.0, green and renewable energy technologies and other frontier technologies (figure I.1).

The market potential for frontier technologies

One measure by which to assess frontier technologies is their market size, namely, the total revenue generated from the sales of products and services in the market. Frontier technologies represented a $2.5 trillion market in 2023 and are estimated to increase sixfold in the next decade, reaching $16.4 trillion by 2033 (figure I.2). This translates into a compound annual growth rate of around 20 per cent, in line with the projection in the previous edition of the *Technology and Innovation Report* that covers the period between 2020 and 2030. Different frontier technologies often overlap and interact with each other, and it is therefore difficult to make clear distinctions for their markets and there may be some double counting. Nevertheless, these technologies are already being deployed on a substantial scale and present strong market potential.

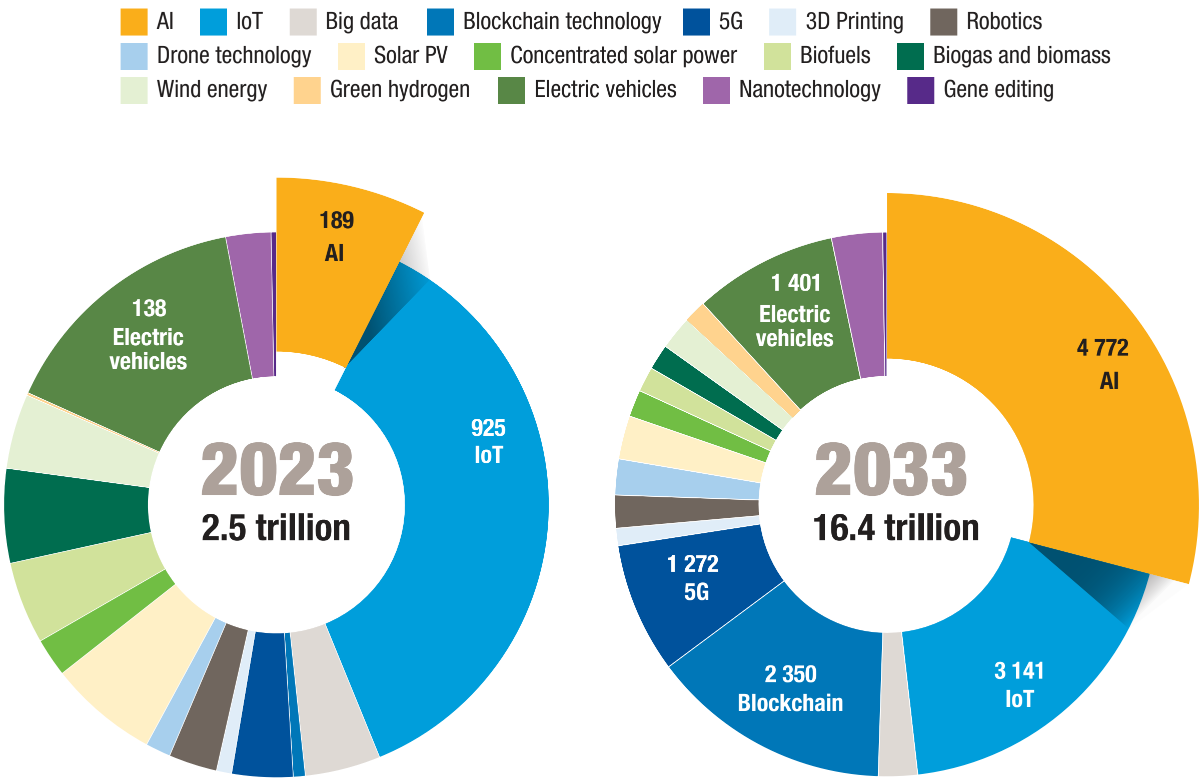
Frontier technologies may increase sixfold in the next decade, **reaching $16.4 trillion in value**

Figure I.1
Three broad categories of frontier technologies



Source: UNCTAD.
Abbreviations: 5G, fifth-generation; 3D, three-dimensional; PV, photovoltaics.

Figure I.2
Rapid expansion of frontier technologies
(Market size estimates, billions of dollars)



Source: UNCTAD based on various online market research reports (see annex I).
Note: Market size data capture the revenue generated by the sales of products and services.

By 2033, AI will have the largest share, almost one third of the frontier technologies market

By 2033, the frontier technology with the largest market size is likely to be AI, at around $4.8 trillion, accounting for 30 per cent of the overall market. Continuous breakthroughs are making AI more powerful and efficient, favouring its adoption in many sectors and business functions (Facts and Factors, 2024). Since 2022, there has been for example, a surge in interest in Generative AI (GenAI), with organizations across different countries and industries experimenting with its use in a wide range of tasks, including content creation, product development, automated coding and personalized customer service (Accenture, 2023; McKinsey & Company, 2023).

Another major market is the Internet of Things (IoT). By 2033, this growing network of physical devices connecting and exchanging data could contribute $3.1 trillion to the global economy (Global Data, 2024).

IoT, coupled with other Industry 4.0 technologies and AI, will accelerate the digital transformation of agriculture, manufacturing and services, increasing productivity and product quality while potentially reducing costs and carbon emissions (Kumar et al., 2021; Matin et al., 2023). These technologies can also benefit consumers if enhanced human-machine interactions lead to more efficient and customized solutions.

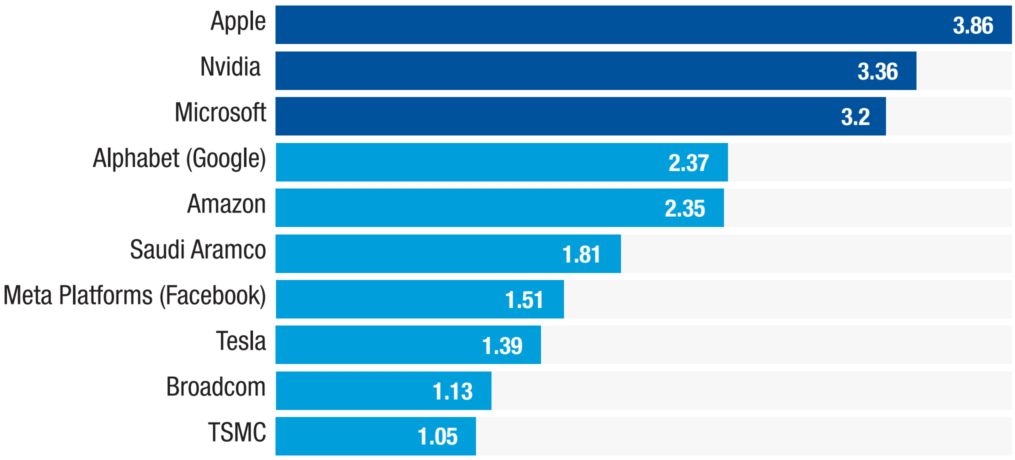
The market dominance of tech giants

The leading frontier technology providers are now among the largest corporations in the world by market capitalization. Apple, Nvidia and Microsoft each have a market capitalization of more than $3 trillion, close to the gross domestic product (GDP) of the African continent, or that of the United Kingdom of Great Britain and Northern Ireland, the world's sixth largest economy. Not far behind are Alphabet (Google) and Amazon, with market capitalizations of above $2 trillion, greater than the GDP of Canada.[1] The top five companies are from the United States, and three leading chipmakers – Nvidia, Broadcom and TSMC[2] – are among the world's top 10 listed companies; almost all are focused on frontier technologies and invest substantially in AI (figure I.3).

The main providers of frontier technologies are from the United States, developed countries in Western Europe, China, Japan and the Republic of Korea. Collecting globally comparable data on frontier technology markets is challenging, but some trends can be identified.[3] Companies in the United States have an edge in digital technologies and computing platforms, such as AI, IoT, big data, blockchain and 3D printing. Companies from Japan lead in robotics development and those from the Republic of Korea are more active in 5G and nanotechnologies. Companies in Western Europe cover a wide spectrum of frontier technologies. Among developing countries, the dominant player is China, which leads technological development in 5G, drones and solar photovoltaics (solar PV). There are only a few top frontier technology providers from other developing countries, for example, Brazil (e.g. some biofuels companies).

Leading technology giants each have market capitalizations of over $3 trillion, **comparable to the GDP of the entire African continent**

Figure I.3
Market dominance of technology giants
Top 10 listed companies in the world by market capitalization
(Trillions of dollars)



Source: UNCTAD, based on data from Companies Market Cap.
Note: The ranking shows the most valuable listed companies worldwide, as at end-2024.

[1] Market capitalization data are as at end-2024 (Companies Market Cap, 2024). GDP figures are from the UNCTADstat database. GDP is a flow variable and market capitalization is a stock variable; the present comparison is for illustrative purposes only, to highlight the significant market size of leading technology companies.
[2] Nvidia and Broadcom, United States; TSMC, Taiwan Province of China.
[3] There is no structured, reliable information about market share or company profit readily available for frontier technologies. The top frontier technology providers were identified through an online search of companies most commonly referred to as top providers. Since the search was conducted in English, more favourable results may have been returned for companies from English-speaking countries.

How to direct frontier technology providers **towards progress that benefits all?**

While there are substantial innovation activities among small and medium-sized enterprises (SMEs) and startups, most leading frontier technology providers are large multinational corporations. Some have developed the technology in-house and most stay at the frontier by investing in startups or acquiring highly innovative firms that offer cutting-edge technology and expertise. For example, in 2014, Alphabet acquired DeepMind, a leading United Kingdom-based research lab pioneering the field of deep reinforcement learning that developed the programme 'AlphaGo' that defeated the world Go champion in 2016. Another major player is Microsoft that, in 2019, forged a partnership with OpenAI, which developed ChatGPT (GPT stands for generative pre-trained transformer), and in 2022, made a record acquisition, for more than $18 billion, of Nuance Communications, a company that specializes in large-scale speech applications and is behind the Siri voice assistant of Apple.[4]

Market dominance is worrying, particularly in winner-takes-all markets, because the top players reap most of the rewards and have the resources to eliminate potential competition or even control the flows of information and revenue (UNCTAD, 2021). Leading technology companies are gaining control over our technology future, but their commercial motives may not always align with the public interest and could put societies on a suboptimal development trajectory (Ahmed et al., 2023; Oxfam International, 2024). For instance, studies suggest that companies generally direct AI development towards substituting for human labour rather than augmenting human capabilities (Acemoglu and Johnson, 2023). Labour-saving and capital-intensive frontier technologies could undermine the comparative advantage of low labour costs in many developing countries, threatening much of the gains they have made in recent decades (Korinek et al., 2021).

For these reasons, it is essential to explore policies and regulations that incentivize and guide technology firms towards a path that promotes inclusivity and benefits for everyone. Chapter IV presents an overview of STI and industrial policies for AI at the national level. Chapter V focuses on global AI governance.

B. Concentration of research and development

100 companies account for **over 40% of world business investment in R&D**

The potential of frontier technologies has attracted significant research and development investments. For example, between 2022 and 2025, AI-related investment was expected to double to $200 billion (Goldman Sachs, 2023). By comparison, this is about three times the global spending on climate change adaptation. By 2030, AI-related investment could represent 2 per cent of GDP in countries leading in AI (Goldman Sachs, 2023).

While many companies undertake various forms of R&D, the bulk of investment is by a small number of enterprises. In 2022, more than 80 per cent of business-funded R&D worldwide was carried out by 2,500 companies, which invested €1.25 trillion; 40 per cent of such investment was by only 100 companies (European Commission, Joint Research Centre, 2023).

[4] For a list of the largest AI acquisitions of United States companies, see Bratton, 2024.

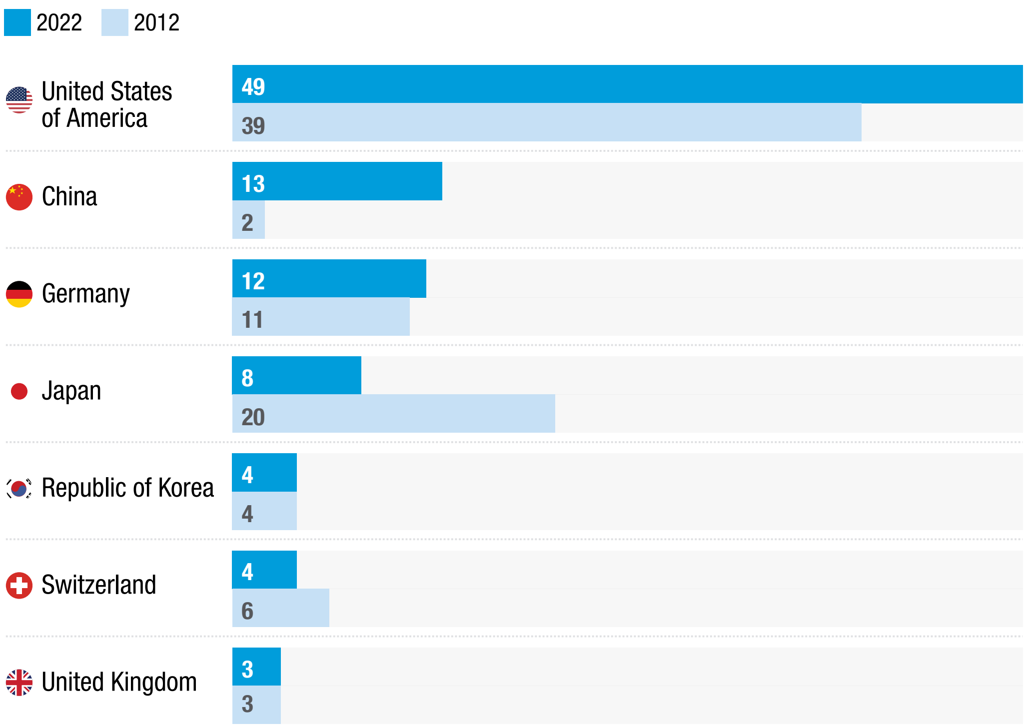
Among the largest 100 corporate R&D investors, around half are headquartered in the United States, led by Alphabet, Meta, Microsoft and Apple. Around 13 per cent are headquartered in China, led by Huawei and Tencent, up from 2 per cent 10 years ago and overtaking traditional R&D leaders such as Germany, Japan, the Republic of Korea, Switzerland and the United Kingdom (figure I.4). Other than China, none of the top 100 corporate R&D investors are from developing countries.

The software and computer services industry, in which most AI, big data and blockchain technologies are developed, accounted for around one quarter of the total R&D investment of the top 100 corporate R&D investors in 2022, more than doubling their share from a decade ago and overtaking the pharmaceuticals and biotechnology industry (figure I.5).

Other leading companies operate in the technology hardware and equipment industry, which includes IoT, 5G networks, 3D printing, robotics, drone technology and green frontier technologies, and accounts for one fifth of the R&D investment. The automobile and parts industry, which includes electric vehicles, still represents a considerable share of R&D investment despite a gradual decrease over the past decade.

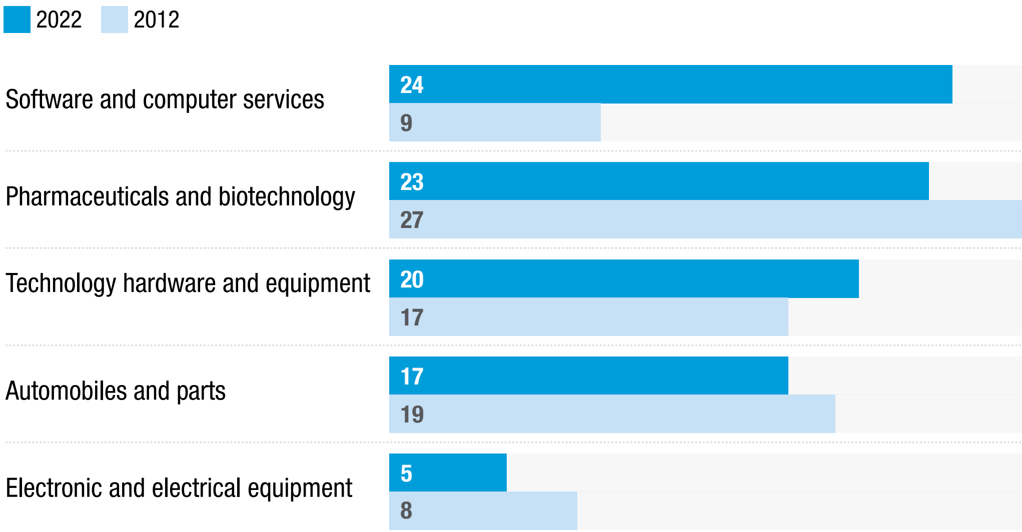
The software and computer services, technology hardware and equipment and pharmaceuticals and biotechnology industries are largely headquartered in the United States, which accounts for more than 80 per cent of the corporate R&D investment in software and computer services. Germany and Japan lead in such investment in automobiles and parts and the Republic of Korea is strong in electronic and electrical equipment.

Figure I.4
Significant concentration of research and development in a few countries
(Share of investment by global top 100 corporate R&D investors, by country; percentage)



Source: European Commission, Joint Research Centre, 2023.

Figure I.5
The share of R&D in software and computer services has increased sharply
(Share of investment by global top 100 corporate R&D investors, by industry; percentage)



Source: European Commission, Joint Research Centre, 2023.

C. Asymmetries in knowledge creation

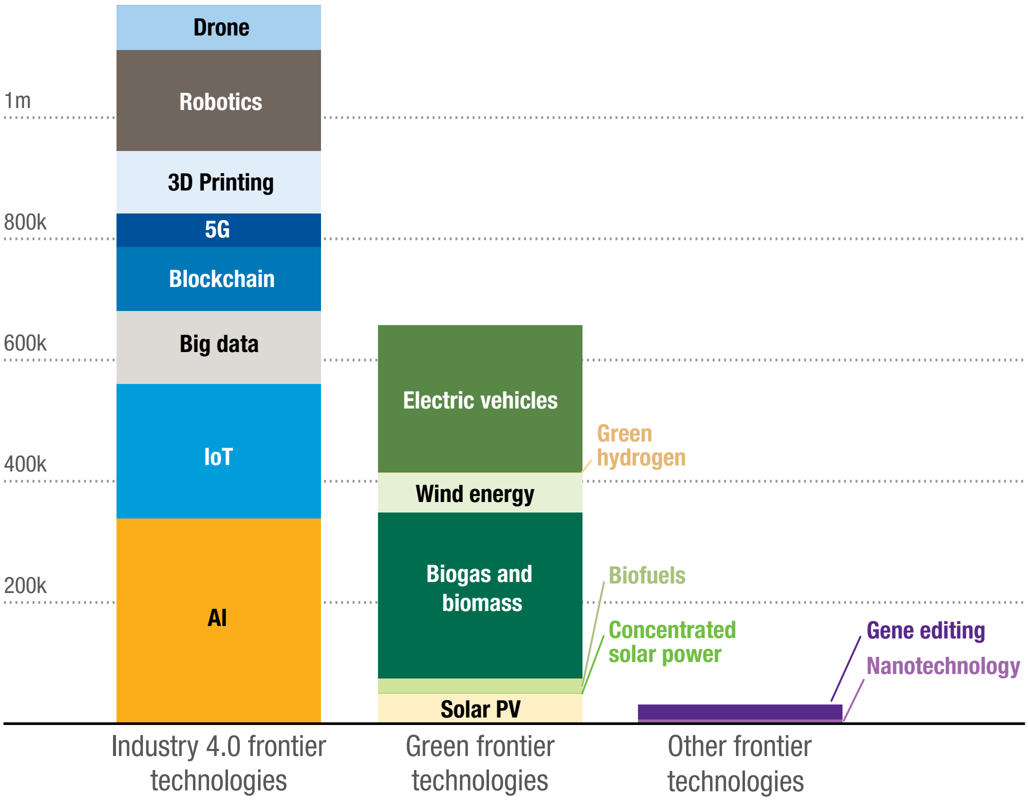
China and the United States lead in knowledge creation in frontier technologies

Knowledge creation in frontier technologies has been gathering pace, with a rapid rise in research publications and patents. Over the period 2000–2023, for AI alone, more than 713,000 peer-reviewed scientific articles were published and 338,000 patents were filed, with a sharp increase since 2020. Other industry 4.0 technologies, such as IoT, robotics and big data, also generated a large number of publications and patents. Among green technologies, knowledge creation was more significant in biogas and biomass (274,000 patents) and in electric vehicles (243,000 patents) (figure I.6).

As with R&D investments, knowledge creation in frontier technologies is dominated by China and the United States, which together are responsible for around one third of global peer-reviewed articles and two thirds of patents. These countries are more dominant in patents than scientific articles.

Different countries often specialize in particular fields. This is evident in the revealed technology advantage of a country, that is defined as its share of patents in a particular technology field divided by its share in all fields (table I.1). A value above 1 indicates specialization. For example, Germany is highly specialized in wind energy, India in nanotechnology, Japan in electric vehicles, and the Republic of Korea in 5G technology. Certain countries or regions may become global hubs for particular types of knowledge, attracting investment and talent, and giving them an edge in shaping the technological trajectory.

Figure I.6
Number of frontier technology patents, 2000–2023



Source: UNCTAD calculations, based on data from PatSeer.

Market dominance, at both the corporate and national levels, risks widening global technological divides, making it even more difficult for latecomers to catch up, particularly when coupled with the slowdown in technology diffusion observed in recent decades (Andrews et al., 2016).

The growing complexity of technologies and innovations requires increasing investments in physical and human capital, to find new ideas, as well as greater adjustment and learning costs for effective implementation. In addition, modern technologies need to be integrated with multiple components within increasingly interconnected systems, further raising entry barriers and limiting technology and knowledge diffusion.

The gap in productivity growth between firms at the global frontier and laggards is particularly marked in digital and skill-intensive industries (Berlingieri et al., 2020).

These challenges, along with structural barriers such as inadequate infrastructure and a lack of technical expertise, make it difficult for lagging firms and countries to keep pace with technological advances. The slowdown in technology diffusion also limits aggregate productivity growth. Technology development and innovation in developing countries can also be hindered by data and intellectual property policies in developed countries, with the risk of the diffusion of AI technology further widening existing gaps.

Table I.1
Revealed technology advantage of selected countries based on filed patent, 2000–2023

		Patents					
		USA	China	Germany	India	Korea	Japan
Industry 4.0 frontier technologies	AI	1.2	0.8	1.3	1.7	1.1	1.4
	IoT	0.6	1.3	0.2	2.3	1.4	0.3
	Big data	0.1	1.7	0.0	0.4	0.9	0.1
	Blockchain	1.2	1.0	0.4	0.8	1.0	0.6
	5G	0.4	1.0	0.1	0.2	4.4	0.2
	3D printing	0.8	1.2	1.5	0.2	0.5	0.2
	Robotics	2.5	0.5	0.9	0.9	0.3	1.0
	Drone	1.0	1.0	0.8	0.7	1.6	0.7
Green frontier technologies	Solar PV	0.2	1.6	0.0	0.8	0.5	0.4
	Concentrated solar power	2.8	0.1	1.5	1.7	0.2	1.8
	Biofuels	2.1	0.3	0.8	0.9	0.5	0.7
	Biogas and biomass	1.0	0.9	1.2	0.6	0.3	0.9
	Wind energy	0.3	1.2	4.3	0.5	0.2	0.2
	Green hydrogen	0.7	1.1	1.0	1.5	0.8	0.4
	Electric vehicles	0.7	1.0	1.3	0.4	1.5	3.0
Other frontier technologies	Nanotechnology	1.3	0.5	0.9	3.0	0.4	0.3
	Gene editing	2.9	0.6	0.6	0.0	0.3	0.6

Source: UNCTAD calculations, based on data from PatSeer.
Note: The revealed technology advantage gives an indication of the relative specialization of a given country in a technology. It is calculated as the country's share of patents in a particular technology field divided by its share in all fields, potentially ranging from zero to infinity. The figure is equal to 1 when a country's share in a technology equals its share in all frontier technologies; a figure above 1 indicates a specialization and a figure below 1 indicates "no specialization".

D. Evolution of AI

To help in understanding the promises and perils of AI, the following sections discuss different waves of AI and the intersection of AI with other technologies.

There is no universal definition of AI, but it is generally considered to be the capability of a machine to engage in cognitive activities similar to those performed by the human brain, such as reasoning, learning and problem-solving (Collins et al., 2021).

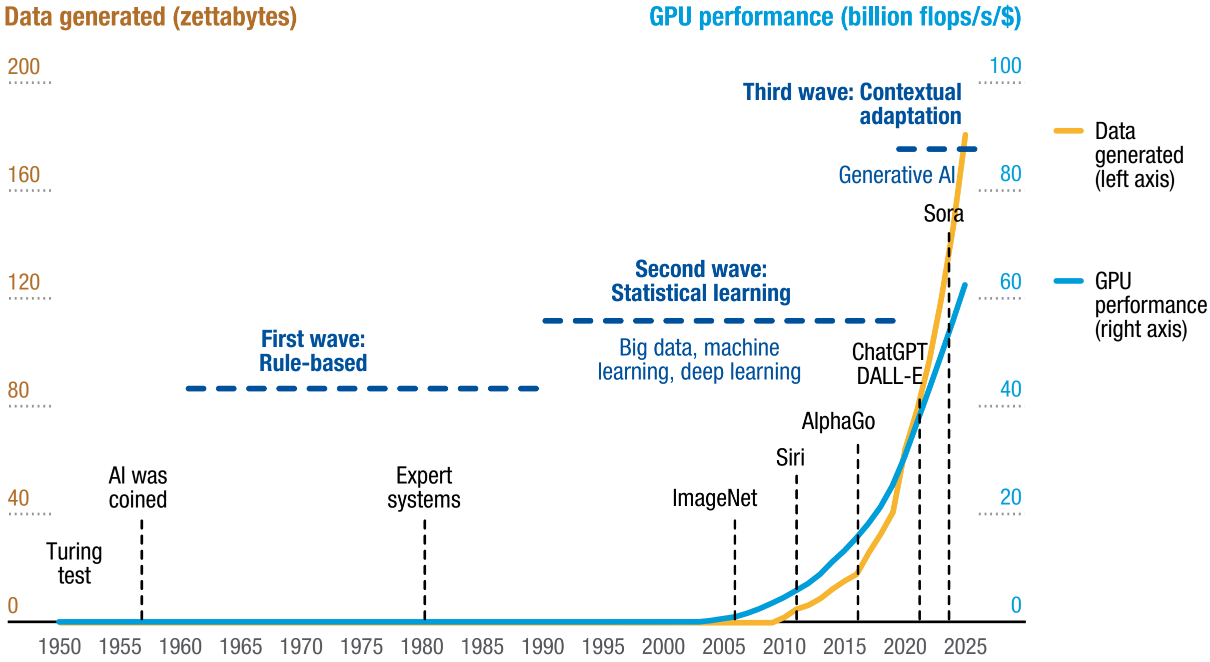
The notion originated in the 1940s as part of the concept of machine intelligence by Alan Turing, who suggested that machines could simulate both mathematical deduction and formal reasoning.[5] The term artificial intelligence was coined in 1956 for the Dartmouth Summer Research Project on Artificial Intelligence (McCarthy et al., 2006).

[5] In the seminal paper "Computing Machinery and Intelligence", the concept of the Turing test was introduced, whereby if a human evaluator could not distinguish the written responses of a machine from those of a human, the machine would pass the test and be considered as exhibiting intelligent behaviour equivalent to that of a human (Turing, 1950).

Since then, progress has been uneven and can be considered to have taken place in three waves (figure I.8). The first was in the 1950s and the 1960s, when AI developed rapidly as a rule-based system that used a set of predetermined "rules of choices" to make decisions and solve problems. Progress slowed in the 1970s due to a lack of computational power and scalability, the first "AI winter". There was a brief thaw in the 1980s, when expert systems mimicking the human decision-making process became popular. However, as these systems showed the same limitations as earlier systems, interest and funding in AI diminished once again.

The second wave started in the 1990s, based on statistical learning. By analysing large quantities of data, machines could revise rules and provide more flexibility. The resurgence in AI research and application was driven by three major forces, namely, increasing computational power at low cost, unprecedented data volumes and more sophisticated and efficient algorithms.[6] One landmark was the launch in 2007 of ImageNet, a large-scale system for image recognition based on millions of human-annotated images (Deng et al., 2009). A second was the creation of the digital assistant Siri in 2011. A third, in 2016, was the defeat of the world Go champion by a computer programme.

Figure I.8
The three waves of AI



Source: UNCTAD, based on various estimates (see note below).
Note: Graphics processing units (GPUs) were initially designed for computer graphics and image processing but later became useful in non-graphic calculations and have been widely used in training AI models. GPU performance is expressed in terms of floating-point operations (flops) per second per dollar, adjusted for inflation. The curve represents the best fitted line based on data from 2000 to 2020 and extrapolated figures between 2020 and 2025 (Hobbhahn and Besiroglu, 2022). For the amount of data generated, figures for before 2010 are extrapolated based on the estimates from 2010 to 2025 (Taylor, 2023).

[6] For example, machine learning emerged as a subset of AI that use statistical techniques to detect patterns and make predictions based on the data. Big data and the rise of deep learning further propelled significant advancements.

Nevertheless, at this stage, AI was largely confined to specific tasks within limited domains and did not possess human-like intelligence. This is considered narrow artificial intelligence, or weak AI (Collins et al., 2021).

The third and current wave gathered momentum in the 2020s, with the use of significant computer power for systems not only based on rules but seeking contextual adaptation or factoring in contexts and explaining decisions. Recent years have seen the emergence of GenAI, driven by advances in natural language processing and large language models, along with exponential growth in computational power and data. This differs from discriminative or predictive AI, which typically analyses and classifies data for particular outcomes such as pattern recognition. GenAI instead mostly identifies relationships in large amounts of data and uses these to create new content. However, this is at the cost of explainability, as it may be difficult to understand the decision-making logic behind a model's results because it is probabilistic, and the same conditions or inputs might subsequently produce different outputs.

Breakthroughs in AI are transforming it **into a general-purpose technology**

GenAI is trained on huge data sets and uses complex algorithms to generate statistically probable outputs, as well as new content that resembles existing data, whether in the form of texts, images or videos.[7] Public interest in AI was fuelled by the launch of the online application ChatGPT in 2022 by OpenAI. Other examples are DALL-E, which creates images from text, and Sora, which has been conceived for video creation. The growing capabilities and adaptability of AI represent a paradigm shift that is transforming it into a general-purpose technology configurable for different uses (Dhar, 2023; box I.1).

Between 2024 and 2030, the GenAI market is predicted to grow from $137 billion to $900 billion, a compound annual growth rate of 37 per cent (Bloomberg, 2023). Expectations are high, comparable to the enthusiasm in the late 1990s that boosted investment during the initial diffusion of the Internet. Nevertheless, there are still high levels of uncertainty. Evidence of the impact of GenAI applications and how they could be best utilized remains limited, particularly in developing countries, and further research and observation is required. Moreover, AI applications are valuable but not infallible. If the training data are incomplete or biased, the model may learn incorrect patterns, make inaccurate predictions or hallucinate to offer information that is not present in the training data or that contradicts a user's prompt.

The rapid development of GenAI has reignited the expectation of developing artificial general intelligence or "strong AI" that could even surpass human intelligence and operate autonomously. AI has already outperformed humans in handwriting, speech and image recognition, as well as in reading comprehension and language understanding (figure I.9). However, human intelligence is complex and multifaceted; it may be more challenging than expected to achieve artificial general intelligence.

The driving forces behind the rapid progress of AI in recent decades involve three key leverage points, that can trigger transformational cascades for AI, namely, infrastructure, data and skills; infrastructure in the form of increasing computational power and cost-effective information transfers; data, with regard to the massive and diverse amounts of quality data produced at accelerating speeds; and skills in the form of advanced expertise in developing and applying sophisticated AI models. The present report provides evidence with regard to these three key leverage points.

[7] GenAI is a subset of deep learning, which utilizes multilayer neural networks to automate data analysis from large unstructured data sets.

Box I.1
Is AI a general-purpose technology?

General-purpose technologies lead to new methods of production and innovation, transform industries and create new markets over decades. Such technologies are characterized by:

- *Pervasiveness* – They offer applications across various industries and economic activities.
- *Dynamicity* – They offer room for continuous technical improvements that create new opportunities for applications.
- *Innovational complementarities* – They enable innovations in application sectors and new complementary technologies developed around them.

AI is considered a general-purpose technology because it can impact a wide range of tasks and jobs. AI is continuously evolving, with growing functionality, and may affect around half of human jobs in the future.

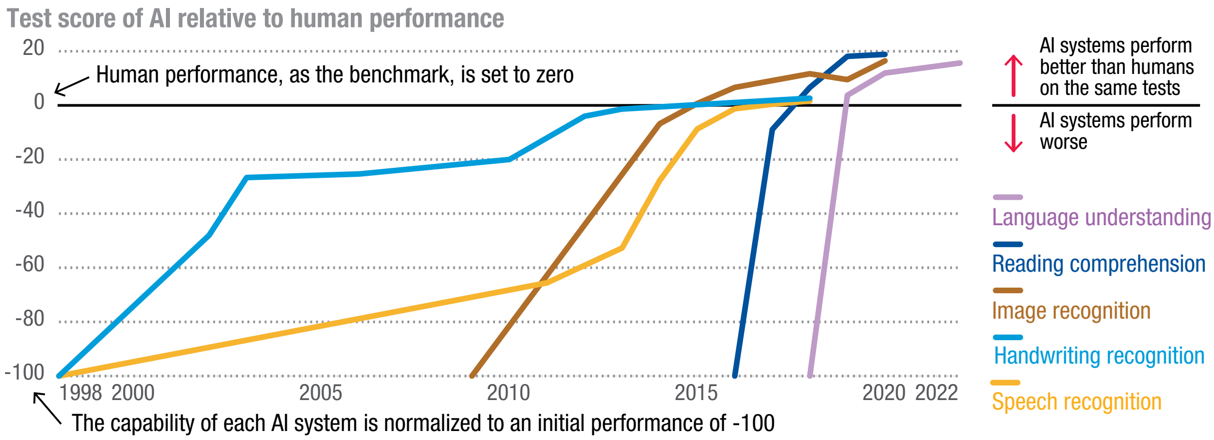
Moreover, AI is already transforming the way research and innovation are conducted. While it can speed up processes, it is unclear whether the use of AI can help address the increasing difficulties in discovering new ideas and the decreasing rate of the emergence of disruptive ideas.

In any case, as with previous general-purpose technologies, it will take time and effort for the full potential of AI to be realized. For example, the introduction of electric motors in manufacturing initially boosted productivity by reducing energy costs, but the most significant impacts did not emerge until companies began to redesign factories and business processes to take advantage of the flexibilities offered by the new source of energy.

Rather than being final solutions, general-purpose technologies open up new opportunities and feedback loops throughout the economy. However, the complementary productive and innovative activities are usually widely dispersed, making it difficult to coordinate efforts and provide incentives within both the technology and the application sectors.

Source: Bresnahan and Trajtenberg, 1995; Bloom et al., 2020; Krenn et al., 2022; Park et al., 2023; Eloundou et al., 2024.

Figure I.9
Evolution of language and image recognition capabilities of AI systems



Source: Roser, 2022.

Synergies among three key leverage points – **infrastructure, data, and skills** – can accelerate AI progress

Infrastructure – Infrastructure requirements go beyond the basic provision of electricity and the Internet. They also comprise computing power and server capabilities, such as significant storage, network connectivity, security and backup systems. These are needed to process huge amounts of data, run algorithms, execute models and transmit results worldwide.

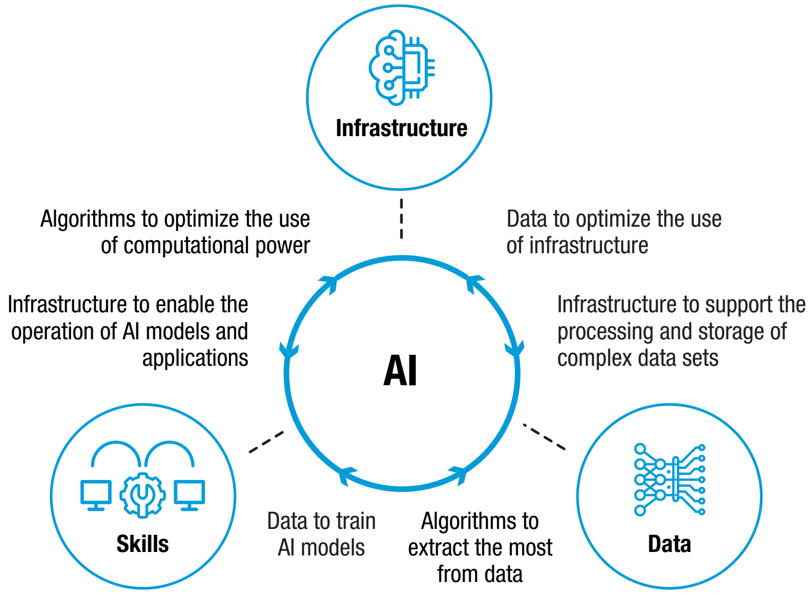
Data – Data are the primary input for the training, validation and testing of algorithms, thereby enabling AI models to classify inputs, generate outputs and make predictions. Data are therefore a critical socioeconomic asset in decision-making processes. High-quality, diverse and unbiased data are essential in building effective and trustworthy AI systems. Data and AI systems interact dynamically, whereby more data provide more training for an AI model, making it more popular and thus capable of collecting (and generating) more data.[8] This dynamic and scale effects could widen existing data-related and technological gaps, creating higher entry barriers for latecomers.

Skills – Skills range from basic data literacy to the use or development of appropriate techniques, algorithms and models, and from proficiency in data analysis to a combination of technical expertise and domain knowledge. Such skills empower the workforce to use AI to solve complex problems and increase productivity.

These three leverage points create synergistic, positive feedback loops. More affordable and powerful computational resources enable the processing of vast and complex data sets, allowing sophisticated algorithms to analyse and learn from data more effectively, which in turn accelerates the adoption and development of AI, thereby generating more data. The abundance of diverse data provides a rich foundation for training AI models, enhancing their ability to generalize and perform well in different scenarios and across different tasks. At the same time, advanced algorithms optimize the use of computational power and data, leading to more rapid and efficient AI development. This dynamic interaction fosters continuous improvement and innovation in AI technologies (figure I.10).

[8] For example, Chat GPT-4 uses 45 gigabytes of training data, around three times that used by GPT-3, and was trained using reinforcement learning with human feedback on Microsoft Azure AI supercomputers. The number of parameters increased from 1.5 billion for GPT-2 to 175 billion for GPT-3 and estimates suggest that the number of parameters for GPT-4 are around 1.77 trillion, 10 times those of its predecessor (Heaven, 2023).

Figure I.10
Synergies among three key leverage points can accelerate AI progress



Source: UNCTAD.

E. Synergy between AI and other technologies

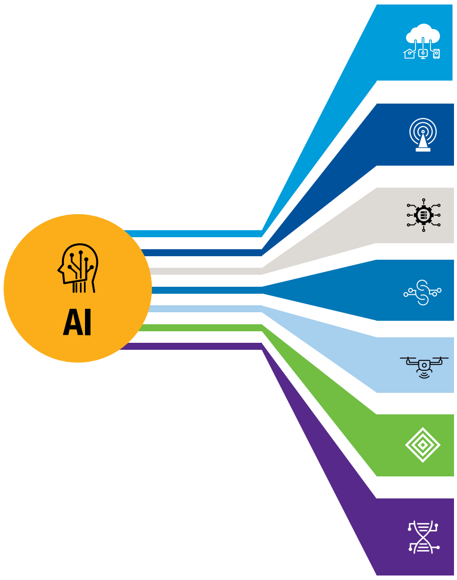
Compared with earlier AI waves, the current AI surge has greater depth and breadth of penetration, with AI technology having a wide range of potential applications in different fields. AI is already embedded in our daily life and serves as a general-purpose technology that augments other technologies (Damioli et al., 2024). The intersection of AI with other frontier technologies opens up opportunities for innovation, including the following (figure I.11):

IoT – Connected devices, given a further boost by AI, can analyse data, make decisions and take actions with minimal human intervention, to create an artificial intelligence of things. This is becoming the basis of smart factories. Combined with the 5G networks that support higher-speed connections with lower latency, this can lead to intelligent connectivity (Yarali, 2021). Smart transportation, for example, enables vehicles to communicate in real time on road conditions and accidents, for better traffic control and management.

Big data – There is a strong synergy between AI and big data. AI can improve data analysis and pattern recognition, while big data can be used in training models. Video surveillance systems, for example, can process large amounts of video and sensor data, to identify anomalies or patterns of interest.

AI can augment other technologies

Figure I.11
AI augments other frontier technologies



Source: UNCTAD.

Blockchain – AI is increasingly being used with blockchain, particularly in the fields of cybersecurity, financial services and supply chain management. AI provides better data analytics to improve or develop new solutions, for example, detecting threats and fraudulent activities and optimizing inventory levels and routing. Blockchain augments AI-based security measures with linked cryptographic authentication and decentralized computing power and data processing (Ekramifard et al., 2020).

3D printing – Human designers can explore feasible options for 3D printing by running many different design scenarios and carrying out virtual stress tests. Less experienced designers can also benefit from GenAI-driven tools, such as Style2Fab and 3D-GPT that facilitate design and development processes (Zewe, 2023; Sun et al., 2023).

Robotics and drones – AI can reinforce the capacity of robots to learn and make decisions and execute tasks in dynamic conditions. AI-powered industrial robots are widely used in manufacturing. AI also helps with crop-harvesting in agriculture (Birrell et al., 2020). Similarly, AI enables drones to operate autonomously and adapt to changing scenarios, making them more efficient and versatile.[9]

Green frontier technologies – The use of AI models can consume significant amounts of energy, but can also help unlock the potential of clean energy and accelerate decarbonization.[10] For example, the use of AI can optimize the use and management of renewable energy through smart grids and the storage and distribution of energy from renewable sources (Rozite et al., 2023).

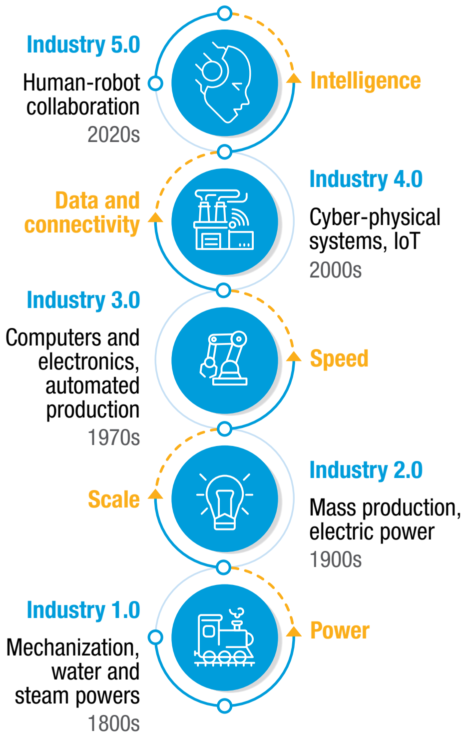
[9] For example, in 2023, a drone developed by the University of Zurich performed better than human competitors in a physical drone race for the first time (Swissinfo, 2023).

[10] It is estimated that AI has more greenhouse gas emissions than the global airline industry and data centres account for around 1 per cent of global electricity demand. Nevertheless, AI could lead to a 4 per cent reduction in global greenhouse gas emissions by 2030 from efficiency improvements alone (The United Nations Economic and Social Council, 2024).

Nanotechnology and gene editing – AI is widely used in nanotechnology and gene editing, including in autonomous nanorobots, for material design and discovery, and AI-driven genetic research (Dixit et al., 2024).

The salient features of AI, from data analytics, natural language processing and automation to the latest breakthroughs in content generation and contextual adaptation, make it a general-purpose technology that can also augment mature technologies and be configured to dedicated uses.[11] A compelling capability of AI is its ability to learn and adapt. It is also possible to have a smaller (and less capable) model supervising a more complex and capable one, known as "weak to strong generalization". This offers a scalable way for humans to guide and control complex AI models by using more easily understandable AI models (Burns et al., 2023).

Figure I.12
Industrial revolutions and their transformative changes



Source: UNCTAD.

A fifth industrial revolution

AI may be considered the latest in a sequence of industrial revolutions, all of which have reshaped production systems (figure I.12). In the 1800s, during the first industrial revolution, the power of human labour was expanded by the spread of a range of new technologies, including spinning machinery and the steam engine. The second industrial revolution in the 1900s was driven by the diffusion of electrical power and standardization of machine tools, which led to mass production.

The third industrial revolution began in the 1970s with the introduction of computers and electronics, which increased the speed of information processing, for the further automation of production processes and the advent of the service economy. The fourth industrial revolution, since the 2000s, often referred to as Industry 4.0, has leveraged the diffusion of the Internet and mobile devices to integrate cyber and physical systems, multiplying the quantity of information produced and its potential uses.

A distinctive feature of AI is its ability to amplify human intelligence. Intelligent machines allow for more effective human and robot collaboration that may spark a fifth industrial revolution (box I.2). A new wave of technological transformation will reshape the economy and society. For example, there is the risk that the use of AI will replace many workers while not creating enough new jobs, and may also widen job polarization and increase income inequality. Chapter II discusses the importance of inclusive AI adoption that puts workers at the centre of technological development.

AI could spark a fifth industrial revolution, in which humans and intelligent machines collaborate

[11] For example, in China, the AI Plus initiative emphasizes the deep integration of AI with the real economy, highlighting its broad applicability across various sectors (Xinhua News Agency, 2024).

Box I.2
Key features of the fifth industrial revolution

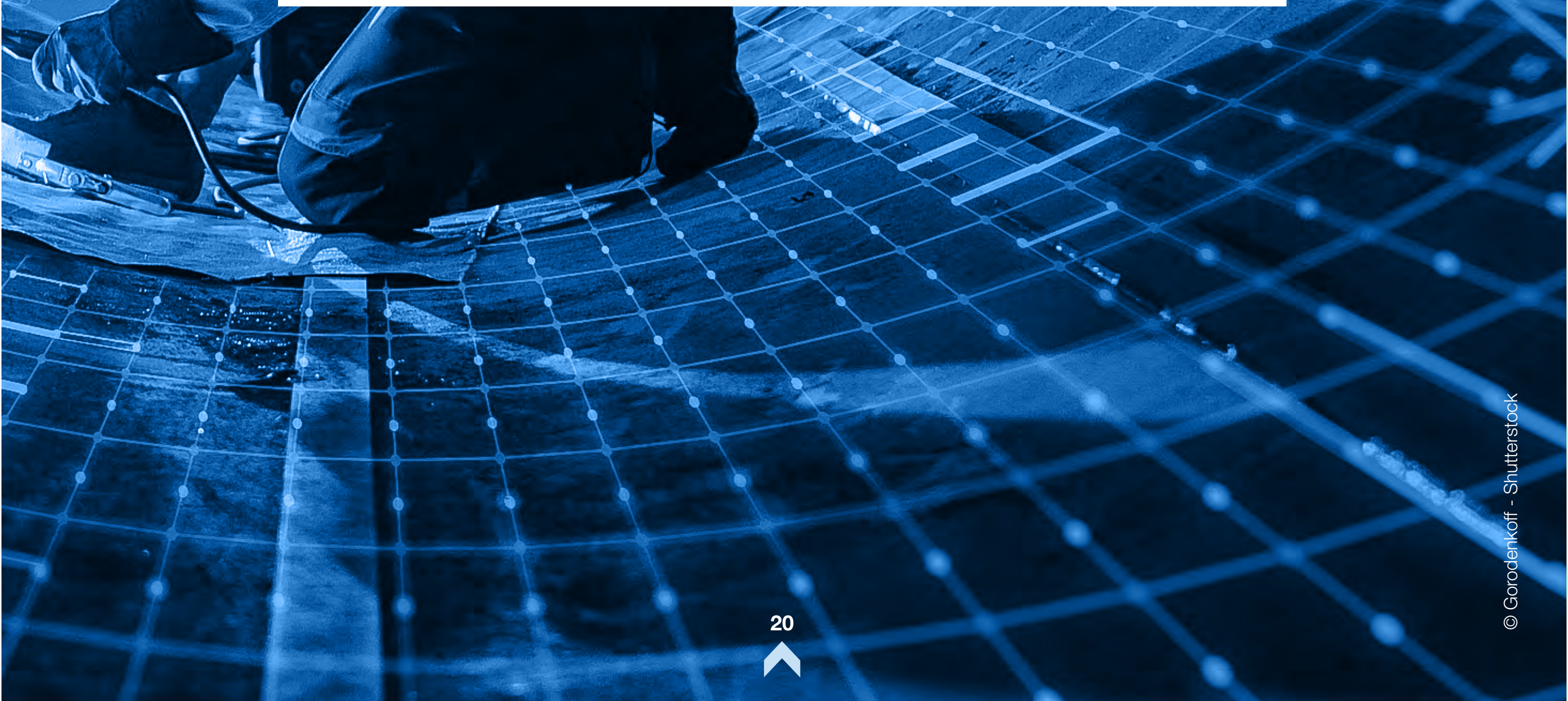
The concept of the fifth industrial revolution is still evolving, but it can be distinguished from the fourth industrial revolution by three key features, namely, human–machine collaboration, sustainability and personalization. These elements point to a future that can be more inclusive and sustainable, but achieving this vision requires deliberate effort and action.

- *Human–machine collaboration* – As opposed to the automation focus of the fourth industrial revolution, it focuses on human–machine collaboration, or human-centric co-creation. This involves redirecting technological advances towards serving humanity, prioritizing collaboration and co-creation between humans and machines. Rather than focusing solely on efficiency it aims to promote dynamic and inclusive production systems that enhance human well-being. Rather than asking which new technological solution is feasible, the question should be why such a solution is being developed; what human and societal needs does it address and how does it help solve them?

- *Sustainability* – While prioritizing worker well-being and competitiveness, in the fifth industrial revolution, sustainability is also considered, with industry playing an increasing role in providing solutions to societal challenges. This aligns with a shift toward digitalization, to create more sustainable and environmentally friendly business and consumer practices.

- *Personalized products and services* – The fifth industrial revolution can use the advanced capacity of AI to analyse vast amounts of data on individual preferences and behaviours to create highly personalized products and services. Innovations such as GenAI and chatbots have transformed marketing practices, allowing companies to deliver tailored experiences in near real-time. The impact of personalization extends beyond improving consumer satisfaction; it can also be a way to enhance the well-being of workers, communities and the planet.

Source: Adel, 2022; Noble et al., 2022; UNCTAD, 2023; Van Erp et al., 2024.



F. The AI divide

History shows that technological shifts generally begin with upgrades in hardware and infrastructure, for example, from mainframes to personal computers, from landlines to mobile devices and from intranets to the Internet. This enables additional capabilities, including software and services, and facilitates the adoption and further development of technologies. The different phases are not linear; they usually overlap and create feedback loops that take years to mature and for society to realize their full potential.

Currently, the diffusion of AI applications is associated with investment to upgrade critical AI infrastructure components such as semiconductors, data centres and supercomputers. These support high-speed processing, significant data-handling and advanced computation.[12] During a gold rush, the most likely winners are often those who sell shovels. In the AI boom, one of the main winners has been Nvidia, the world's largest semiconductor company. In 2023, based on high expectations of revenue growth, its market capitalization more than tripled to $1.2 trillion, and it nearly tripled again in 2024.[13] The surge in AI has also benefited other top semiconductor companies, which have experienced significant growth since 2023, notably, Advanced Micro Devices, ASML, Broadcom, Samsung and TSMC.

Supercomputers and data centres

Most of the leading semiconductor companies are from the United States and other developed economies, and there is a remarkable divide between developing and developed countries in other components of AI infrastructure. The United States has around one third of the top 500 supercomputers and more than half of overall computational performance (TOP500, 2024). China ranks second, with 80 of the top 500 supercomputers, although its total computational performance is less than one tenth that of the United States.[14] A similar situation is seen with regard to data centres, with most of them located in the United States (Data Center Map, 2024).

Few developing countries have powerful supercomputers or large data centres, apart from Brazil, China, India and the Russian Federation. Most developing countries have limited capacities in AI hardware and infrastructure, which hinder their adoption and development of AI. Chapter III presents an assessment of countries' preparedness for AI.

[12] For example, an alliance between BlackRock, Global Infrastructure Partners, MGX and Microsoft, plans to mobilize up to $100 billion to invest in data centres and supporting power infrastructure (Microsoft, 2024).

[13] In June 2024, Nvidia also became the largest company in the world by market capitalization, at $3.3 trillion (Companies Market Cap, 2024).

[14] The computational power ranking is based on the sixty-third edition of the Top500 list, in which supercomputers are ordered primarily by their Rmax value, which represents the maximum Linpack performance achieved, measured in trillions of floating-point operations per second.

Services providers

The private sector leads AI research, surpassing Governments and academia combined

The market of AI services providers is also dominated by companies based in the United States, for example, Amazon, Alphabet, IBM, Microsoft and OpenAI, and by those based in China, including Baidu and Tencent. The private sector is responsible for most frontier AI research and produces most machine-learning models, leaving Governments and academia some way behind, with less than half combined (Maslej et al., 2024).

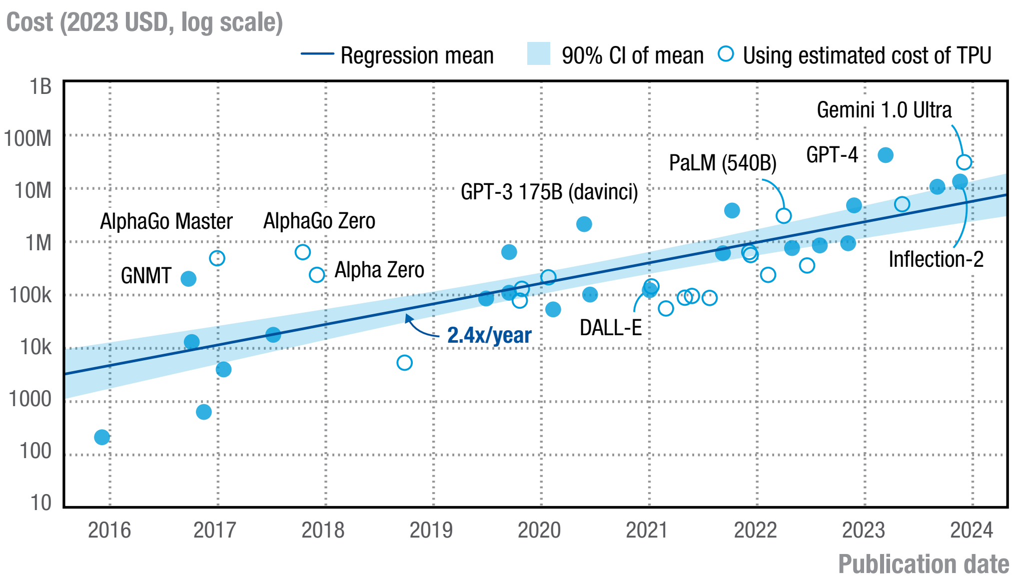
This is partly because of escalating costs. Since 2016, the cost of training frontier AI models has increased 2.4 times per year (figure I.13). More than half of the development cost is directed to hardware, making frontier AI model training unaffordable for all but the most well-funded organizations. Most SMEs, particularly those in developing countries, are unlikely to develop new AI models from scratch. Instead, they can adopt and adapt existing AI technologies to meet their particular business needs.

Through interactions with numerous users and devices, companies are building up valuable data sets, enabling them to extend their advantages from hardware to data and beyond. This concentration of computing power and services in a few countries has raised concerns about their impacts on the national interests of other countries, particularly because of supply chain vulnerabilities and the interest of Governments to achieve autonomy in the development of technologies that are crucial for advancing national developmental goals.

Investment

The United States leads the world in terms of private investment in AI, at $67 billion in 2023, or 70 per cent of global AI private investment. The only developing countries with significant investments were China in the second position, with $7.8 billion, and India in the tenth position, with $1.4 billion. In 2023, the United States also continued to lead in terms of the total number of newly funded AI companies, around seven times the number in the next highest country, China (Maslej et al., 2024).

Figure I.13
Amortized hardware and energy cost to train frontier AI models



Source: Cottier et al., 2024.

Startups are key drivers of technological developments and the most valuable AI startups are primarily located in the United States and China (OxValue.AI, 2024).

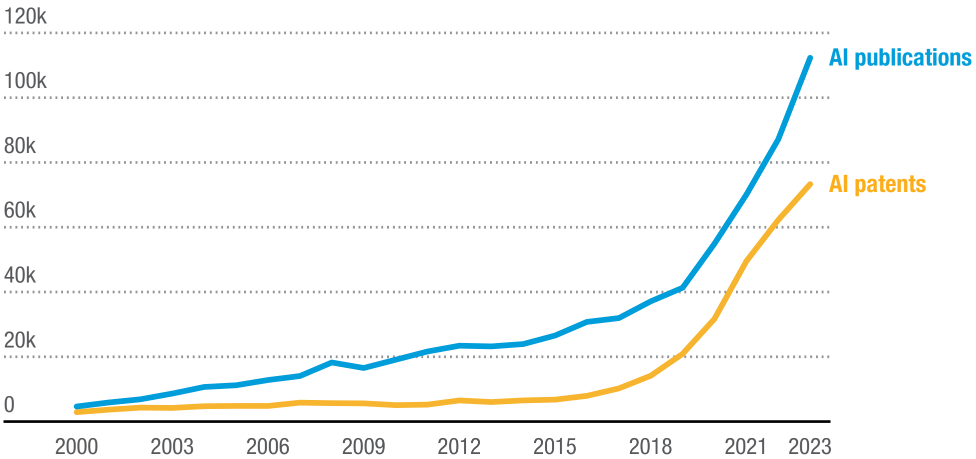
Knowledge creation

Over the period 2000–2023, China and the United States were responsible for around one third of global publications in AI and 60 per cent of patents (figure I.14). Apart from China and India, most developing countries have had limited progress, and the distance from developed countries has increased. The situation is similar with regard to GenAI, with most such technologies invented in China and the United States (WIPO, 2024). There is a corresponding gap in AI talent distribution; around half of the world's top-tier researchers in AI originate from China, followed by 18 per cent from the United States and 12 per cent from Europe (MacroPolo, 2024).

The AI-related breakthroughs in recent years could mark the beginning of a new industrial revolution. AI has emerged as a general-purpose technology that can revolutionize processes in various areas powered by highly connected and intelligent production systems that can augment rather than replace humans through improved human–machine interaction. In principle, the use of AI could also help accelerate progress towards the achievement of the Sustainable Development Goals. Yet there are risks and ethical concerns arising from the use of biased training data and the invasion of privacy, as well as security threats, cyberattacks or autonomous weapons. If AI is unevenly distributed and lacks ethical oversight and transparency, its use may exacerbate existing inequalities, hindering sustainable human development (Vinuesa et al., 2020).

In addition, with high computational demands, AI consumes significant amounts of electricity and water, with significant implications for climate change. This highlights the need for environmentally sustainable and inclusive digitalization strategies (UNCTAD, 2024). Developing countries urgently need to strategically position themselves to harness the benefits of the AI era, while addressing potential risks and promoting equitable and inclusive AI development.

Figure I.14
AI-related publications and patents are rising
(Number of publications and patents)



Source: UNCTAD calculations, based on data from PatSeer and Scopus.

G. Navigating the report

To shape a future in which AI contributes positively to achieving the Sustainable Development Goals, a multidimensional and evidence-based approach is required. To that end, this report focuses on the need to build resilient infrastructure and promote inclusive and sustainable industrialization and innovation (Goal 9). Concentrated AI development coupled with existing gaps in digital infrastructure risks widening inequalities both within and among countries (Goal 10).

The following chapters analyse and provide recommendations on the far-reaching implications of AI, gradually zooming the focus out from its effects on productivity and the workforce to encompass aspects related to global governance (table I.2).

Chapter II explores productivity and workforce dynamics from a microeconomic perspective, focusing on economic growth and decent work (Goal 8). Chapters III and IV adopt a national perspective, addressing requirements and policies to support AI adoption, adaptation and development (Goal 9). Chapter V concludes by addressing AI governance from a global perspective, emphasizing the importance of international collaboration, to steer AI towards inclusive and equitable development (Goal 17).

Table I.2
Overview of the report, areas of focus, recommendations and related Sustainable Development Goals

	Focus		Recommendations	Main SDGs
AI adoption Ch. II	AI, productivity and workforce	Case studies: AI applications in developing countries	• Adapting to local infrastructure • New sources of data • Worker-centric approach • Partnerships	8 TRABAJO DECENTE Y CRECIMIENTO ECONÓMICO
AI preparedness Ch. III	Requirements for AI adoption and development	AI preparedness assessment along infrastructure, data and skills	• Country-level gap analysis • Strategic positioning • Catch-up trajectories	9 INDUSTRIA, INNOVACIÓN E INFRAESTRUCTURA
AI policies Ch. IV	Evolution of industrial and STI policies	Examples: AI policies and strategies across countries	• Overarching approaches • ICT infrastructure upgrade • Data policies • Strengthening digital skills	9 INDUSTRIA, INNOVACIÓN E INFRAESTRUCTURA
AI global governance Ch. V	Fragmented AI governance landscape	Emerging common approaches	• Accountability • Digital public infrastructure • Open innovation • Capacity building for AI and STI	17 ALIANZAS PARA LOGRAR LOS OBJETIVOS

Source: UNCTAD.

Annex I

Technical note on frontier technologies

This annex provides a brief description of the 17 frontier technologies covered in the report. It presents the search queries used in obtaining publication and patent data and the sources of market-size data.

Table 1
Frontier technologies covered in the report

Artificial intelligence (AI)	Generally defined as the capability of a machine to engage in cognitive activities typically performed by the human brain. AI implementations that focus on narrow tasks are widely available and used, for example, in recommending purchases online, for virtual assistants in smartphones and for detecting spam or credit card fraud. New implementations of AI are based on machine learning and harness big data.
Internet of things (IoT)	The myriad Internet-enabled physical devices that collect and share data. There are many potential applications. Typical fields include wearable devices, smart homes, healthcare, smart cities and industrial automation.
Big data	Data sets whose size or type is beyond the ability of traditional database structures to capture, manage and process, allowing computers to tap into data that have traditionally been inaccessible or unusable.
Blockchain	An immutable time-stamped series of data records supervised by a cluster of computers not owned by any single entity. Blockchain serves as the base technology for cryptocurrencies, enabling peer-to-peer transactions that are open, secure and fast.
5G	The next generation of mobile Internet connectivity, offering download speeds of around 1 to 10 gigabits per second (4G speeds are around 100 Mbps), as well as more reliable connections on smartphones and other devices.
3D printing	3D printing, also known as additive manufacturing, produces three-dimensional objects based on a digital file, and can create complex objects using less material than traditional manufacturing.
Robotics	Programmable machines that can carry out actions and interact with the environment via sensors and actuators, either autonomously or semi-autonomously. They can take many forms, including disaster response robots, consumer robots, industrial robots, military and/or security robots and autonomous vehicles.
Drone technology	Also known as Unmanned aerial vehicles (UAV) or unmanned aircraft systems (UAS). A flying robot that can be remotely controlled or fly autonomously using software with sensors and a global positioning system. Drones have often been used for military purposes, but also have civilian uses such as in videography, agriculture and delivery services.

Solar photovoltaics (Solar PV)	The technology transforms sunlight into direct current electricity using semiconductors in photovoltaic cells. In addition to being a renewable energy technology, solar PV can be used in off-grid energy systems, potentially reducing electricity costs and increasing access.
Concentrated solar power	Concentrated solar power plants use mirrors to concentrate the sun's rays and produce heat for electricity generation via a conventional thermodynamic cycle. Unlike solar (PV), these plants use only the direct component of sunlight and can provide carbon-free heat and power only in regions with high direct normal irradiance.
Biofuels	Liquid fuels derived from biomass and used as an alternative to fossil fuel-based liquid transportation fuels such as gasoline, diesel and aviation fuels.
Biogas and biomass	A mixture of carbon dioxide, methane and small quantities of other gases produced by the anaerobic digestion of organic matter in an oxygen-free environment. Biomass is renewable organic material that comes from trees, other plants and agricultural and urban waste. It can be used for heating, electricity generation and transport fuels.
Wind energy	The kinetic energy created by air in motion, transformed into electrical energy using wind turbines. Many parts of the world have strong wind speeds, but the best locations for generating wind power are sometimes remote and offshore ones.
Green hydrogen	Hydrogen generated entirely by renewable energy sources or from low-carbon power. The most fully established technology for producing green hydrogen is water electrolysis fuelled by renewable electricity. Compared with electricity, green hydrogen can be stored more easily. Excess renewable capacity from solar and wind power can be used to power electrolysers that use this energy to create hydrogen, which can be stored as fuel in tanks.
Electric vehicles	Vehicles that use one or more electric motors for propulsion. They can be powered by a collector system, with electricity from extravehicular sources, or autonomously, by a battery. As energy-consuming technologies, electric vehicles create new demand for electricity that can be supplied by renewable sources. In addition to the benefits of this shift, such as reducing carbon dioxide emissions and air pollution, electric mobility also creates significant efficiency gains and could become an important source of storage for variable sources of renewable electricity.
Nanotechnology	A field of applied science and technology dealing with the manufacturing of objects in scales smaller than 1 micrometre. Nanotechnology is used to produce a wide range of products such as pharmaceuticals, commercial polymers and protective coatings. It can also be used to design computer chip layouts.
Gene editing	Also known as genome editing. A genetic engineering tool to insert, delete or modify genomes in organisms. Potential applications include drought-tolerant crops or new antibiotics.

Source: UNCTAD.

Table 2
Publications search conducted for the report

Technology	Search query
AI	TITLE-ABS-KEY (ai OR «artificial intelligence») AND PUBYEAR > 2000 AND PUBYEAR < 2024
IoT	TITLE-ABS-KEY (iot OR «internet of things») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Big data	TITLE-ABS-KEY («big data») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Blockchain	TITLE-ABS-KEY (blockchain) AND PUBYEAR > 2000 AND PUBYEAR < 2024
5G	TITLE-ABS-KEY («5g communication» OR «5g system» OR «5g network») AND PUBYEAR > 2000 AND PUBYEAR < 2024
3D printing	TITLE-ABS-KEY («3D printing») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Robotics	TITLE-ABS-KEY (robotics) AND PUBYEAR > 2000 AND PUBYEAR < 2024
Drone technology	TITLE-ABS-KEY (drone) AND PUBYEAR > 2000 AND PUBYEAR < 2024
Solar PV	TITLE-ABS-KEY («solar photovoltaic» OR «solar pv») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Concentrated solar power	TITLE-ABS-KEY («concentrated solar power») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Biofuels	TITLE-ABS-KEY («biofuel») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Biogas and biomass	TITLE-ABS-KEY («biogas» OR «biomass») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Wind energy	TITLE-ABS-KEY («wind energy») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Green hydrogen	TITLE-ABS-KEY («green hydrogen») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Electric vehicles	TITLE-ABS-KEY («electric vehicle») AND PUBYEAR > 2000 AND PUBYEAR < 2024
Nanotechnology	TITLE-ABS-KEY (nanotechnology) AND PUBYEAR > 2000 AND PUBYEAR < 2024
Gene editing	TITLE-ABS-KEY (gene-editing OR genome-editing OR «gene editing» OR «genome editing») AND PUBYEAR > 2000 AND PUBYEAR < 2024

Source: UNCTAD.
Notes: Publication data were retrieved from the Elsevier Scopus database of academic publications for the period 2000–2023 since, according to Elsevier, the data on papers published after 1995 are more reliable. The Scopus system is updated retroactively and, as a result, the number of publications for a given query may increase over time. The search was conducted using keywords alongside the title, abstract and author keywords.

Table 3
Patents search conducted for the report

Technology	Search query
AI	TAC:(ai OR «artificial intelligence») AND PBY:[2000 TO 2023]
IoT	TAC:(iot OR «internet of things») AND PBY:[2000 TO 2023]
Big data	TAC:(«big data») AND PBY:[2000 TO 2023]
Blockchain	TAC:(blockchain) AND PBY:[2000 TO 2023]
5G	TAC:(«5g communication» OR «5g system» OR «5g network») AND PBY:[2000 TO 2023]
3D printing	TAC:(«3D printing») AND PBY:[2000 TO 2023]
Robotics	TAC:(robotics) AND PBY:[2000 TO 2023]
Drone technology	TAC:(drone) AND PBY:[2000 TO 2023]
Solar PV	TAC:(«solar photovoltaic» OR «solar pv») AND PBY:[2000 TO 2023]
Concentrated solar power	TAC:(«concentrated solar power») AND PBY:[2000 TO 2023]
Biofuels	TAC:(«biofuel») AND PBY:[2000 TO 2023]
Biogas and biomass	TAC:(«biogas» OR «biomass») AND PBY:[2000 TO 2023]
Wind energy	TAC:(«wind energy») AND PBY:[2000 TO 2023]
Green hydrogen	TAC:(«green hydrogen») AND PBY:[2000 TO 2023]
Electric vehicles	TAC:(«electric vehicle») AND PBY:[2000 TO 2023]
Nanotechnology	TAC:(nanotechnology) AND PBY:[2000 TO 2023]
Gene editing	TAC:(gene-editing OR genome-editing OR «gene editing» OR «genome editing») AND PBY:[2000 TO 2023]

Source: UNCTAD.
Notes: Patent-related data were retrieved from the PatSeer software for patent research and analysis. To align with the publication data, the search period was set to 2000–2023. The patent search was conducted using keywords alongside the title, abstract and claims.

Table 4
Market-size data search conducted for the report

Technology	Source
AI	https://www.fnfresearch.com/artificial-intelligence-ai-market
IoT	https://www.globaldata.com/store/report/iot-market-analysis/
Big data	https://www.globaldata.com/store/report/data-and-analytics-technology-market-analysis
Blockchain	https://www.globaldata.com/store/report/blockchain-market-analysis/
5G	https://www.polarismarketresearch.com/industry-analysis/5g-services-market
3D printing	https://www.globaldata.com/store/report/3d-printing-market-analysis/
Robotics	https://www.globaldata.com/media/thematic-research/robotics-market-will-worth-218-billion-2030-forecasts-globaldata/
Drone technology	https://www.factmr.com/report/62/drone-market
Solar PV	https://www.precedenceresearch.com/solar-photovoltaic-market
Concentrated solar power	https://www.fortunebusinessinsights.com/industry-reports/concentrated-solar-power-market-100751
Biofuels	https://www.precedenceresearch.com/biofuels-market
Biogas and biomass	https://www.precedenceresearch.com/biomass-power-market
Wind energy	https://www.thebusinessresearchcompany.com/report/wind-energy-global-market-report
Green hydrogen	https://www.alliedmarketresearch.com/green-hydrogen-market-A11310
Electric vehicles	https://www.marketsandmarkets.com/Market-Reports/electric-vehicle-market-209371461.html
Nanotechnology	https://www.giiresearch.com/report/bc1361105-global-nanotechnology-market.html
Gene editing	https://www.grandviewresearch.com/press-release/global-genome-editing-market

Source: UNCTAD.
Notes: Market size data, as measured by the revenue generated in the market is based on market research reports available online. Each report covers a different base year and prediction year; the reported figures therefore use 2023 as the base year and 2033 as the prediction year and apply the compound annual growth rate presented in each report.

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