The Intelligence Revolution: How AI Is Redefining Value Creation Across Industries

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1 Introduction

Artificial Intelligence (AI) is reshaping the global economy with a speed and magnitude rarely seen in technological history. Enterprise adoption has more than doubled since 2017, driven by advances in large language models (LLMs) and generative AI systems that are rapidly becoming core to business operations across sectors.[1] Artificial Intelligence (AI) is projected to boost global GDP by 15% by 2035—making it one of the most significant economic drivers of our time.[2] Generative AI alone could contribute $2.6-$4.4 trillion per year across industries.[3] Combined with non-generative AI, the total potential economic impact ranges from $11.0-$17.7 trillion.[1] The impact is industry-wide: accelerating drug development in healthcare, enhancing fraud detection in financial services, automating logistics in manufacturing, and transforming customer experiences in retail.[1,3] At the organizational level, AI is already boosting knowledge worker productivity.[4] We believe AI has the potential to increase employee productivity by 40% by 2035.

Importantly, AI is not only transforming how existing industries operate, but it is also enabling entirely new markets that were previously unimaginable.[5] From industrial automation and intelligent energy systems to personal AI agents and autonomous scientific discovery, the technology is catalyzing business models that didn't exist just a few years ago.[5,6] With foundational models advancing rapidly, cost curves declining, and infrastructure proliferating, AI has reached a tipping point in mainstream enterprise adoption.[5]

In healthcare, for example, AI is already enhancing clinical outcomes and reshaping care delivery. Dr. Eric Topol, Executive Director of Scripps Research, notes that AI is reducing diagnostic errors, improving risk screening, and strengthening doctor-patient interactions.[7] His research highlights that AI-driven "digital eyes" have demonstrated superior diagnostic accuracy in detecting lung, breast, and colon cancers—conditions that contribute to the estimated 800,000 Americans who are seriously harmed or die each year due to misdiagnosis, according to Johns Hopkins.[7,8]

To better understand the magnitude of these shifts and the investment landscape ahead, this white paper explores both the revenue and cost reduction opportunities enabled by AI. We examine how advances in parallel processing and quantum computing are expanding computational frontiers and powering a new wave of innovation. We analyze how AI is actively reshaping traditional sectors, such as healthcare, industrials, and financial services, while accelerating the emergence of entirely new categories, including Digital asset infrastructure, Intelligent energy systems, Embodied AI, and the Next Gen Space Economy. On the cost side, AI-driven automation is redefining productivity, compressing decision cycles, and lowering operating expenses on a broad scale. These are not merely enhancements; they represent a foundational shift in how value is created, measured, and captured.

As shown in Figure 1, AI is projected to continue to grow at a rapid rate, boosting the associated opportunities we believe come along with it.

Technology Market Share by Sector

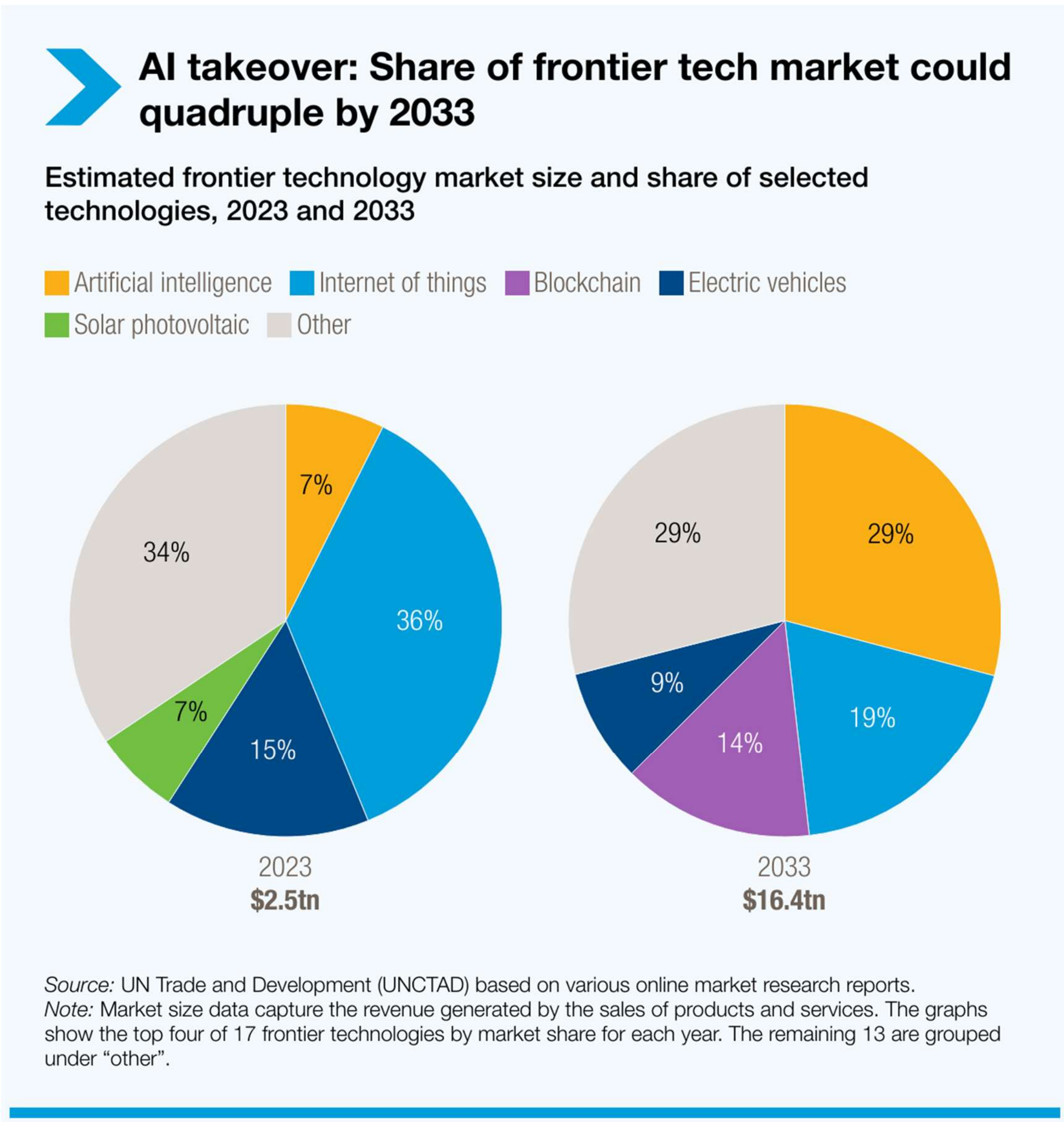


Figure 1. Technology Market Share by Sector (UNCTAD)

At Science & Technology Partners, we believe that understanding these developments is essential for identifying the next wave of long-term value creation. Our objective is to systematically map where these opportunities are emerging, the technologies propelling them, and the companies and sectors best positioned to lead in this new era of intelligent innovation.

2 Revenue Opportunities

Parallel Processing's Application in Artificial Intelligence Capabilities

Underpinning AI advancements, in our view, is the continued impact of a tectonic shift in computing. This shift is the transition from serial computing to parallel and/or accelerated computing. Serial computing dominated the PC and server markets for decades, whereby the central processing unit (CPU) would take on and process each instruction one at a time. Serial processing made advancements by expediting CPU processing time for each sequential problem and increasing the number of bits in each instruction set. However, serial processing is limited by its very nature of handling one problem at a time.

Parallel computing changed the landscape by splitting up tasks, which can be completed simultaneously by multiple processors working in tandem. Parallel processing is like having a team of chefs, each preparing a different part of the final meal, rather than having one chef cook each dish one after the other. It is faster and more efficient. Accelerated computing is a derivative of parallel computing where instruction sets that are especially computationally intensive are handled by a dedicated graphics processing unit (GPU) with thousands of cores. Another key change with parallel processing is a shift from a chip-based approach to a solution-based approach, which considers architecture and utilizes software to optimize performance. This critical role for software to further support computational capabilities will continue to be a major focus. Recognizing this shift is key to understanding why AI gained so much momentum quickly and is a critical step in taking a longer-term view of what may be possible in the future. When we ask the question of what may come next in computing advancements, we see further evolution into this new standard.

In recent quarters, hyperscalers have increasingly shifted toward custom application-specific integrated circuits (ASICs/XPUs[1]) for AI acceleration. Broadcom's management, speaking on a recent Mizuho Group call, highlighted that ASICs offer cloud service providers meaningful cost advantages over GPUs, driving expected adoption of AI accelerators from roughly 40% today to 50% in 2026 and 60% in 2027. Because ASICs are designed for specific workloads, they deliver optimized performance and power efficiency,

[1] An xPU is an auxiliary processing unit that runs inside a data center server or appliance. The term "xPU" can refer to a Data Processing Unit (DPU), Infrastructure Processing Unit (IPU), Function Accelerator Card (FAC), Network Attached Processing Unit (NAPU), or other processing units that offload and accelerate specialized tasks more efficiently than a general-purpose CPU.

with the flexibility to fine-tune frameworks or models. We believe this market has substantial growth potential in the coming years.

In addition, not only do we see the ability to "scale" many more processors and/or cores into accelerated computing, whether GPU or ASIC, whether out or up (with more cores or coordinating servers to work in parallel), but we see a possible new addition. We think this next step will be quantum. Unlike traditional computing that processes "bits," either in a serial manner or divided into groups, with parallel computing, quantum computing uses quantum bits, otherwise known as "qubits". This is unique in that quantum can explore many practical solutions simultaneously, which makes it particularly useful for things like understanding the natural world on a molecular level. Just as parallel computing works with serial computing in many cases, we see a path forward in which quantum computing uses a hybrid scenario with parallel computing to unleash extraordinary advances. Given the early examples demonstrating the utility and feasibility of quantum computing, we can anticipate decades of improvements that will further support advances in AI.

As seen in Figure 2, quantum computing is projected to accelerate growth and expand its consumer base as it becomes more widespread and accessible.

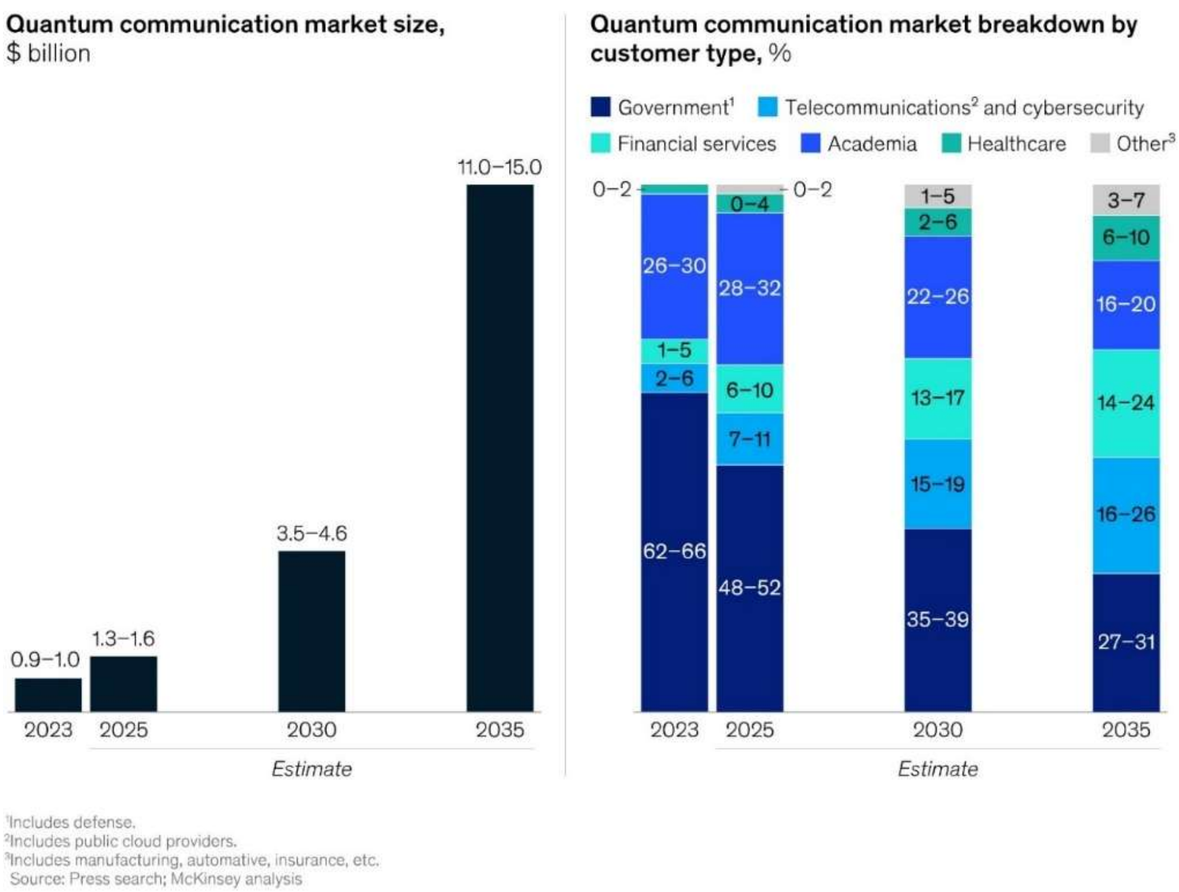


Figure 2. Quantum Communication Market Size and Breakdown by Consumer Type (McKinsey & Company)

Thus, AI advances to date have been possible with a combination of parallel and accelerated computing. The continued improvements in this new paradigm, along with the future addition of quantum, will accelerate capabilities at a pace that is quite underappreciated. This new way of computing sorts and processes massive amounts of data quickly and efficiently. Parallel computing platforms often "train" AI models, as the process is distributed over multiple cores, reducing training time. Inference is taking lessons learned from the training phase and implementing them into something useful (like text/image generation, providing answers to questions in real time, or allowing for a vehicle to measure and map all the inputs around it for self-driving); this must be done in parallel to reduce latency. In our view, this is the future, explosive growth in training and a multiplying effect in inference to make effective use of those lessons learned. Ultimately, quantum will offer a step change in multi-dimensional calculations, which we expect will produce substantial advances in several sectors, including material science and drug discovery.

Computing: Implications for Semiconductors

As for the competitive landscape, we see a long runway for growth for GPUs and ASICs to dominate in parallel processing. We would not be surprised to see increased M&A activity among smaller players in quantum computing as these systems are adapted for specific workloads, especially in the material science and drug discovery sectors. Quantum examines cause and effect on a molecular level and the potential impacts of drugs on exceptionally large sets of variables. Quantum is also critical for energy storage advances. For example, IBM uses quantum simulation to design sustainable electrolytes without heavy metals like cobalt. Additionally, Sandbox AQ is exploring the optimization of lithium-ion battery lifecycles using simulation techniques. Furthermore, we predict a tremendous amount of growth for networking processors to direct traffic in this ecosystem. We see increasing demand for photonics not only to analyze and represent the real world but also as a critical component for networking speeds. Memory, too, will be important. As we gather more data to improve the training processes, there will be tremendous demand for analog semiconductors to measure the real world. However, these processors are increasingly being commoditized due to Chinese innovation that enables them to overcome export control restrictions and reduce supply chain risk. As you can see from Figure 3, semiconductor sales as a percentage of global GDP have steadily grown across the previous computing waves.

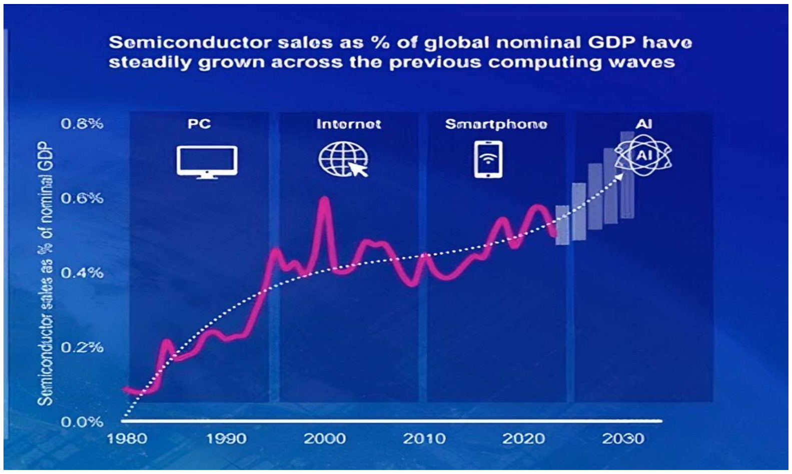


Figure 3. Semiconductor Sales as % of Global Nominal GDP Have Steadily Grown Across the Previous Computing Waves (ASML)

AI's Reshaping of Industries

We've moved well past the exploratory stage of AI. A recent National Research Group study, *The ROI of Gen AI* (commissioned by Google Cloud), shows that while roughly one-third of organizations are still evaluating or piloting generative AI, many others are already deploying it at scale with hundreds of use cases delivering measurable business results.[9]

What sets the leaders apart is not simply adopting new technology but identifying the specific applications that unlock the greatest value in their industries. Figure 4 highlights some examples of industries with high potential for AI impacts.

Industries That Could Be Affected by AI

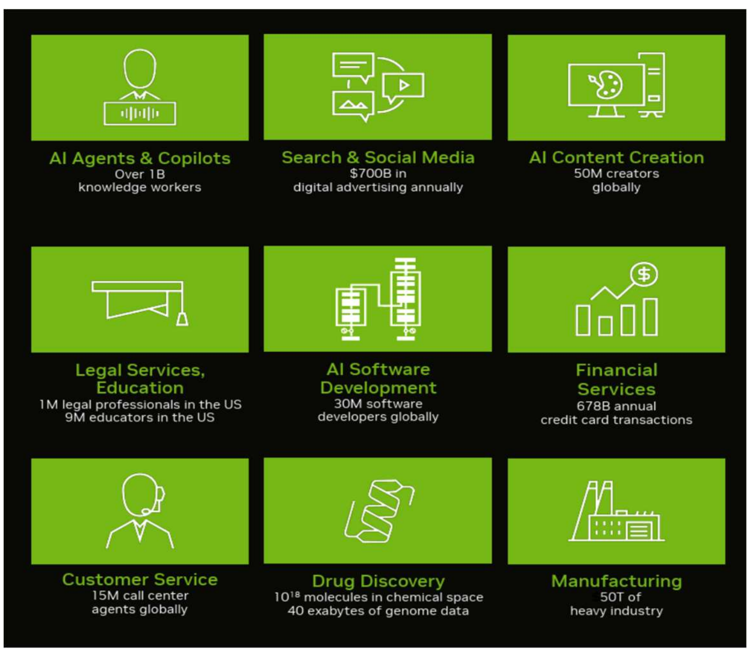


Figure 4. Industries That Could be Affected by AI (NVIDIA)

AI will span and evolve every industry, transforming the way it works. Some examples of AI usage within different industries include:

1. Retail giants like Amazon and Walmart use AI to forecast demand, automate restocking, and optimize last-mile logistics. Computer vision in cashier-less checkout stores, i.e., Amazon Go, and AI-powered customer service chatbots are reshaping consumer experiences and expectations.
2. DeepMind's AlphaFold and Insilico Medicine's AI-driven discovery systems are compressing the time to identify viable compounds from years to months, reshaping clinical research and lowering development costs.
3. Starbucks is deploying an AI-driven inventory counting system across 11,000 company-owned locations in North America by the end of September 2025. Inventory can be counted 8x more frequently, improving shelf availability and reducing time spent in stockrooms.
4. Mastercard employs generative AI chatbots for customer support, personalized recommendations, and fraud detection using predictive modeling.
5. BMW has rolled out over 600 AI-based use cases, from enterprise data insights to predictive maintenance alerts via onboard models and sales chatbot assistance.
6. Wayfair introduced Decorify, which lets customers upload a photo of their room to see furniture items overlaid virtually in their space, improving product visualization.
7. Shopify offers generative AI tools for merchants, generating product descriptions, marketing content, emails, and personalized recommendations.
8. Bank of America is citing "Erica," its homegrown AI chatbot, to process millions of customer queries and drive satisfaction. In August 2025, the company announced that its AI virtual assistant had surpassed 3 billion client interactions since its launch in 2018.
9. JPMorgan's COiN (Contract Intelligence) uses natural language processing to review and extract key data from legal documents. It has saved the legal team over 360,000 work hours annually and significantly reduced compliance-related errors.
10. Salesforce spoke about global edtech companies using AI to automate lead scoring, prioritize follow-up, and personalize customer interactions. The Edtech company saw a 30% increase in lead conversion rates by focusing sales efforts on high-potential leads identified by AI.
11. Netflix uses AI to personalize recommendations (driving over 80% of viewing), adapt thumbnails to user preferences, and optimize streaming quality to minimize buffering. It also applies AI to identify and scale regional hits—such as *Money Heist*, which became a global phenomenon after algorithms detected strong engagement in Spain and Latin America.

12. Siemens powers AI transformation through platforms like Siemens Xcelerator and the Industrial Copilot, an AI assistant to support automation and engineering workflows.

Stanford University's analysis produced sector-specific AI Impact Scores, illustrating that artificial intelligence permeates every industry. The top 5 sectors poised for the most significant transformation are Healthcare, Transportation, Manufacturing, Retail, and the Supply Chain, as illustrated in Figure 5.

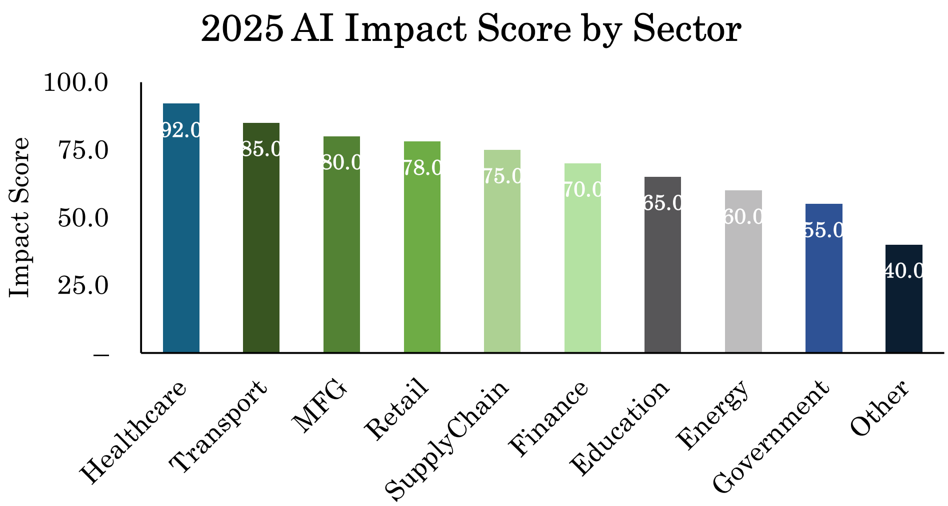


Figure 5. 2025 AI Impact Score by Sector (Stanford University HAI)

Figure 6 highlights where AI disruption and readiness intersect, showing the potential of revenue growth in industries best positioned to adopt AI.

Productivity Growth Rate of Industries by AI Exposure Level

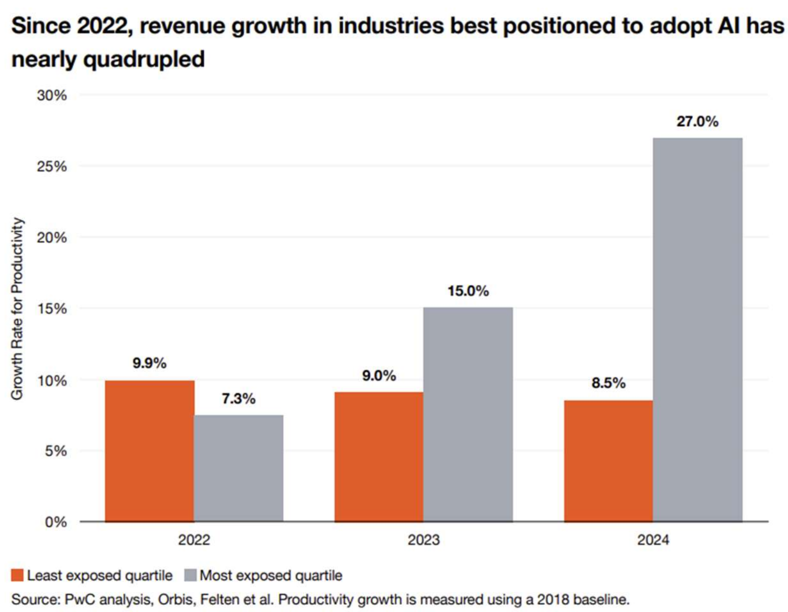


Figure 6. Productivity Growth Rate of Industries by AI Exposure Level (PwC analysis, Orbis, Felten)

AI in Healthcare

Improvements in Diagnostics

With increased use of technology in healthcare, areas that rely on efficient data analysis and highly accurate diagnoses are poised for disruption. Technological evolutions in Minimal Residual Disease (MRD) detection, genomics, and imaging – spurred by AI – expand access to transformative healthcare while simultaneously personalizing the technologies to improve outcomes. In genomics, for instance, AI helps interpret complex sequencing data to identify disease-causing mutations and match patients to targeted therapies. It also makes analysis far more efficient for researchers. These advances have lowered the cost of sequencing a human genome from $100 million to less than $1000 in the last two decades, as illustrated in Figure 7.

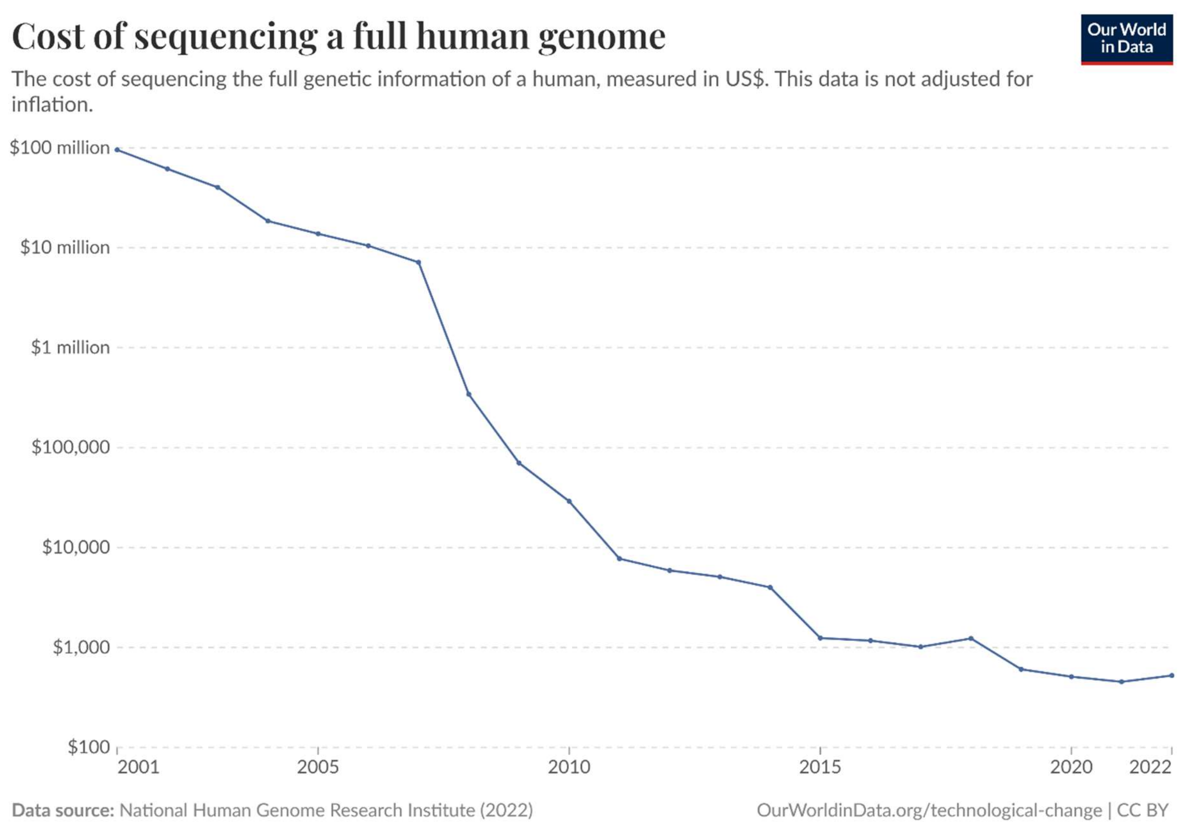


Figure 7. Cost of Sequencing a Full Human Genome (National Human Genome Research Institute via Our World in Data)

MRD detection is a unique space in molecular diagnostics that leverages the advancements in genomics, incorporating its own innovations. AI enhances the analysis of sensitive assays, such as next-generation sequencing, allowing for the detection of a single cancer cell among one million normal cells (1 ppm) through a simple blood draw. As illustrated in Figure 8, WGS (whole genome sequencing) is a comprehensive genetic test that analyzes your entire DNA to identify known and potential disease-causing variants and can now detect a single cancer cell among one million normal cells (1 ppm), which is a significant improvement in detection sensitivity. Highly sensitive detection of circulating tumor DNA (ctDNA) creates an entirely new way to detect early-stage cancers, predict relapses, and inform treatment decisions, much earlier than traditional screening methods. As genomic and MRD data become more integrated into routine care, AI will enable dynamic, adaptive treatment plans that respond to molecular changes in real time. The dramatic improvements in diagnostics are leading to rapid changes as AI tools continue to improve.

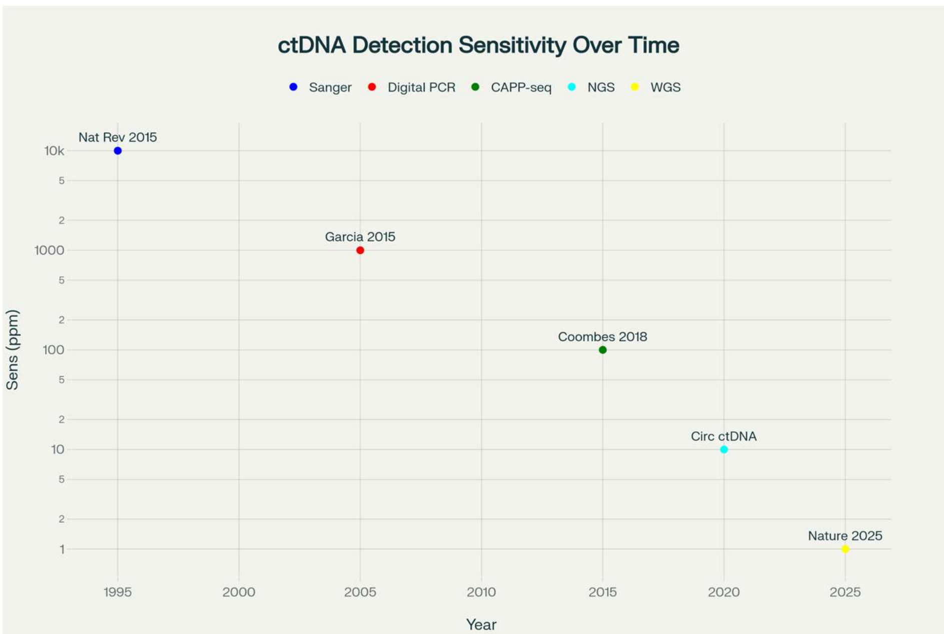


Figure 8. ctDNA Detection Sensitivity Over Time (Generated by Perplexity)[2,3,4,5,6,7]

Acceleration in Clinical Trials

The traditional process of drug discovery is notoriously costly and protracted, with timelines often extending over decades and cumulative expenditures surpassing billions of dollars. A growing body of research has examined how AI can address these inefficiencies by streamlining early-stage discovery and clinical development. Companies are increasingly investing in machine learning platforms to accelerate target identification,

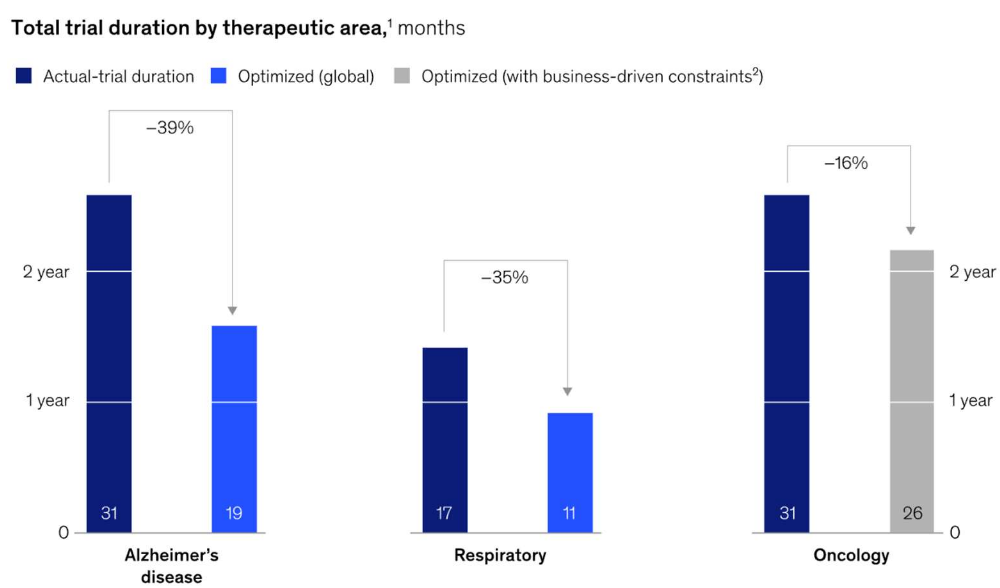
[2] Bettegowda C, Sausen M, et al. "Detection of circulating tumor DNA in early- and late-stage human malignancies." Nat Med. 2014 May; 20(5): 548-54.
[3] García-Murillas I, et al. "Mutation tracking in circulating tumor DNA predicts relapse in early breast cancer." Sci Transl Med. 2015 Mar 25;7(302):302ra133.
[4] Coombes RC, et al. "Personalized detection of circulating tumor DNA." Annals of Oncology. 2018 May; 29(5): 1035-1042.
[5] Abbosh C, et al. "Early stage lung cancer ctDNA detection." Nature Medicine. 2017.
[6] Ultra-sensitive molecular residual disease detection through whole genome sequencing. EMBO Molecular Medicine, 2024.
[7] A comprehensive database for identifying and interpreting ctDNA profiles. Nature Scientific Data, 2025.

predict molecular interactions, and optimize lead compounds. By leveraging large-scale biological and chemical datasets, AI systems can identify promising drug candidates with greater speed and precision than conventional approaches, reducing both the time to market and the probability of late-stage trial failures.[10] Over the next 3-5 years, we see a significant opportunity for AI to improve the efficiency and scope of clinical trials.

Several pharmaceutical and biotechnology firms have already demonstrated the practical value of AI integration. For example, Insilico Medicine reported the design of a novel fibrosis drug candidate in under 18 months for $2.6 million, utilizing deep generative models, which surpasses a process typically taking three to six years and $430 million under standard protocols.[11] In 2022, the partnership between Sanofi and Exscientia illustrated the industry's shift toward AI-driven pipelines.[12] This partnership has continued to advance and hit necessary milestones, further cementing AI's place in clinical trials.[13] These partnerships are not only intended to compress discovery cycles but also to uncover novel therapeutic pathways that might remain invisible under traditional laboratory methods. Collectively, these efforts signal a transformative era in which AI functions as a critical enabler of biomedical innovation, aligning commercial incentives with urgent global health needs.

Figure 9 shows how AI-driven site selection can accelerate enrollment and reduce total trial duration, which will significantly reduce the timeline and cost of the clinical trial process.

Actual Vs. Optimized Trial Durations by Therapeutic Area



1 Average by indication across multiple clients
2 Not using certain countries due to regulatory, cost, or other non-clinical considerations

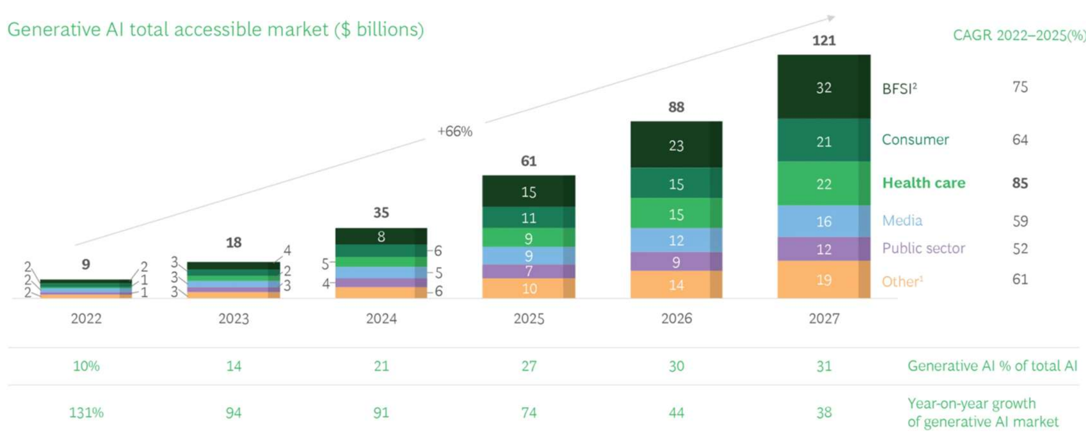
Figure 9. Actual Vs. Optimized Trial Duration by Therapeutic Area (McKinsey & Company)

Medical Devices & Imaging

Generative AI is projected to grow faster in healthcare than in any other sector, according to Boston Consulting Group (BCG).[14] In MedTech, the technology can lead to more efficient processes, personalized customer interactions, greater innovation, and increased value. With the emergence of robotic-assisted surgery, such as Intuitive's da Vinci Surgical System, procedures continue to shift to minimally invasive approaches that reduce recovery times and improve long-term health outcomes. AI enhancements, such as tremor reduction, precision-guided movements, and real-time motion prediction, have significantly transformed the capabilities of surgical robotics, with demonstrated success in delicate, micro-level procedures within fields like ophthalmology and urology. AI-enhanced vision systems help surgeons identify organs, vessels, and tumors with greater accuracy, and can detect early signs of surgical complications.[15] Additionally, surgeon training programs are beginning to use generative AI to develop Augmented Reality (AR) simulations and bolster rare-case learning, giving the next generation of surgeons a more immersive and comprehensive experience than before. AI continues to make major strides in medical imaging as well, where deep learning models consistently detect abnormalities with radiologist-level precision. These models can highlight subtle features that might go unnoticed by the human eye, while quickly dismissing normal scans.[15] Leveraging the vast datasets generated by hospital CT, MRI, X-ray, and ultrasound records, AI has the potential to streamline workflows and enhance diagnostic outcomes across the board.

Figure 10 shows that Generative AI is projected to grow faster in healthcare than in any other industry, with a compound annual growth rate of 85% through 2027.

Generative AI Projected Growth Vs. Other Health Care Sectors



Source: AI TAM research; expert interviews; BCG analysis.

¹Industries in the "Other" category include industrial goods, energy, telecom, and financial services (including retail and wholesale banking, asset and wealth management, insurance, and private equity).

²BFSI = banking, financial services, and insurance.

Figure 10. Generative AI Projected Growth Vs. Other Health Care Sectors (BCG)

Consumerization of Healthcare and the Rise of Self-Health

As life expectancy rises, people are increasingly focused on maintaining both physical and mental well-being. One of the most powerful long-term shifts underway is the "consumerization" and democratization of healthcare. Individuals are taking greater ownership of their health decisions, aided by technologies that make information and monitoring tools more accessible than ever before.

As seen in Figure 11, wearable adoption exemplifies this trend: in 2024, the market size of wearable technology devices increased by 13.8%, reflecting the growing appeal of a "Self-Health" approach. Devices such as smartwatches and continuous glucose monitors (CGMs) now enable users to track their vital signs daily, including blood sugar levels, heart rate, and sleep quality, helping to prevent serious health issues before they arise. The Precedence Research chart below illustrates the expected growth of the global wearable technology market from 2023 to 2034.

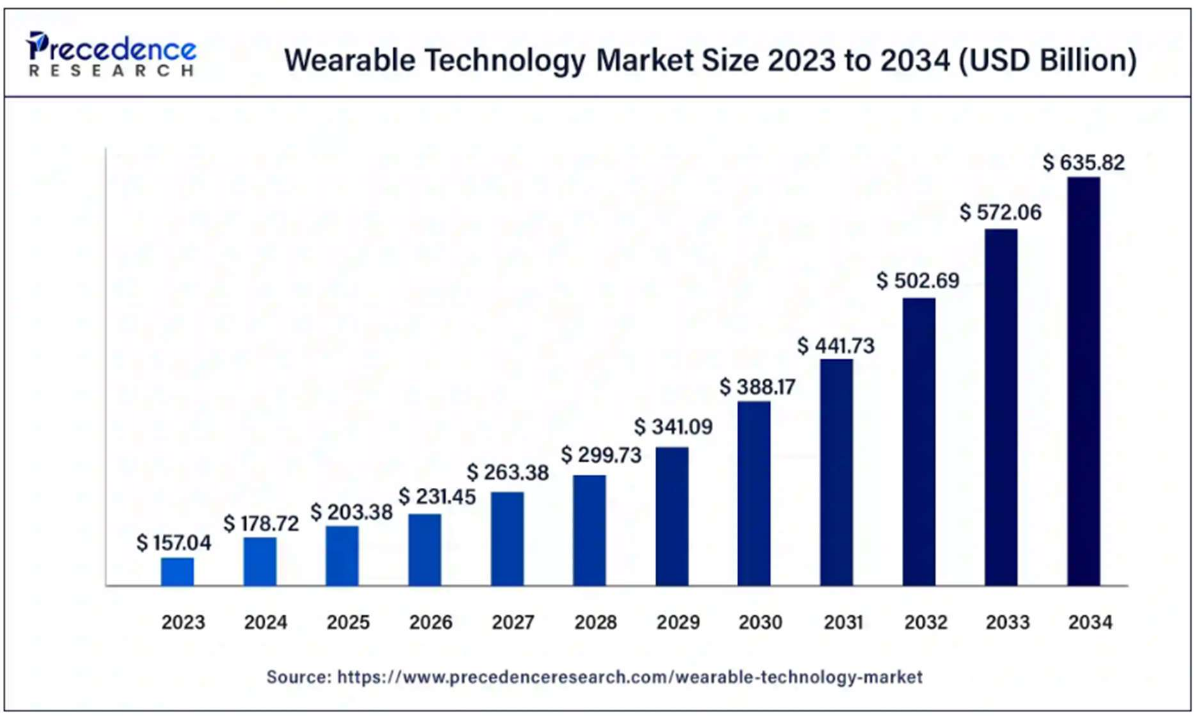


Figure 11. Wearable Technology Market Size 2023 to 2034 (USD Billions) (Precedence Research)

At the same time, digital information access is changing how patients engage with the healthcare system. LLMs are making it easier for individuals to synthesize medical data, explore treatment options, and compare therapies, thereby granting unprecedented access to knowledge that was previously filtered exclusively through professionals. Social platforms are amplifying this trend: according to a LifeStance Health survey, nearly a third (29%) of Americans have self-diagnosed a mental health condition using online information, with the numbers even higher among younger demographics – 50% of Gen Z and 38% of Millennials report doing so.[16] Similarly, a survey by Tebra found that one in four people have used social media for self-diagnosis, including 30% of Gen Z.[17] Platforms like TikTok have become hotspots where teens increasingly self-diagnose conditions such as ADHD, autism, and OCD, often influenced by oversimplified algorithm-driven content.[18]

Community-driven platforms also play a role. Online forums such as Reddit and Quora are commonly used spaces where individuals share symptoms and receive advice from peers rather than medical professionals. These resources empower consumers with greater agency.

Life Expectancy and AI

The United States is entering a pivotal demographic and health shift that will reshape both society and the healthcare system. The baby boomer generation (those born between 1946 and 1964) is moving into retirement and living longer than any generation before it, as shown in Figure 12. By 2030, the U.S. Census Bureau projects that every baby boomer will be over 65, meaning nearly one in five Americans will be of retirement age.[19] This reality presents a twofold challenge: addressing the rising, often complex medical needs of older adults while ensuring the healthcare system is ready to deliver accessible, high-quality care to an expanding senior population.

Artificial intelligence is poised to play a critical role in meeting this challenge. AI-driven technologies can support seniors by powering robotics that monitor vital signs, manage medication schedules, detect early signs of disease, and provide safety checks in the home. Beyond elder care, AI can transform healthcare more broadly by enabling faster drug discovery, tailoring treatment plans to an individual's genetics and medical history, improving diagnostic accuracy, and reducing the administrative burden on providers. Together, these innovations point to a fundamental shift in healthcare, one that not only extends independence and agency for the elderly but also provides all patients with more personalized, efficient, and accessible care. Remote patient monitoring technologies enable individuals, whether managing chronic conditions or seeking to improve their overall health, to track their own health journey. The chart below illustrates the increase in life expectancy of the US population since the 1960s. These new technological tools are expected to drive explosive market growth. The global AI in healthcare sector is estimated to be roughly US $26-29 billion in 2024, with Clevland Clinic citing a projection of up to $188 billion by 2030.[20,21] This momentum will set the stage for a new era in healthcare.

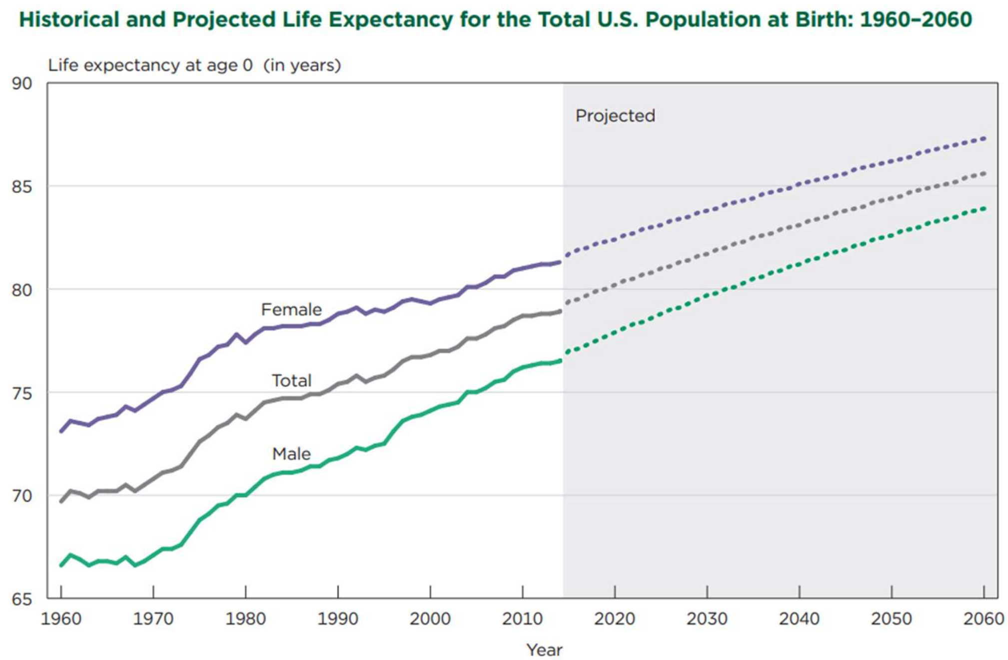


Figure 12. Historical and Projected Life Expectancy for the Total U.S. Population at Birth: 1960-2060 (U.S. Census Bureau, National Center for Health Statistics Life Tables)

Developments in Robotics

The global use and development of robotics will continue to grow as LLMs and chips improve, and geopolitical and societal trends spark demand for robotics. Robotics is an umbrella term encompassing various automated machines, including drones, humanoids, autonomous vehicles, and manufacturing bots. Currently, robots have a narrow set of functions, such as assembly, navigation, or inspection. However, as technology improves, they will be able to perform cross-functionally and complete new tasks with greater efficiency and accuracy, especially in sectors like autonomous vehicles (AVs) and manufacturing robotics. Trends across geopolitics and global trade will also drive demand across various industries. Ukraine's attack on Russia's Borisoglebsk Airfield demonstrated the effectiveness of using cheap drones for military operations instead of billion-dollar bombers. Tariff uncertainty and the increase in onshoring in the US will accelerate the need for robotics in manufacturing.

Humanoids

The robotics sector with the most potential, in our view, is humanoids. We are already seeing a good deal of progress in prototypes, both in the US and abroad. The potential of humanoids arises from their capabilities in both home and manufacturing environments. Despite developers such as Tesla, Ajibot, and UBtech having different applications for their bots, each has ambitions for mass adoption of humanoids. Chinese companies have prioritized the development of humanoids for factory use, implementing them in factories throughout the country. Although this seems like a major head start compared to consumer-focused US companies, these robots are still in the early stages of utility. Tens of thousands of people perform simple tasks such as carrying boxes in Chinese factories. Nevertheless, humanoids struggle to carry boxes with moving parts inside, while they find success carrying boxes with a single, solid item. Improvements will come as LLMs, chips, and simulations develop, and costs come down with scale.

Autonomous vehicles (AV)

Autonomous vehicles are another vital aspect of the robotics sector. Some automobile OEMs are developing their own in-house sensory systems for autonomous driving (GM, Toyota, Volkswagen, Tesla, and others). Others are relying more heavily on third-party manufacturers. While developing and designing their own systems has some potential advantages in compatibility, safety, and redundancy, we believe the majority of OEMs will ultimately turn to third-party designs.

The main types of sensors used for driving at speed are radar, LiDAR, and cameras. Nearly all companies have opted for a combination of all three, as they have different strengths and weaknesses in terms of perception. Tesla is the most notable camera-only user, while Waymo, May Mobility, and Mobileye use all three in concert. Cameras are easier and cheaper to produce, but performance greatly suffers under weather conditions. Glare, heavy rain, and other elements have led to crashes or unexpected stops, with Tesla AVs pulling over and waiting for better conditions. Tesla's biggest advantage with its camera system is that it allows for Full-Self Driving updates without the need to retrofit hardware onto the car. Adding LiDAR and radar gives the vehicle much better perception and the ability to use the best sensor for the given conditions and task, although the cost of producing these sensors is much higher. Rollout of these AVs has already begun. Tesla launched Robotaxis on June 22nd in Austin, and Waymo is looking to expand to be in nine US cities by the end of 2025.

Despite rapid progress, companies face several key hurdles as they invest in AI-driven robotics.

1. Robotics development remains fragmented, with most systems limited to narrow, task-specific functions in specific environments.
2. Hardware tradeoffs, such as the cost and performance gap between LiDAR and camera systems in autonomous vehicles, continue to slow reliable deployment.
3. Humanoid robots hold immense promise but remain years away from large-scale viability due to technical fragility and limited dexterity.

4. Access to rare earth elements and critical minerals is a major bottleneck. These materials are essential for motors, batteries, sensors, and structural components across nearly all robotics applications.
5. Geopolitical tensions and supply chain vulnerabilities further complicate the sourcing of these inputs, posing strategic risks to scalability and innovation.

Developing Sectors in Space

Space today stands where AI stood a decade ago: an untapped frontier with vast, world-altering potential that could redefine corporations and governance. We are interested in zero-gravity biotech research, the deployment of satellites, and their increasing use cases.

According to McKinsey, the space industry is projected to be a $1.8 trillion opportunity by 2035. Space opportunities are expected to grow faster than global nominal GDP, as illustrated in Figure 13.

Projected Growth of the Global Space Economy

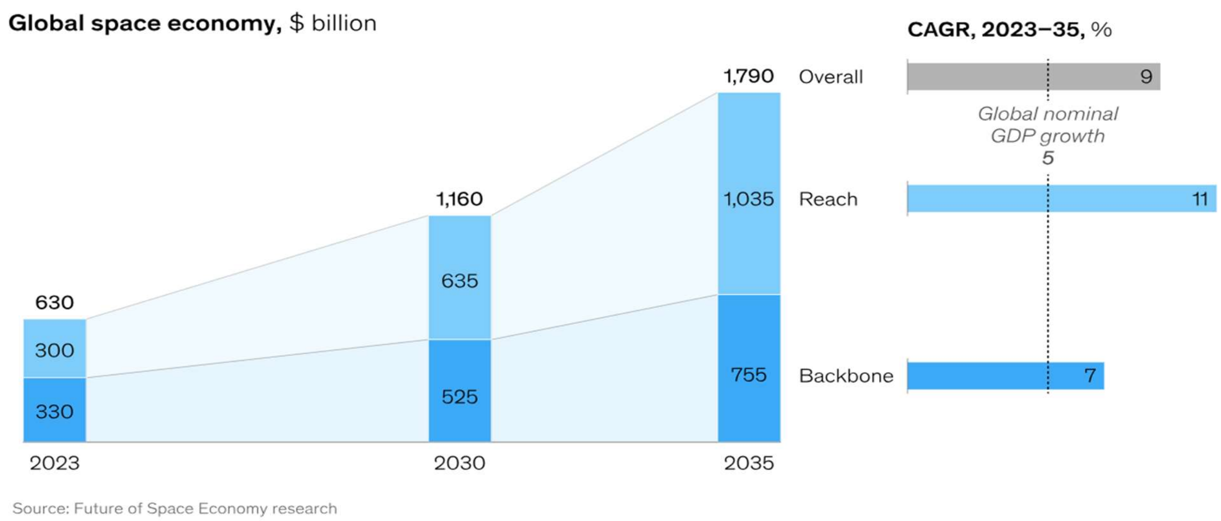


Figure 13. Projected Growth of the Global Space Economy (McKinsey & Company)

On Earth, gravity influences everything from cell growth to fluid dynamics. By removing it, researchers can better isolate fundamental biological processes that influence cell differentiation or mutation. Microgravity also enables the growth of crystals that are difficult or impossible to form under normal gravitational force. While the ability for zero-gravity research has existed for years, typically aboard the International Space Station (ISS) or in parabolic flight and drop tower settings, new companies are accelerating zero-gravity environments for research.

Since the first launch in 1957, the deployment of satellites has been expensive, inaccurate, and clunky. Regardless, satellites have been widely utilized due to their incredible utility. We are now witnessing some of the largest steps in satellite deployment technology since its inception, with increased options, lower costs, and greater overall efficiency. One of the most significant advancements comes by way of accuracy. In the past 10 years, ride-sharing has become standard for launching payloads into space. Companies or governments that wanted to put a satellite into orbit would have to hitch their payload onto a rocket with 60-100 others and be content with wherever they were dropped off. More recently, emerging companies have developed the technology to place a payload in a specific orbit with tight control over altitude, inclination, phase, and even timing. Precision deployment allows satellites to reach their exact target orbit, saving fuel, extending mission life, and enabling time-sensitive or coordinated operations. It is critical for maximizing sensor accuracy, ensuring consistent communications coverage, and avoiding orbital congestion. This is especially valuable for missions that cannot afford the delays, limitations, or imprecision of large rideshare launches.

Satellite deployment has also become far less expensive. Since 2010, the cost of deploying a small satellite via rideshare has become over 20 times less expensive. This dramatic cost reduction is due to the rise of reusable rockets, greater launch competition, a higher tolerance for failure in certain scenarios, and standardized satellite form factors. As a result, space access has expanded beyond governments and large defense contractors to include startups, universities, and commercial enterprises, fueling a surge in orbital innovation. The dramatic increase in orbital launches every year is illustrated in Figure 14 below.

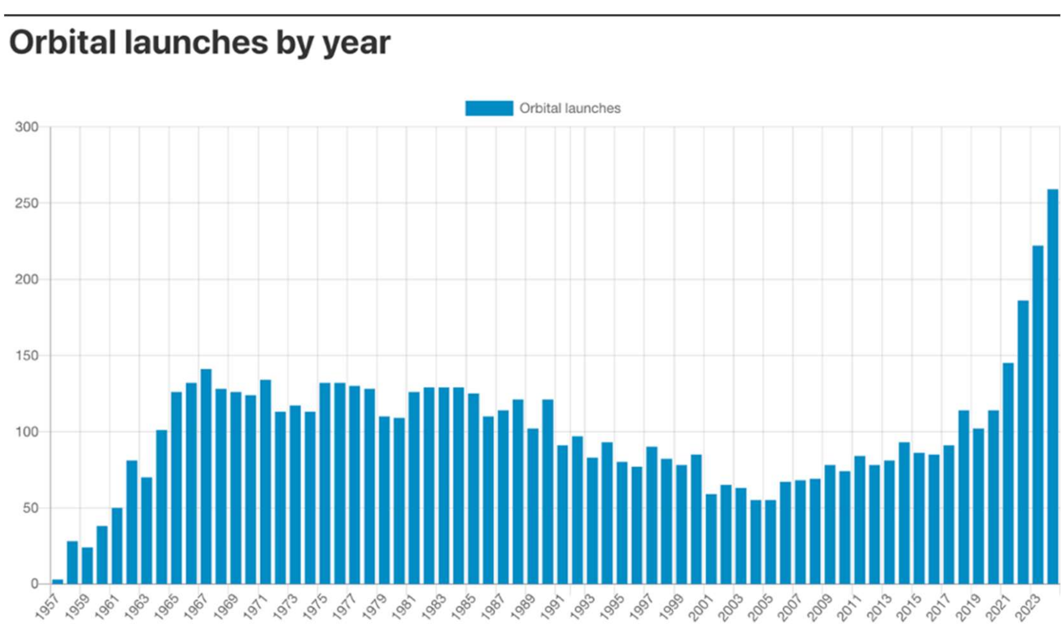


Figure 14. Orbital Launches by Year (Universe Today)

The satellite industry is on the cusp of a high-growth inflection point on the back of new Earth observation and next-gen communication technologies. On the observation side, satellites are quickly becoming critical infrastructure for agriculture, energy, insurance, and other climate risk applications, with the overall geospatial analytics market expected to exceed $170 billion by 2030[22], according to Mordor Intelligence. On the communications side, previous satellite-to-ground networks are shifting to interconnected Internet-of-Things constellations with a focus on low-Earth orbit platforms. Reduced latency and extended coverage will facilitate the rapid expansion of global internet access. Consequently, it establishes the basis for global internet access and functions as the backbone of autonomous transportation and data services.

In addition to the above-stated potential for the development of space, we believe there will be immense capacity for defense applications, including the much-discussed Golden Dome initiative. Nations' use of satellites for communication, infrastructure, connectivity, and warfare makes them prime targets for adversaries. In the burgeoning field of space robotics, militaries are developing capabilities to disable adversaries' satellites in space, creating new needs for direct communications from satellite to satellite and the ability to move satellites quickly to evade threats. Nations will look to enhance the mobility, accessibility, durability, and redundancy of strategic satellites to defend national security interests.

Beyond these essential defense advancements, the emergence of a viable lunar economy is a promising frontier. Recently, Firefly completed a successful mission with its lunar lander, Blue Ghost, for research purposes. Depending on the findings of these research projects, lunar missions could become increasingly attractive for companies for everything from mining to experiments. Uncovering the Moon's resources and their potential benefits to humanity remains a significant task, but the rewards would be undeniable. Defense and lunar exploration are two segments of the emerging satellite and space area that hold considerable promise.

Despite the above opportunities, however, companies must be prepared to navigate a few key hurdles as they invest in this developing sector.

1. High capital requirements, complex international regulations, and long development timelines make it difficult for new entrants to scale.
2. Technical hurdles, such as ensuring satellite reliability, managing orbital congestion, and enabling advanced capabilities like in-orbit servicing, add further complexity.
3. As satellite numbers rise, space debris and collision risks also increase, threatening long-term sustainability.

4. Intense competition, particularly in satellite communications from established players and terrestrial networks, can limit market access and pricing power.
5. Cybersecurity and data sovereignty concerns are growing, especially in defense and Earth observation.

Overcoming these obstacles is critical to unlocking the full potential of the space economy.

Digital Wallet and Cryptocurrency

As the digital revolution continues, payments and banking are moving online, with mobile banking and electronic payment platforms such as Venmo and Cash App being the new standard. As seen in Figure 15, Evercore ISI data indicates a surge in usage of digital wallets and mobile payments, both online and in-store, over the past five years, as cash becomes increasingly obsolete. In this digital world, we observe that a digital currency alternative is not only logical but potentially superior. Cryptocurrencies, particularly stablecoins like USDC, represent a scalable, transparent, and programmable alternative to legacy infrastructure. The SWIFT network, established in the 1970s, still governs most cross-border transfers, imposing significant friction in the form of high fees and multi-day settlement.[23] By contrast, blockchain-based stablecoin transactions can reduce costs significantly, and settlement times from days to minutes. When combined with the increasing adoption of digital wallets, this efficiency edge suggests that the ecosystem is approaching an inflection point.

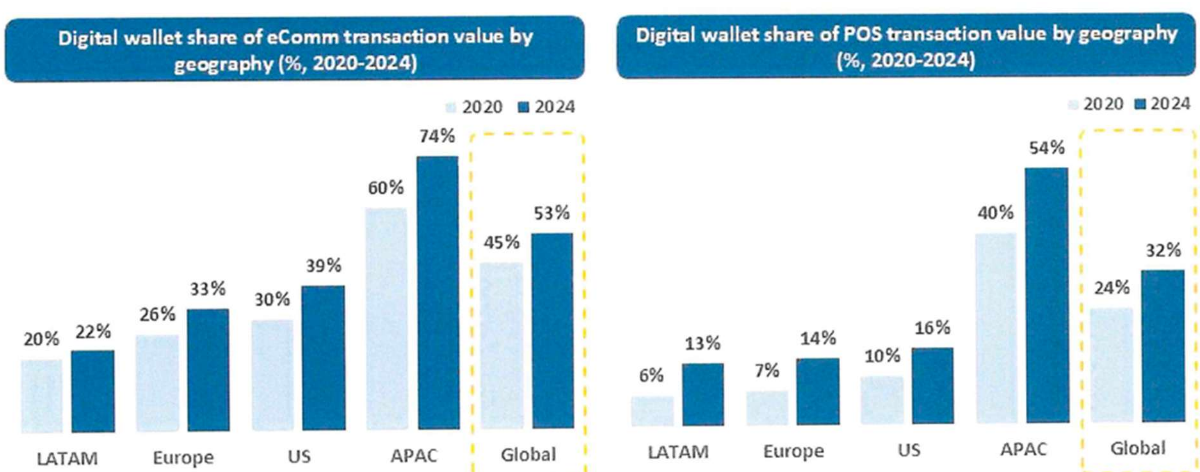


Figure 15. Digital Wallet Share Transaction Value by Geography [eComm and POS] (Worldpay 2025 Global Payments Report, Evercore ISI Analysis)

The recent surge in stablecoin popularity and USDC transaction volume also suggests acceleration towards critical mass. The key advantage of stablecoins, particularly fully reserved and regulatory-compliant instruments like USDC, is their accessibility without volatility. USDC is a fully reserved stablecoin designed to maintain price equivalence to the

US dollar. Unlike earlier iterations of crypto, stablecoins serve as digitally native currencies without the price instability of assets like Bitcoin. This enables real-world utility for consumers and institutions alike.

Historically, limited blockchain adoption has stunted the upside of cryptocurrencies, rendering many decentralized services inert. This is beginning to change. The growing traction of USDC offers a potential "bridge asset" for the average consumer, bringing with it lower transaction costs, seamless cross-border capabilities, and enhanced security. Widespread adoption of stablecoins may unlock broader usage of blockchain infrastructure, with potential parallels to past technological adoption cycles. Take Google before the internet was widely adopted; it was useless at the time, when nobody understood the internet, as it just served to make an unused tool better. However, once the Internet was widely adopted, the demand for an improved search tool suddenly exploded. We view current stablecoin adoption as analogous to pre-Google internet: useful with high growth potential but underrealized.

Tokenization of private companies provides another example of previously dormant blockchain tools gaining traction. While capability has existed for years, mainstream platforms like Robinhood are just now beginning to offer these investment opportunities, catalyzed in part by Circle's IPO and USDC's rising visibility. What was once a marginal application is becoming established.

That said, usage remains the limiting factor. In the crypto ecosystem today, innovation exists, but demand is thin. Until digital ownership becomes a mass-market need, the infrastructure will remain underutilized. We saw this with NFTs, as their market failure was not due to technological shortcomings but to a misalignment between consumer behavior and the service provided.

We believe stablecoins, particularly USDC, represent the most accessible on-ramp into broad blockchain adoption. As adoption accelerates, the larger blockchain ecosystem can finally begin to realize its potential. However, overall, what concerns us is that this market can be commoditized more quickly if there is enough capital to commit. While regulation has provided an opening for first movers, we believe fast followers, particularly those with large brand name recognition and capital, should be monitored carefully for competitive share dynamics over the next three to five years.

"The Toll Takers"

As we investigate opportunities to drive content through AI, we believe that content will become more personalized, stickier, and able to refresh at a much faster rate. A clear example of this dynamic can be seen in the gaming industry, where creators have released three times as many games year-to-date relative to the entirety of last year. Furthermore, the recent popularity of Roblox's “Grow A Garden” not only demonstrates how platforms can launch an incredibly successful new game in a short period but also encourages developers to utilize more AI tools to produce and refine their own projects, thereby creating a large supply of fresh content. We like that dynamic and are interested in platforms that take a “toll” from content usage. Many of these “toll takers” also produce content, which should benefit from significant revenue growth as user preferences are integrated with improving precision, as shown in Figure 16. From a profitability perspective, Research and Development (R&D) and Selling General and Administrative (SG&A) expenses can also be reduced using AI. Moreover, these toll takers have a unique vantage point to observe user behavior and help content creators with adjacent revenue opportunities, whether it be live events, ad dollars, merchandise, or providing real-time feedback on what is working best with audiences.

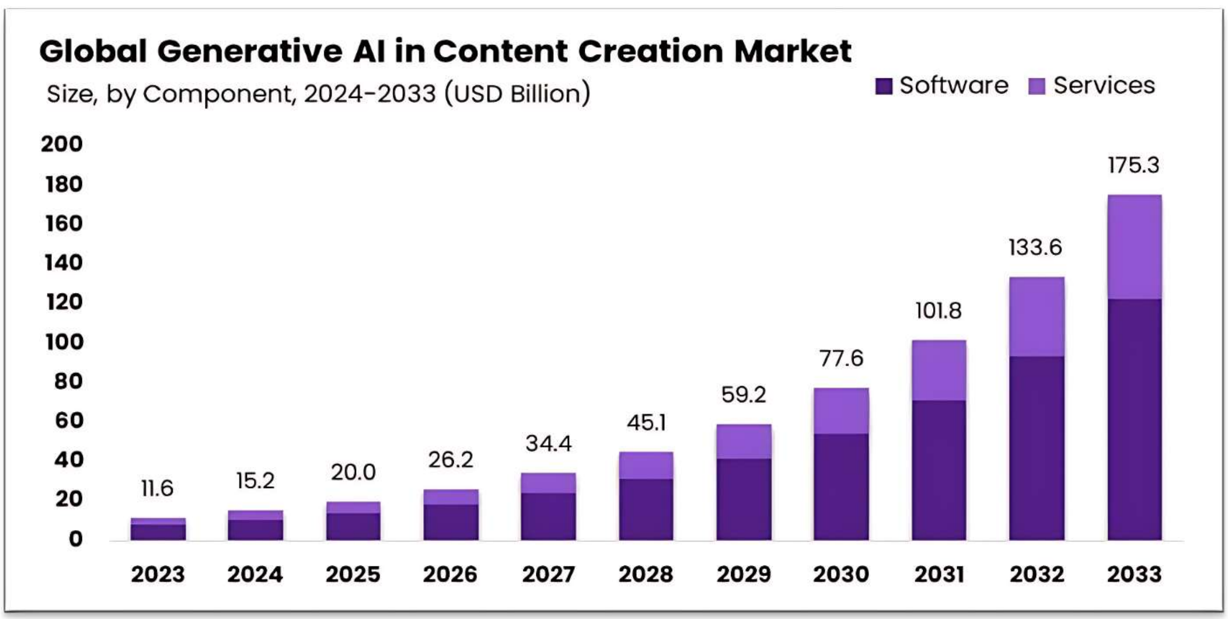


Figure 16. Global Generative AI in Content Creation Market (Market.us)

Underpinning our focus on toll-takers, we note the continued shift of media consumption away from traditional avenues towards platforms incorporating a broader offering. For example, data shows that younger generations continue to gravitate towards streaming platforms, such as Netflix, rather than cable television, which allows for a wider range of content from a multitude of publishers on an on-demand basis. Furthermore, Roblox has also highlighted this focus on breadth versus specificity, with the platform continuing to break records on concurrent users across its thousands of experiences. We view the opportunity of owning these platforms as incredibly attractive, as this shift continues and the market share of traditional media sources continues to deteriorate.

In Figure 17, we identify names within the broader internet landscape that we believe fit the qualities of being a toll taker, benefiting from this platform economy. Each of these names has proven its capabilities in facilitating reliable access to its respective product offering while generating strong top-line returns and sizable FCF per monthly active user.

The Toll Taker Economy

	Equity Value ($mm)	Monthly Active Users (mm)	Equity Value / User ($mm)	FCF ($mm)		'28 FCF / User ($mm)	Equity Value / '28 FCF	3yr. Revenue CAGR
Company				**2025E**	**2028E**			**2028E**
Coinbase Global Inc. (NYSE: COIN)	81,523	9	9,058	2,500	3,300	366.7	24.7x	14.2%
Robinhood Markets Inc. (NYSE: HOOD)	89,836	13	6,910	1,400	2,275	175.0	39.5x	9.9%
Netflix Inc. (NYSE: NFLX)	515,470	310	1,663	10,000	16,500	53.2	31.2x	12.3%
Uber Technologies Inc. (NYSE: UBER)	193,861	180	1,077	9,000	14,700	81.7	13.2x	16.6%
Roblox Corp. (NYSE: RBLX)	88,514	390	227	1,000	3,500	9.0	25.3x	17.8%
Spotify Technology (NYSE: SPOT)	142,769	696[1]	205	2,800	5,200	7.5	27.5x	14.4%
Duolingo Inc. (NYSE: DUOL)	13,247	128[2]	103	350	650	5.1	20.4x	18.8%
Tencent Music Entertainment (NYSE: TME)	38,002	553[3]	69	1,400	2,000	3.6	19.0x	11.8%

1: Paying users are approximately 40% of the total user base.
2: Paying users are approximately 9% of the total user base.
3: Paying users are approximately 22% of the total user base.

Figure 17. The Toll Taker Economy (S&T)

3 Cost-Cutting Opportunities

AI's Underappreciated Impact on Operating Expenses

While investors focus on AI-driven revenue, AI's ability to expand operating margins is underappreciated. This is in part due to a positive correlation between operating margins and multiples.

For sales, AI is an indispensable tool in our view. We see positive effects throughout the entire sales and marketing process, such as:

1. Lead generation and prospecting: Companies can use big data to determine which leads may have the most promise and then automate strategies for those target customers/potential leads.
2. Personalized customer engagement: Increasingly, we see companies generating highly tailored sales emails and follow-ups. Past buyer behaviors are incorporated to let the customer know the email is specific to them and to include offers and content tailored to appeal to them.
3. Sales call analysis: Sales calls are analyzed in real time to detect customer sentiment and position the caller to improve their pitch and drive conversion.
4. Pipeline management/forecasting: AI sales forecasting is used to look at pipeline data and predict what will sell and what will not, which helps managers reduce risks and focus efforts on the highest probability sales conversions.
5. Digitized deal closing: AI streamlines the closing process by automating contract generation, identifying legal or pricing bottlenecks, and coordinating final steps across stakeholders. This not only accelerates revenue recognition but also reduces the power and friction traditionally involved in closing complex deals.

For marketing, we see AI as a very cost-effective tool for generating content, automating emails, assisting with social media, generating video and interactive content, and tracking performance. We have also seen meaningful improvements in the ease of use for marketing with AI, which in turn increases adoption and reduces churn. With these applications, AI is quickly becoming an essential marketing tool to drive higher sales.

We believe that all industries are eligible for reductions in both R&D and SG&A to drive operating margins. Below is an example of trends in spending on software and entertainment/travel.

In R&D, we see AI as particularly useful for weeding out unviable products, enhancing overall development, and bringing newer, better products to market faster. Furthermore, coding assistants are effective in improving software development and the efficiency of these systems. In recent years, we have seen a decrease in the average annual spend on R&D; however, as Figures 18 and 19 show, there is still room for consistent and further cost savings.

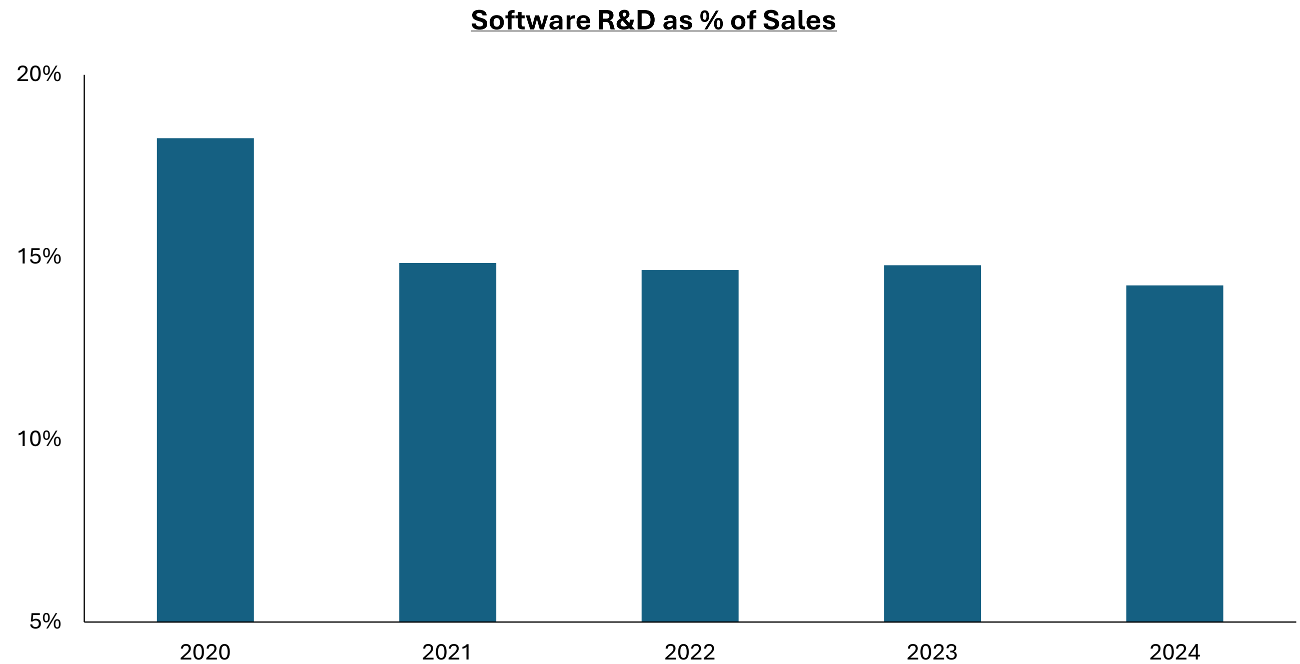


Figure 18. Software sector includes MSFT, AAPL, GOOGL, ORCL, SAP, PLTR, IBM, and CRM (S&T Partners)

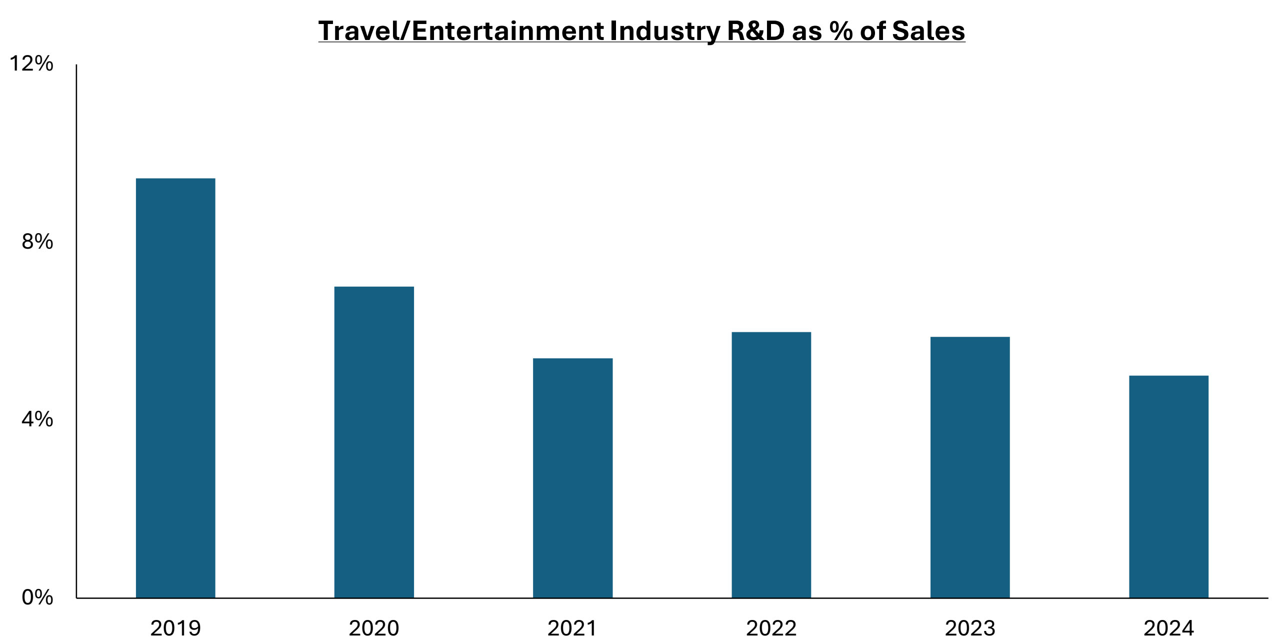


Figure 19. Travel/Entertainment sector includes DIS, UBER, DASH, FOUR, NFLX, SPOT, and HLT (S&T Partners)

We also see room for AI to impact SG&A for things like managing expense reports, overseeing travel bookings, and streamlining legal costs. As Figures 20 and 21 show, there have been significant savings in this area already.

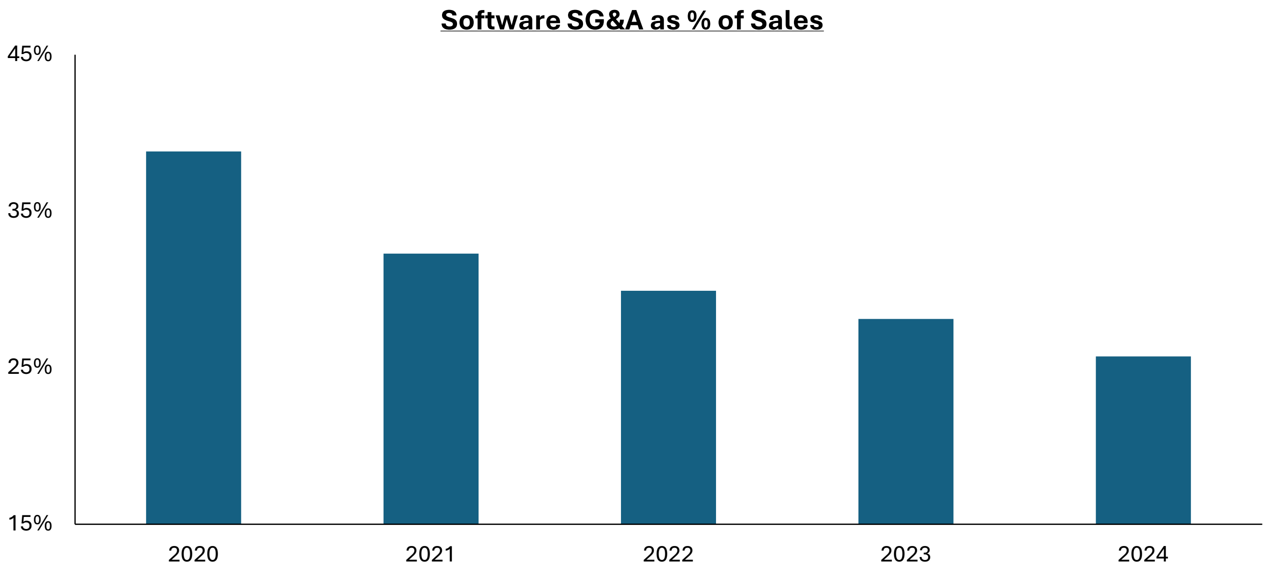


Figure 20. Software sector includes MSFT, AAPL, GOOGL, ORCL, SAP, PLTR, IBM, and CRM (S&T Partners)

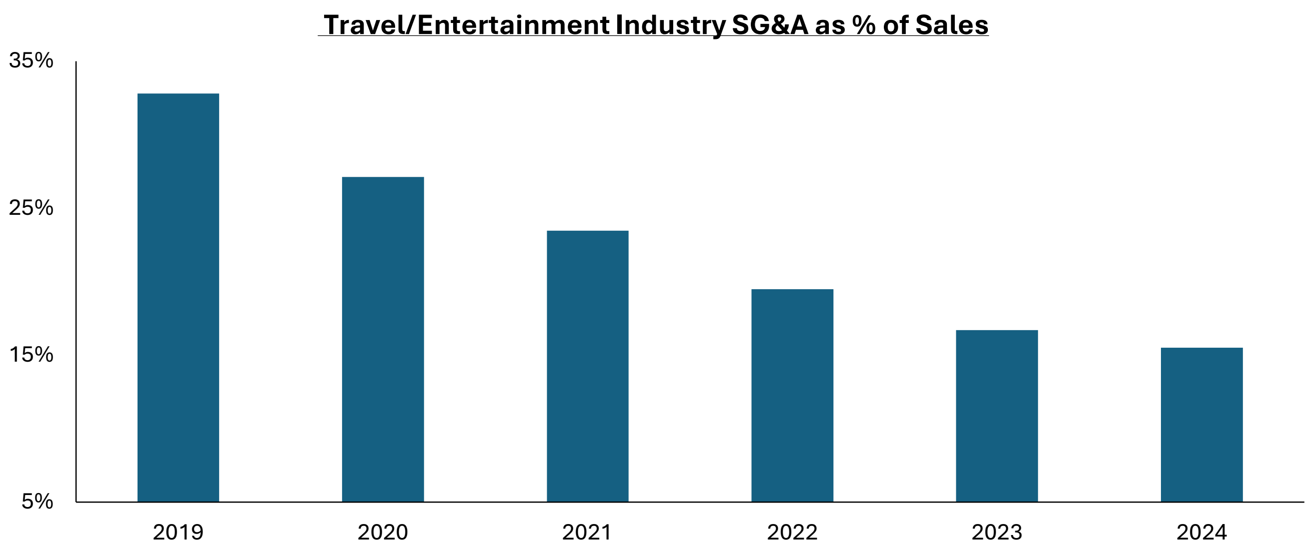


Figure 21. Travel/Entertainment sector includes DIS, UBER, DASH, FOUR, NFLX, SPOT, and HLT (S&T Partners)

If we are correct that AI will drive operating leverage improvements across industries, we think the potential impact of higher margins is still underappreciated and could result not just in earnings outperformance, but also potential multiple re-rating for key AI-enabled winners.

4 Industry Risks

Even with our constructive view, we note risks to our long-term vision. These include:

a. Deglobalization
b. Energy availability and security
c. Rare earth elements and critical minerals
d. Terrorism
e. Higher and longer-lasting inflation
f. Data privacy

However, we also see opportunities associated with each of these risks.

a. Deglobalization

We are witnessing staunch deglobalization because of protectionist political policies, global trade disruption, and potential tariffs. Following Liberation Day's tariff announcements, we have seen global trade disruptions. Companies are reengineering supply chains, freight volumes are declining, and global firms are facing new challenges and costs. Consequently, various countries have adopted protectionist economic policies. In retaliation, Canada, China, the EU, and many other nations have imposed tariffs on the US. BRICS ties have strengthened, and countries are searching for alternatives to the US dollar. The trade disruptions are forcing companies to establish regional supply chains, adding costs and complexity. The most notable example of protectionist economic policies is China's export ban on many rare earth elements (REEs) and critical minerals. This has exposed a brittle and highly monopolistic supply chain. Access to these resources is paramount for Western nations and firms, as their technological competitiveness will remain tethered to China's control of the supply chain. As protectionist policies continue to be implemented, countries will begin to evaluate their advantages in negotiations. This will result in an increasingly fragmented global economy and serve as a risk to growth. The world is transitioning away from the era of globalization's economic integration towards a fragmented trade standard in which tariffs, protectionist policies, and economic advantages are used by nations to exert power and influence.

b. Energy Availability and Security

The U.S. not only needs to upgrade its aging grid, but it will have to add capacity to meet accelerating electricity demand, as shown in Figures 22 and 23. Therefore, with a drive for more energy infrastructure comes the proliferation of alternative energy assets that are renewable and/or scalable, such as hydrogen and nuclear power. Nevertheless, stringent

OE, EPA, and NRC regulations, along with political interventions, both favor and limit the large-scale deployment of these powerful technologies.

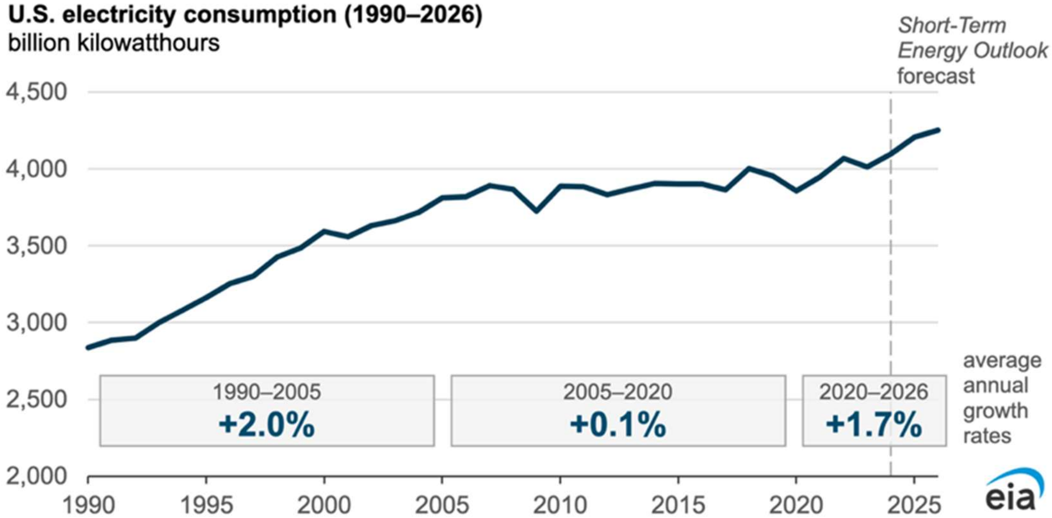


Figure 22. U.S. Electricity Consumption [1990-2026] (EIA Energy)

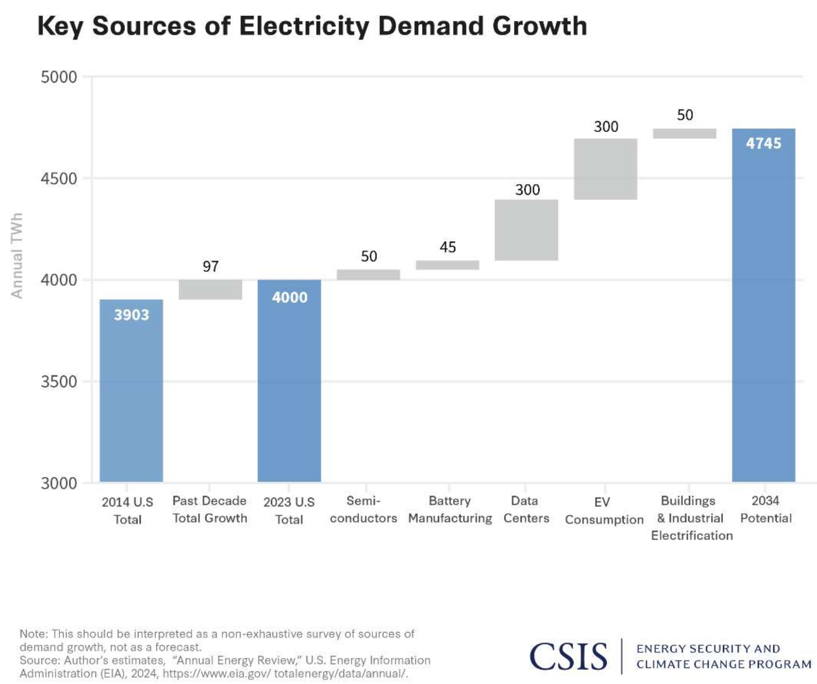
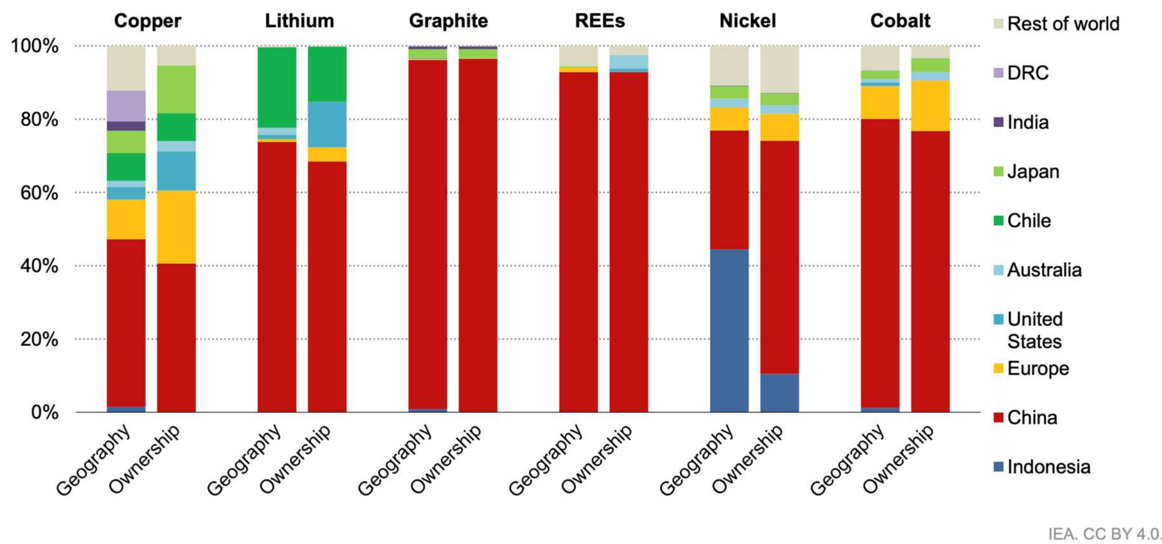


Figure 23. Key Sources of Electricity Demand Growth (CSIS)

c. Rare Earth Elements and Critical Minerals Supply

The global supply of rare earth elements (REEs) and critical minerals is increasingly concentrated and geopolitically fraught, while continuing to be essential to the production of semiconductors, robotics, and batteries. This has exposed a brittle and highly monopolistic supply chain. China refines 90% of REEs, controls 95% of battery-grade graphite, and mines 61% of REEs.[24] This dominance is predicted to continue until 2027 by the International Energy Agency (IAE), as seen in Figure 24.

Refining Concentration by Geography and Ownership, 2024



Notes: DRC = Democratic Republic of the Congo. Ownership based on company headquarters location. For projects run by multiple companies, production is assigned to the company with the largest share. For copper, data are on the top 20 mining companies in 2024 representing 56% of production. For lithium, data cover 100% of production in 2024. For rare earths, data cover 94% of production. For nickel, data cover 91% of production. For cobalt, data cover 94% of production. Rare earths are total rare earths.

Figure 24. Refining Concentration by Geography and Ownership, 2024 (IEA Analysis based on S&P Global and Wood Mackenzie)

The majority of REEs and critical minerals do not reside under American soil in great enough concentration to be mined cost-effectively. While global demand is accelerating, the market remains vulnerable to export restrictions, supply shocks, and conflicts. China's recent export restrictions on antimony, gallium, graphite, tungsten, and germanium, along with seven REEs, mean that over half of the world's critical minerals are under some form of export control. Access to these resources is paramount for Western countries and firms as technological competitiveness will remain tethered to supply chains dominated by rivals.

The availability of rare earth magnets used in semiconductors, electric vehicles, and missiles (among other applications) has become a significant concern for the US-based industry. Recently, Ford was forced to pause a production line for the Ford Explorer for a week due to a shortage of rare earth magnets, highlighting the risk to the American industry. These same magnets are also critical components of missile systems, meaning the US has been dependent on imports from China for strategic defense assets. At least two US-based companies, MP Materials and US Rare Earths, are developing manufacturing capacity in the US to lessen our dependence on Chinese magnets, but won't begin producing finished magnets until the end of 2025 and sometime in 2026, respectively. A recent investment in MP Materials by the Department of Defense will ensure continuity of supply for the US defense industry. As seen in Figure 25, there has been a slight improvement in lessening reliance on China's mining, but there is still a lot of progress yet to be made.

Global Concentrations of Mining and Refining REEs

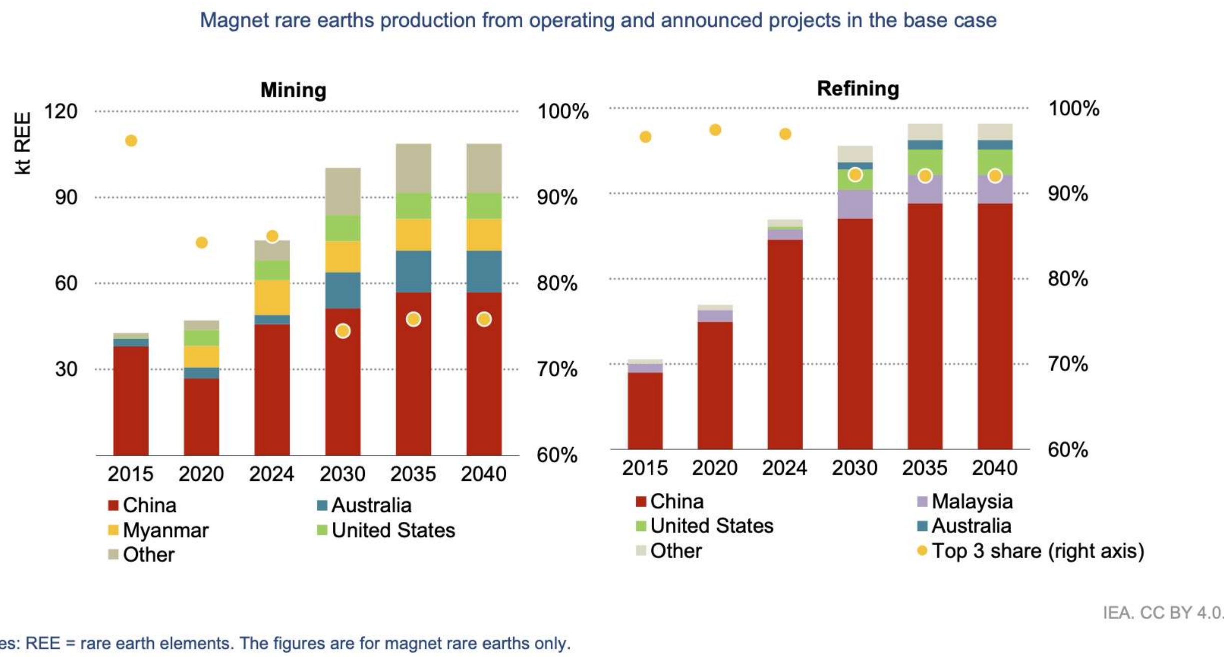


Figure 25. Supply: Geographical Concentration for Mining Sees Slight Improvements, but Refining Remains the Most Concentrated of All Critical Minerals (IEA)

d. Terrorism

AI is a tool that is increasingly being leveraged by bad actors to penetrate the defenses of corporations and governments, holding critical information hostage for ransom. It is noted in The Economist that Anne Neuberger, former deputy national security advisor for cyber and emerging technology in the Biden administration, issued a warning that global cybersecurity costs could get up to $23 trillion in 2027, increasing from $8.4 trillion in 2022.[25] In 2025, we have already seen many high-profile attacks, including X/Twitter, Marks & Spencer, and Blue Shield of California. Cybersecurity is an area of critical importance given how non-negotiable the spend is, and especially now that U.S. regulations mandate companies to disclose if they have been breached by a cyberattack. We think that over time, as AI progresses, bad actors will have increased access to more sophisticated tools to cause damage, providing a durable growth opportunity for leading cybersecurity companies that can provide best-in-class defense capabilities. The shortage of cybersecurity talent necessitates further investment in the best technology.

According to the 2024 IC3 Annual Report, FBI's internet crime complaint center, IC3, has received an average of 836,000 complaints per year. These complaints address a wide array of internet scams affecting individuals around the globe. Over the past 5 years, IC3 has received over 4.2 million complaints and $50.5 billion in reported losses.

Figures 26 and 27 are charts which demonstrate the increasing number of U.S. data breaches and associated losses, supporting the claim that the costs of cybersecurity will continue to increase.

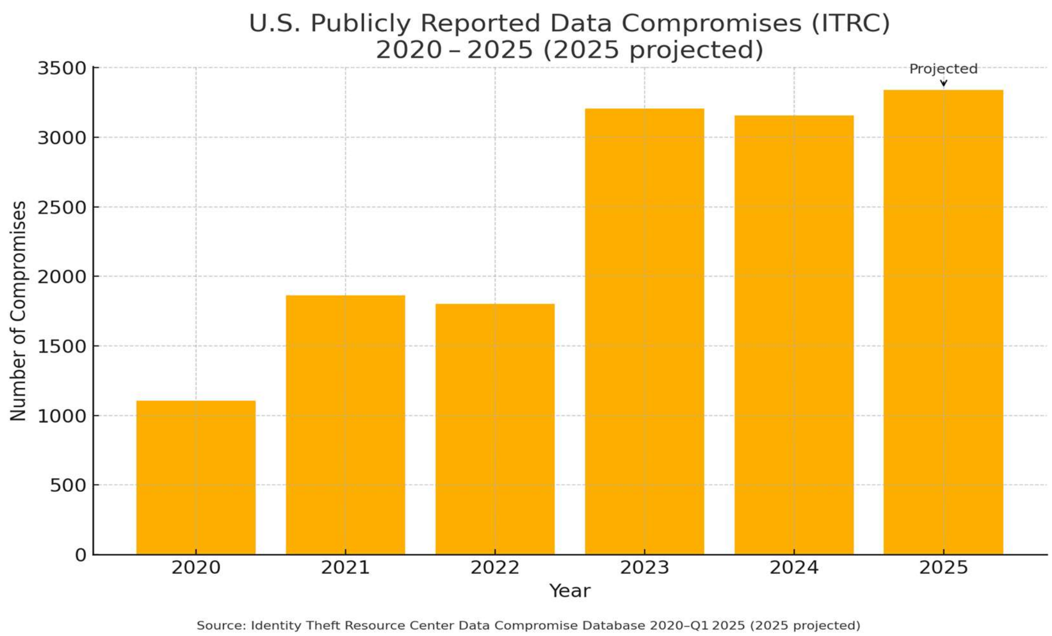


Figure 26. U.S. Publicly Reported Data Compromises [ITRC] (S&T Partners)

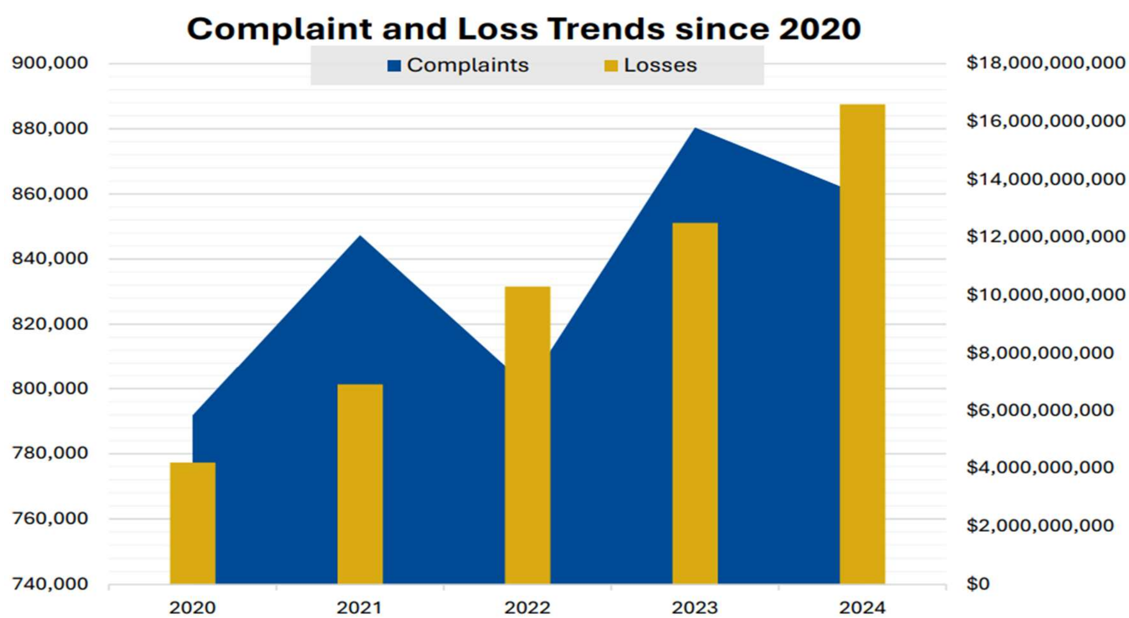


Figure 27. Complaint and Loss Trends Since 2020 (FBI)

Figure 28 shows that the global average cost of a data breach is increasing similarly to the trends in the U.S.

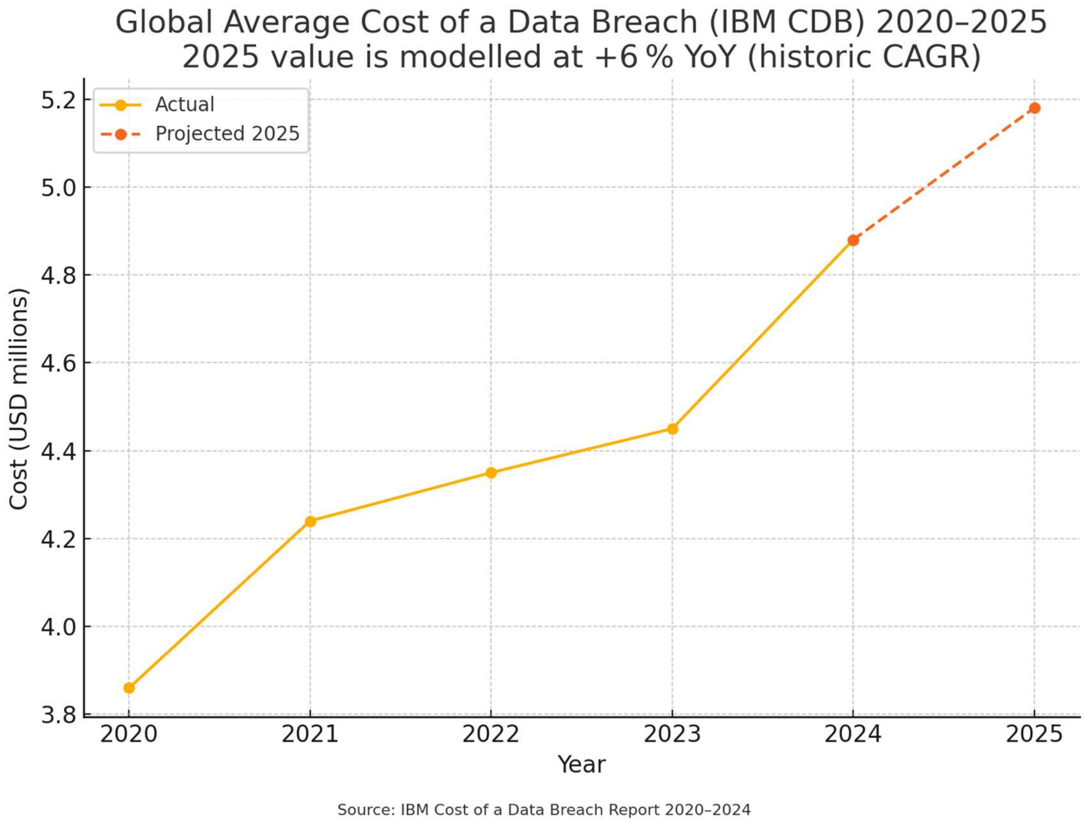


Figure 28. Global Average Cost of a Data Breach [IBM CDB] (S&T Partners)

e. Higher and Longer Lasting Inflation

Ultimately, we believe that technology is an inflation killer. However, if the US dollar continues to decline and the labor pool growth is constrained by an aging population and less immigration, we see risks that inflation may stick around longer. We are especially vigilant on the impact of higher electricity costs and how that is passed through to the prices of many goods, including food, utilities, and technology subscription services. This may result in higher inflation for longer. Figure 29 shows U.S. inflation rates since 2021.

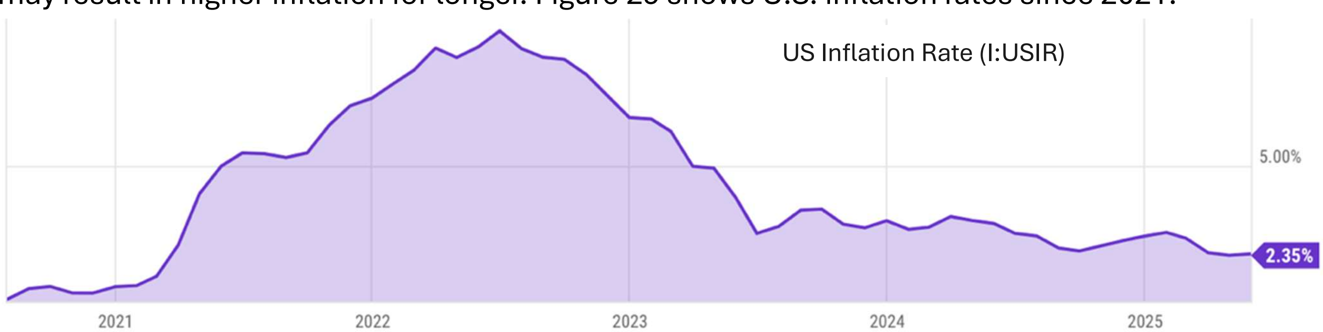


Figure 29. US Inflation Rate [I:USIR] (Y Charts)

f. Data Privacy

Looking ahead, AI is expected to power preventive care, adaptive clinical trials, and even gene-editing strategies, though challenges around data privacy, ethics, and regulation will need to be addressed for widespread adoption. Despite the significant advancements being made in the healthcare industry, we acknowledge and are closely monitoring key hurdles in this sector. The primary three we have identified are privacy, accuracy of social platforms, and difficulty of modeling drugs.

Privacy concerns have always been top-of-mind in the healthcare industry, and the mass adoption of AI has exacerbated these worries. LLMs can analyze massive amounts of data, much faster than is humanly possible, but the data required to train these models is often personal. Many clients do not know that their data is being used, and regulatory gaps make transparency optional. Another issue with LLMs is that they centralize the data they are trained on. While often this is not an issue, when the data is private as with medical records, it creates a significant cybersecurity threat.

5 Our Core Holdings

Our core holdings are concentrated in the companies that we believe are best positioned to capture the most profit share from these crucial market trends: advanced compute, networking, AI "toll taking," cybersecurity, power supply and efficiency, space exploration, advanced defense technologies, vertical software, MRD, genetics, imaging, and healthcare tools. The first few months of the year showed significant volatility, putting many of our core holdings under pressure, but we have seen a solid recovery more recently. More importantly, for these core investments, our long-term thesis remains unchanged, if not stronger than we thought a year ago. Our estimates have been moving up. We are confident that our long-term investments are poised to significantly outperform the market, given our expectation for meaningful earnings outperformance over the duration.

As we look toward the balance of 2025 and the years that follow, our focus sharpens on the companies positioned to define this new era of opportunity. We seek businesses delivering not only powerful top-line growth, but also expanding margins, fortified balance sheets, and leadership teams built to execute. The environment ahead will be fast-moving, disruptive, and unforgiving, yet full of extraordinary possibilities for those ready to lead. Our mission is singular: to identify and invest in these best-in-class winners who we believe will deliver outsized returns.

6 Appendix

REEs and Critical Minerals Required for Chips and Robotics

The largest hindrance to technological advancement is access to REEs and critical minerals. REEs and critical minerals are necessary for many components of the robotics and chip industries. Specific minerals are needed for certain aspects of robotics and their subsystems. Joint actuators, robotic arms, and wheels all require neodymium (Nd). Dysprosium* (Dy) is added to the neodymium magnets to improve heat resistance and durability in robotic motors. Combining praseodymium (Pr) with neodymium increases magnetic strength and stability in motors. Terbium* (Tb) is used in magnet alloys for elevated temperature cases in precision robotic systems. Yttrium* (Y) is used to make sensors, elevated temperature systems, and ceramic parts stronger. Samarium* (Sm) is paired with cobalt to create a material with a strong magnetic field that can withstand intense heat. This is crucial in defense and aerospace robotic systems. Gadolinium* (Gd) is used in robotics for thermal sensing and to protect against neutrons. This is particularly useful for high-radiation and defense applications. Lutetium* (Lu) is part of advanced phosphor systems used in medical imaging robots and high-resolution sensors. Scandium* (Sc) improves aluminum alloys for lightweight, durable robotic frames, namely in aerospace and mobile platforms. Tungsten* (W), a tough metal known for its heat resistance, is used in robotic cutting tools, drilling parts, and heavy-duty mechanical arms. Critical minerals are also necessary. Lithium (Li) powers batteries for mobile, industrial, and consumer robots. It is necessary for lightweight, high-energy power systems. Cobalt (Co) is a key component of lithium-ion batteries, which are used in portable and autonomous robots. Nickel (Ni) makes battery cathodes and structural alloys stronger and thus less likely to erode. Copper (Cu) is essential for powering transmission and signal processing, as it is used in wiring, motors, and sensors. Graphite* (C) oxidizes lithium-ion batteries and lubricates robotic joints. Lightweight structural elements for frames and casings are made of aluminum (Al). Manganese (Mn) is used in battery cathode materials and certain robotic alloys. Microprocessors, semiconductors, and robotic sensors require silicon (Si). Gallium* (Ga), germanium* (Ge), antimony* (Sb), and indium* (In) are used in high-performance sensors, photodetectors, semiconductors, and communication systems within robots.

A growing number of high-efficiency battery technologies use tellurium* (Te) to improve power systems' electrical and thermal conductivity. Bismuth* (Bi) is used in solders and thermal regulation materials across robotic subsystems. Humanoids, industrial robots, drones, autonomous vehicles, and medical robots all rely on the various REEs and critical minerals mentioned above. REEs and critical minerals allow for greater freedom of movement, improved battery life, more accurate sensors, and overall greater precision. Access to these minerals is paramount for any company attempting to develop any form of robot. Beyond robots, REEs and critical minerals are required in many different industries, although the energy sector is leading the growth.

*Denotes a Chinese export restriction.

Dy, Tb, Y, Sm, Gd, Lu, Sc: subject to global export licensing (April 2025).

Ga, Ge, Sb: banned from export to the U.S. (Dec 2024).

W, Te, Bi, Mo, In: require export licenses globally (Feb 2025).

The following figures illustrate various restrictions, uses, and demand for REEs.

Price Movement of Selected Materials Subject to Export Restrictions in Recent Months

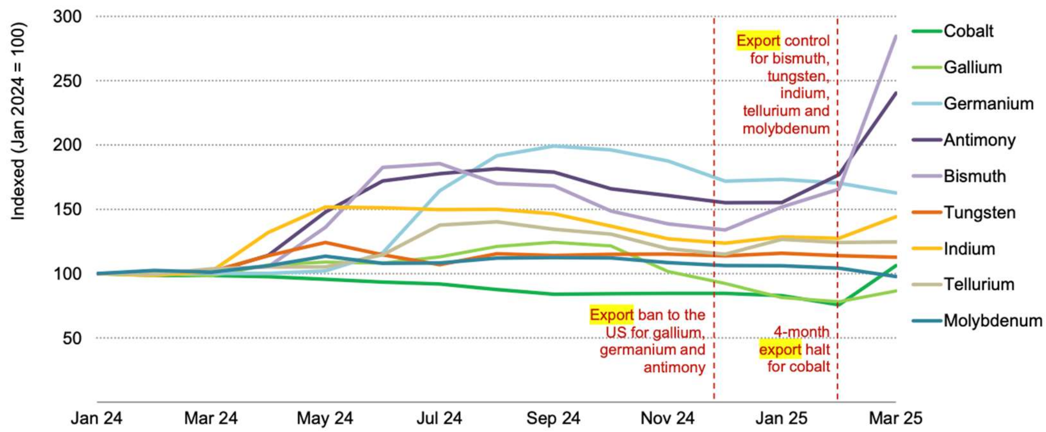


Figure 30. Price Movement of Selected Materials Subject to Export Restrictions in Recent Months (IEA)

Export Restrictions on Energy-Related Minerals Since 2023

		By	Market share	Type of control
Material	Lithium	Zimbabwe	9%*	Imposed a ban on raw lithium ore exports in Dec 2022, followed by export licensing requirements for all unprocessed base minerals in Jan 2023
Material	Gallium	China	99%	Export licensing in Jul 2023, followed by an export ban to the US in Dec 2024
Material	Germanium	China	74%	Export licensing in Jul 2023, followed by an export ban to the US in Dec 2024
Material	Antimony	China	74%	Export licensing in Sep 2024, followed by an export ban to the US in Dec 2024
Material	Rare earths	China	92%	Export reporting requirements from Nov 2023 (effective until Oct 2025), followed by export licensing on seven medium and heavy rare earths in April 2025
Material	Graphite	China	98%	Export licensing in Dec 2023
Material	Cobalt	DRC	68%*	4-month halt to exports announced in Feb 2025
Material	Tungsten	China	44%	Export licensing in Feb 2025
Material	Bismuth	China	80%	Export licensing in Feb 2025
Material	Indium	China	70%	Export licensing in Feb 2025
Material	Tellurium	China	77%	Export licensing in Feb 2025
Material	Molybdenum	China	81%	Export licensing in Feb 2025
Material	Nickel	Philippines	9%*	Proposed ban on raw mineral exports in Feb 2025
Technology	Rare earths	China	92%	Export ban of rare earth extraction and separation technologies in Dec 2023
Technology	LFP cathode	China	98%	Proposed technology export control in Jan 2025
Technology	Lithium refining	China	72%	Proposed technology export control in Jan 2025

* Mined output. Notes: LFP = lithium iron phosphate. Market shares are based on refined output in 2024.

Figure 31. Export Restrictions on Energy-Related Minerals Since 2023 (IEA analysis based on USGS, Mineral Commodity Summaries 2025, EC Raw Materials Information Systems)

Many Energy-Related Minerals are Used Across Multiple Sectors, Including Digital Technologies, Aerospace, and High-Performance Materials

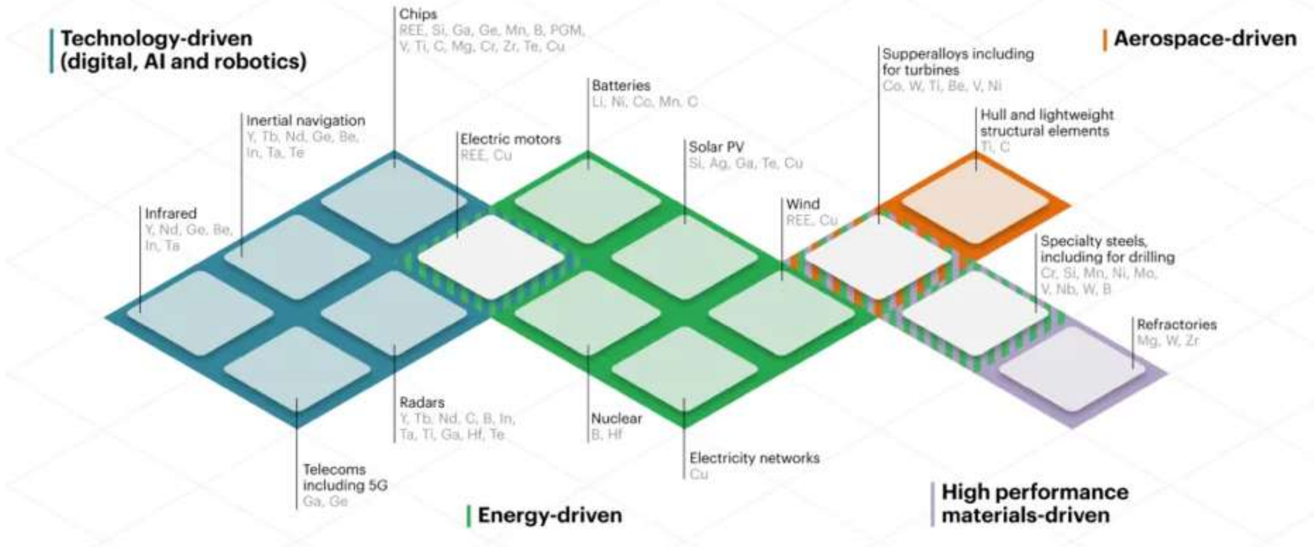


Figure 32. Many Energy-Related Minerals are Used Across Multiple Sectors, Including Digital Technologies, Aerospace, and High-Performance Materials (IEA)

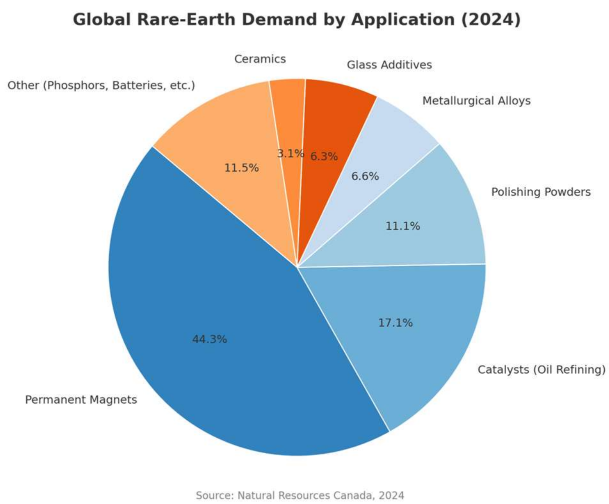


Figure 33. Global Rare-Earth Demand by Application [2024] (S&T Partners)

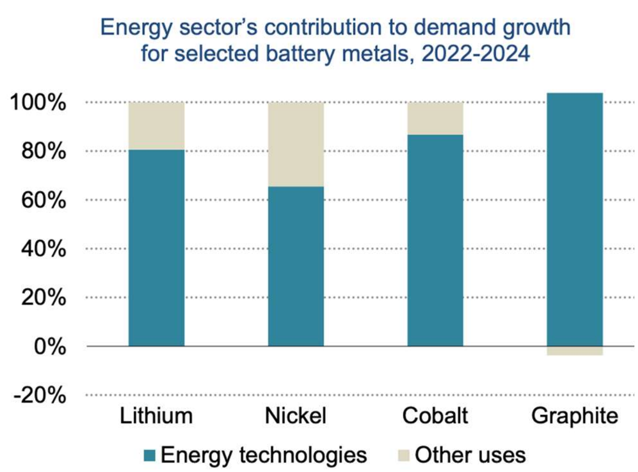


Figure 34. Energy Sector's Contribution to Demand Growth for Selected Battery Metals [2022-2024] (IEA analysis based on S&P Global and Bloomberg)

7 Figure Citations

8 Endnotes

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