WELLS FARGO
Investment Institute

Special Report

Global Securities Research (GSR), Global Investment Strategy (GIS), Global Manager Research (GMR) October 7, 2024

AI buildout continues as monetization challenges emerge

While artificial intelligence (AI) has been evolving for several decades, it has become top of mind for almost everyone on a much larger scale, especially since the launch of ChatGPT in November 2022. Recent AI advancements have been driven by the convergence of big data, high-performance computing power, advances in machine-learning algorithms, and cloud computing. In this report, we discuss our view on how the AI environment has evolved and provide perspective on how investors should navigate the generative-AI landscape, with topics ranging from our macroeconomic perspective to specific investment implementation ideas.

What's inside

Authors

Amit Chanda
GSR Equity Sector Analyst, Information Technology

Tom Christopher
GSR Equity Sector Analyst, Communication Services

Chris Haverland, CFA
GIS Global Equity Strategist

Austin Pickle, CFA
GIS Investment Strategy Analyst

Gary Schlossberg
GIS Global Strategist

Jennifer Timmerman
GIS Investment Strategy Analyst

Brian Youngberg, CFA
GMR Investment Research Analyst

Executive summary — What's changed over the past year

In September 2023, we published a report titled "The ascent of generative AI — What investors should know". Since then, there have been a number of significant developments in the AI environment. Now that we are revisiting the topic a year later, we felt it would be beneficial to review what has changed, what still stands, and the key themes we expect to impact investors.

1. Transition from initial excitement to implementation and rationalization

We believe generative AI has likely progressed from the "peak of inflated expectations" stage in the Gartner Hype Cycle into the "trough of disillusionment" stage. Although interest has not waned, we believe that management teams should continue to balance expenses with productivity gains while also planning implementation on a larger scale.

2. Release of OpenAI model series capable of complex reasoning

The new OpenAI o1 series of large language models are designed to spend more time thinking through harder problems in science, coding, and mathematics before they respond, and they require a significant amount of inference computing resources. Another member of the OpenAI o1 series includes a smaller and more cost-effective version of the model.

3. Emphasis on infrastructure, power, and cooling needs of AI data centers

Following more than a year of excitement, the attention around AI has expanded beyond just technology firms — it now also includes those building out the data-center infrastructure and supporting the need for reliable power and efficient cooling. We expect ongoing interest in generative AI to continue driving spending to build out and support data centers.

4. Acute focus on profitability and sustainability as applications have expanded

We continue to believe that the enterprise environment is key for generative AI to grow to scale. The focus for enterprises has now shifted to returns on investment for the capital being allocated to developing and implementing these new AI-capable software platforms, and we see opportunities for companies able to deliver on this front.

Additional perspective from Wells Fargo Investment Institute on generative AI

Given the broadening out of usage and acceptance of generative-AI technology, we have addressed areas that we believe are seeing downstream benefits from the AI trend in other reports. Ask your investment professional for our reports titled *"Data-center buildout shaped by AI applications"* and *"Generative AI transforming data center landscape"*, where we discuss investment opportunities in sectors beyond Information Technology that we believe are well positioned to benefit from the expansion. Finally, for specific investment ideas, please see pages 22 – 25 of this report.

Global Securities Research

Overview of generative AI

AI has been a dominant theme in the stock market over the past few years with the potential to have much the same effect on the economy. Generative AI has the ability to create new content, moving beyond traditional AI's data analysis and improved forecasting capabilities. It is the latest and, perhaps, most important step so far in the technology's evolution, preceded by traditional AI systems, machine learning, deep learning, neural networks, and automated speech recognition and language processing.[1]

In the past, traditional AI has been helpful in predicting outcomes and focusing on a narrow task, such as accurately identifying and categorizing images. Generative AI, on the other hand, is based on a text prompt, whereby a user types text-based inputs in the form of a question or request, and the large language model does its best to produce an appropriate response.[2] It offers broader applications, using deep-learning techniques and large language models to generate unique and new content using trained data. A few examples of this advancement include images, videos, music, essays, language, conversations, and even software code itself.[3] Multimodal large language models represent another example of advancement— unlike large language models based on generative AI that handle text inputs and outputs, these models process information from multiple types of media, including images, videos, audio, and text.

Key takeaways

We favor a clear-eyed evaluation of risk and reward in every investment decision, and that remains true in the early stages of even a transformative technology.

History teaches us that investors have tended to overestimate the impact of a new technology in the short run — even if they eventually underestimate its long-term impact.

Over the next two decades, we believe that AI will reach far beyond the software industry to transform the health care, education, manufacturing, transportation, financial, and retail industries, among others. In our view, generative AI has the potential to accelerate innovation, improve productivity in the workplace, and drive faster economic growth in the coming decade. Yet, historically, markets have often priced in technological advances well in advance of adoption. Additionally, there are several evolving risks that need to be understood in this case. The pace of adoption may be slower than the market is currently expecting. Debates among the investment community regarding when hyperscalers[4] will generate an adequate return on investment in terms of sufficient generative-AI revenue monetization as well as the sustainability of the AI capital expenditure (capex) supercycle underway remain front of mind. The rise of generative AI could lead to significant white-collar job losses that could dampen economic growth and raise social tension at some point in the future. Investors also should note that government regulation so far has been uneven across global regions. That regulation is likely to accelerate and may need time to balance economic growth and social concerns.

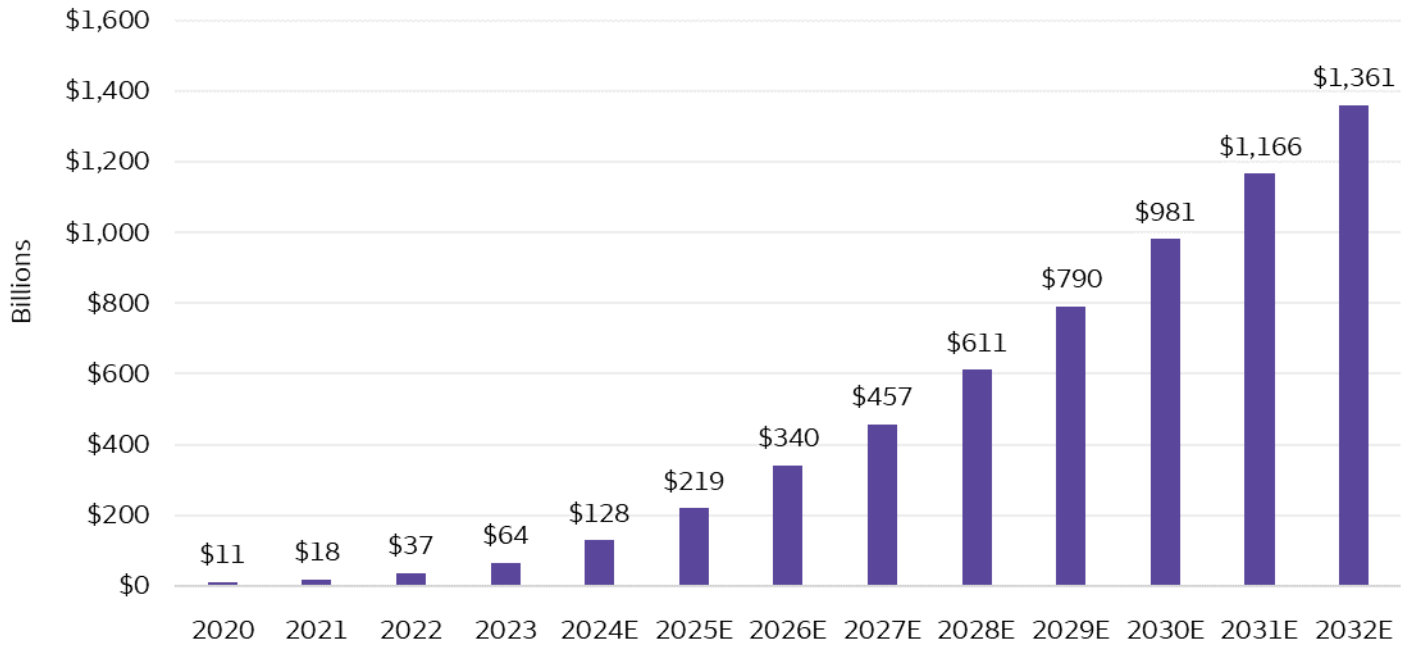
We always favor a clear-eyed evaluation of risk and reward in every investment decision, and that remains true in the early stages of even a transformative technology. As we have previously noted, history teaches us that investors have tended to overestimate the impact of a new technology in the short run — even if they eventually underestimate its long-term impact. This report evaluates potential short- and long-term investment opportunities, and it also includes Global Securities Research (GSR) specific investment ideas.

1. Deep learning refers to a type of AI that uses layers of neural networks to mimic how humans learn.
2. A large language model is a deep-learning neural network that is trained on massive amounts of existing text to generate new text similar to human language.
3. Specific examples detailed in Table 1: Potential generative AI use cases and capabilities by industry.
4. Hyperscalers refers to hyperscale cloud providers, a small group of companies who operate large networks of large data centers to facilitate cloud computing.

Large addressable generative-AI market

According to Bloomberg and International Data Corporation (IDC), the overall market for generative AI could grow at a compound annual growth rate of approximately 49%, from $11 billion in 2020 to $1.36 trillion in 2032 (Chart 1). The rapid growth in generative-AI tools has been driving demand for semiconductor chips, software, networking equipment, memory, and storage solutions.

Chart 1: Generative AI market



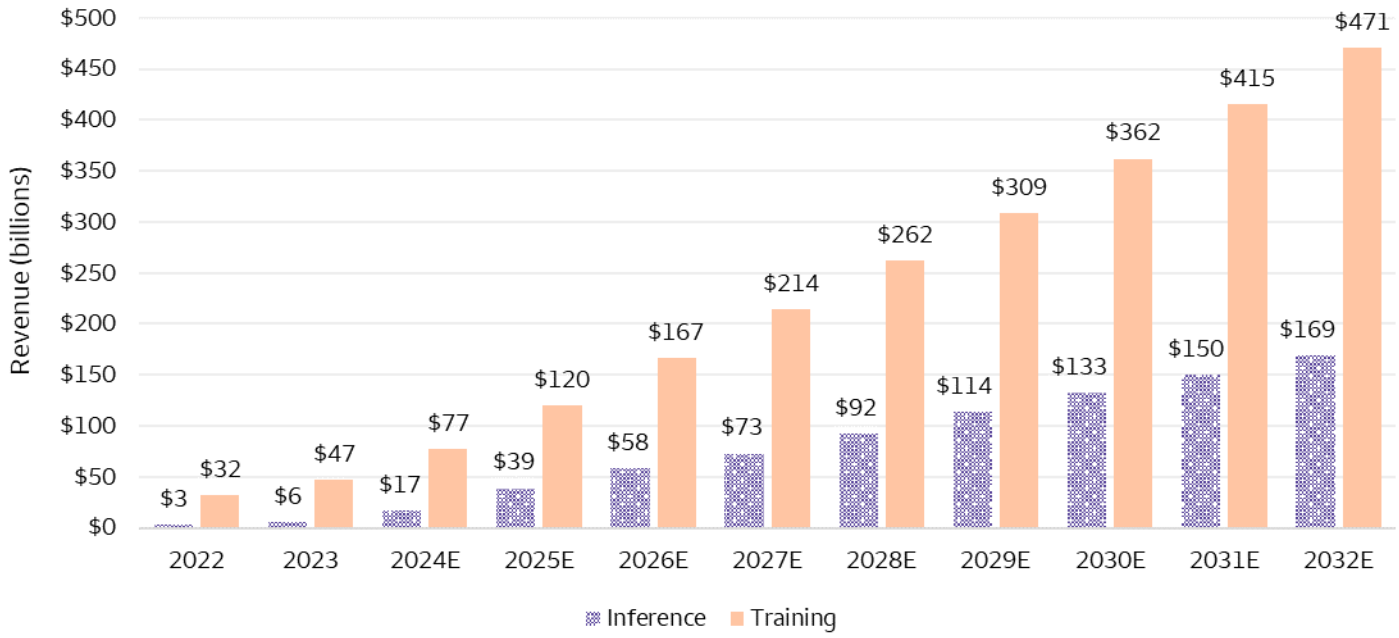
Sources: Wells Fargo Investment Institute, Bloomberg, and IDC. Data as of March 28, 2024. E = estimated. Estimates based on Bloomberg Intelligence forecasts using IDC, eMarketer and Statista data for the overall generative-AI market.

Over the past few years, a considerable part of generative AI's initial infrastructure-buildout phase has been driven by the need to train the latest large language models on increasingly large datasets of text and code. The costs associated with developing, training, and managing generative-AI large language models effectively are fairly prohibitive as these models are very compute-, semiconductor-, networking-, and storage-intensive. Further, the high cost of training large language models can increase exponentially as models grow in size, which occurs as they are trained on more parameters (that is, variables in a neural network[5] that the model learns during the training process).

Although the vast majority of the hyperscalers' massive capex spending cycle is being allocated toward training large language models, inferencing (the thinking that occurs when the already trained large language model generates a response to an inquiry) is also gaining traction. OpenAI's new o1 series of models is an example of this — the models are capable of complex reasoning and will require higher levels of computing resources for both training and inference, but particularly for inference. On its most recent earnings call, Nvidia Corporation (Nvidia) highlighted that over the past four quarters, 40% of its data-center revenue has been tied to inference-related products and solutions. According to Bloomberg and IDC, the overall market for training could grow at a compound annual growth rate of approximately 31%, from $32 billion in 2022 to $471 billion in 2032. Meanwhile, the overall market for inferencing is projected to grow at a compound annual growth rate of 49%, increasing from $3 billion in 2022 to $169 billion in 2032 (based on inferencing revenue; Chart 2).

5. In deep learning (a subset of machine learning), a neural network is a mathematical model that can learn and model relationships between input and output data that are nonlinear.

Chart 2: Forecasts for training versus inference revenues



Sources: Wells Fargo Investment Institute, Bloomberg, and IDC. Data as of March 28, 2024. E = estimated. Estimates based on Bloomberg Intelligence forecasts using IDC data.

We are also seeing more evidence of generative AI moving to the edge, meaning that generative-AI models are being deployed directly onto local edge-computing devices (such as personal computers (PCs) and smartphones) that allow devices to process data locally instead of relying on the cloud. The PC original equipment manufacturers (OEMs) are optimistic about AI PCs — that is, PCs with generative AI integrated into both the hardware and software. We believe demand for these devices may drive an overall PC-replacement cycle in 2025. Looking back, as we emerged from the pandemic, consumers shifted their preferences from consumption of goods to services and experiences, which led to double-digit year-over-year declines in PC unit demand. Additionally, we expect more consumer-centric smartphones to be launched that can run on-device generative-AI models this year. On September 9, Apple Inc. (Apple) introduced its next-generation iPhone 16 that embeds new AI features, Apple Intelligence, and the use of ChatGPT seeking to enhance the user experience on the devices.

Major computing platform shift underway

We have witnessed multiple computing-related platform shifts that have had a material impact on society. One important shift was the transition from mainframe computers to personal computers in the 1980s. Another shift in the 1990s was the transition to networking. The late-1990s saw the buildout of desktop internet, which eventually led to new applications and business models based on online commerce as well as social media in the early 2000s. In the 2010s, another shift toward mobile internet computing occurred following the rapid adoption of smartphones. The emergence of public cloud computing (in the mid-2000s) with the introduction of Amazon.com, Inc's (Amazon's) Amazon Web Services in 2006, Alphabet Inc.'s (Alphabet's) Google Cloud Computing service in 2008, and Microsoft Corporation's (Microsoft's) Azure in 2010 led to public, cloud-based, software-as-a-service business models that took off in the 2015 – 2020 timeframe.

When looking back to prior emerging-technology cycles, we see that the infrastructure was built out initially, platforms soon evolved, and then applications were developed and adopted on a wider scale. For example, during the tech boom of the 1990s, the internet infrastructure (DSL connections) was being built out despite users not really knowing what the technology would ultimately become and how to actually use it. A decade later, search and e-commerce applications have

developed, and everyday use of the platforms has increased substantially. If the infrastructure was not already in place, developers would likely not have had the vision to create the actual uses and applications that are part of our daily lives.

AI has been around since the 1950s and has experienced several false starts along the way. However, over the past two decades, the convergence of big data, advances in high-performance computing power, advances in machine-learning algorithms, and cloud computing were instrumental in driving recent AI advancements. In terms of size and importance, it is widely believed that generative AI represents the next major computing platform shift where various types of software and applications will be developed. However, it may take several years for these generative-AI applications to develop, and demand may not materialize until the buildout phase of the core AI-focused infrastructure has been completed.

Key takeaways

It is widely believed that generative AI represents the next major computing platform shift.

It may take several years for generative-AI applications to develop, and demand may not materialize until the buildout phase of the core AI-focused infrastructure has been completed.

We believe a significant step was recently made with the introduction of OpenAI's o1 models, which were designed to perform complex chain-of-thought reasoning and step-by-step problem solving.

Ongoing adoption of ChatGPT

ChatGPT was created by OpenAI, an AI research organization founded by various entrepreneurs and researchers in December 2015. ChatGPT gained widespread attention when it reached 100 million active users in two months after its introduction in November 2022. The migration to ChatGPT represented one of the fastest-growing consumer applications in history, and OpenAI recently stated that it has more than 200 million weekly active users. Microsoft has been OpenAI's largest financial backer, with approximately 49% ownership and $13 billion invested (as of April 8, 2023).[6] OpenAI's latest completed round of funding (October 2024) valued the company at approximately $157 billion, which included investments from several large-cap technology companies.[7] That represents a near doubling in value from the prior round of funding completed in February 2024, where the company's valuation was $80 billion.[8] While still unprofitable, OpenAI's revenue is now projected to reach $11.6 billion next year from approximately $3.7 billion in 2024.[9]

ChatGPT is based on OpenAI's Generative Pre-Trained Transformer (GPT) series of large language models, and the transformer model represents one of a handful of popular generative-AI large language models. Google first introduced the transformer model in a 2017 research paper which, compared to neural network architectures from many years ago, represented an evolutionary step forward for natural-language-processing tasks. The transformer model assesses the importance of each word in a sentence relative to other words. This allows the model to better understand the context of the dialogue and track sequential relationships between words to more accurately predict the next word. We also believe the recent introduction of ChatGPT's o1 models marks a significant development in the evolution of the transformer-model architecture in terms of the models' complex reasoning capabilities.

OpenAI released GPT-4 on March 14, 2023. Although OpenAI has yet to introduce ChatGPT-5, OpenAI did release multiple upgrades and performance enhancements to Chat GPT-4 in 2024. On September 12, OpenAI introduced OpenAI o1, which is a new series of models trained with reinforcement learning to perform complex chain-of-thought reasoning and step-by-step problem solving. The OpenAI o1 series includes the release of OpenAI o1 preview, which was designed to accomplish advanced reasoning in science, coding, and mathematics and to spend more time thinking through complex problems before responding with an appropriate answer. OpenAI o1-mini is another member of the series and was designed to be

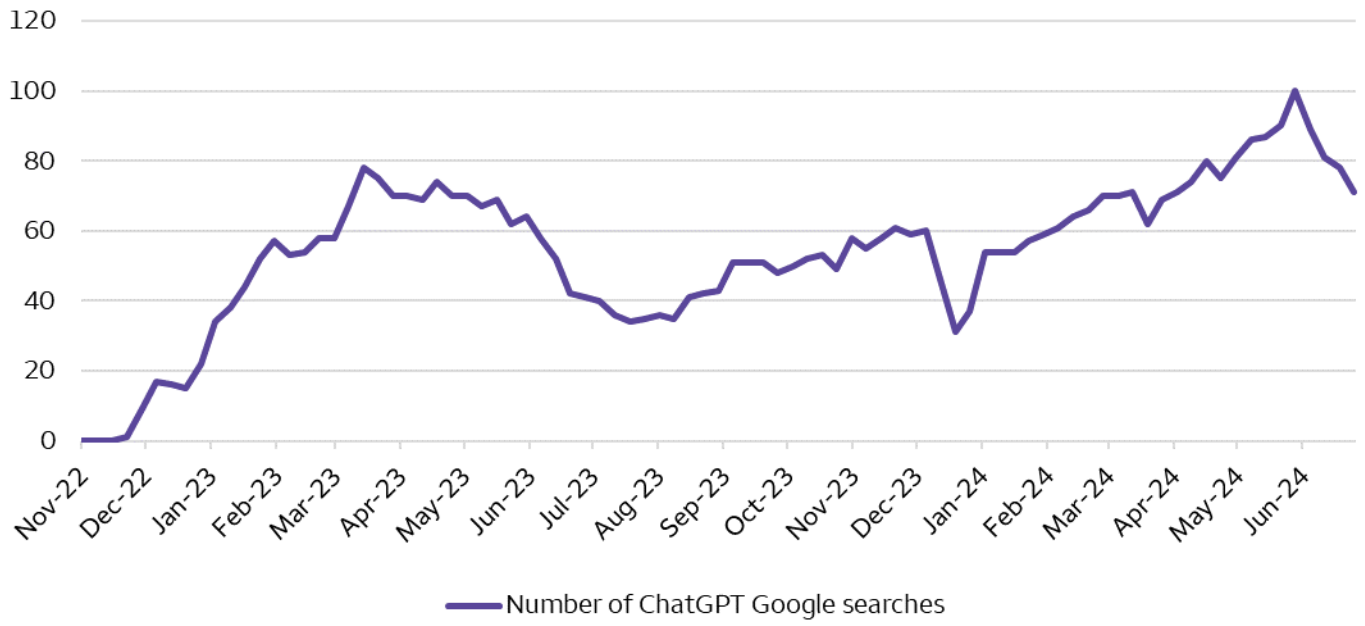
6. CNBC, "Microsoft's $13 billion bet on OpenAI carries huge potential along with plenty of uncertainty," April 8, 2023.
7. Hayden Field, "OpenAI closes funding at $157 billion valuation, as Microsoft, Nvidia, SoftBank join round," CNBC, October 2, 2024.
8. Antonio Pequeño IV, "OpenAI Reaches $80 Billion Valuation In Venture Firm Deal, Report Says," Forbes, February 16, 2024.
9. Krystal Hu and Kenrick Cai, "OpenAI offers one investor a sweetener that no others are getting," Reuters, September 27, 2024.

more cost efficient than the o1 preview model while still delivering strong performance in the subjects of science, technology, engineering, and math.

An additional feature, a generative-AI powered search engine (a prototype of SearchGPT), was launched by OpenAI earlier this year to compete with Google and the startup Perplexity. Multiple large language models compete with ChatGPT in the generative-AI marketplace today — a few examples include Google's Gemini, Microsoft's Copilot, Character.AI, Meta Platforms' open-source Llama 3.2, xAI's Grok, and Claude 3.5 Sonnet. Among the more popular text-to-video and text-to-image generative-AI models are OpenAI's Sora and OpenAI's DALL-E3, respectively. Meta Platforms' new Llama 3.2 model can process both text and images. Other releases include GPT-4 Turbo, GPT-4o, and GPT-4o mini. A trend we have noticed is the release of smaller, less expensive models such as Chat GPT-4o mini and Google's Gemini 1.5 Flash. We believe these will help facilitate the transition of generative AI to local devices (such as smartphones) as these smaller generative-AI models are designed to be fast, efficient, and cost effective.

ChatGPT's popularity among consumers has been evidenced by the rising number of ChatGPT Google searches over the past few years (Chart 3). Nevertheless, we believe the enterprise marketplace is the potential larger opportunity over the longer term. ChatGPT introduced ChatGPT Enterprise in August 2023 in order to gain traction amongst an enterprise customer base. OpenAI recently announced it has more than one million paying users across its business products as enterprises warm up to adopting generative AI to enhance productivity and remain competitive.

Chart 3: Number of Google searches as a proxy for growing interest in ChatGPT



Source: Google Trends. Weekly, worldwide data from November 2022 to June 2024. Current as of July 2024.

Microsoft launched Microsoft 365 Copilot in November 2023, which embedded enhanced AI capabilities into its existing software platform. Since the introduction, the company has seen steady user growth with enterprise customers noting faster completion of tasks, more effective meetings, and automated workflows.[10] There is a $30 per month subscription premium for the added AI-supported Microsoft 365 Copilot software. Additionally, Microsoft has successfully leveraged its partnership with OpenAI to expand the use of its cloud platform (Azure). Other software vendors are also embedding generative-AI solutions within their enterprise products, with examples including Salesforce, Inc.; Adobe Inc., Oracle Corporation; ServiceNow, Inc.; and Workday, Inc., among others.

10. Microsoft's fiscal fourth-quarter 2024 quarterly earnings conference call dated July 31, 2024.

Global Investment Strategy

Economic implications of AI

Generative AI's two most visible macroeconomic issues are its potential impact on labor productivity and the job market. Beyond that is the direct, more immediate impact on economic growth from business investment in AI-related technology equipment and software. A McKinsey & Company (McKinsey) study estimated that generative AI could add 0.1% – 0.6% to the global economy's average annual productivity growth between now and 2040, depending on the speed with which the technology is absorbed and workers' time savings are realized.[11] Increases of that magnitude in the U.S. would imply a material lift to U.S. productivity growth, which fell to 1.5% in the past 10 years from its 2.8% average in the decade before the 2008 – 2009 global financial crisis. A potential boost could also come indirectly from AI's ability to spur and accelerate innovation, especially as it tends to have the biggest impact on the productivity of cognitive work.

AI's support to productivity gains is coming at a crucial time — an aging workforce and slowing growth of labor supply are weighing increasingly on economic growth potential for the U.S. and global economies. Stronger productivity growth should help accommodate healthier, noninflationary wage gains and resulting improvements in household living standards.

As with major technology innovations in the past, we expect to see initial labor-market disruptions that will likely vary across occupations. Productivity enhancements should have the greatest impact on data-entry, knowledge-based, and research jobs, particularly in support analyst roles and other professional-service positions.[12]

We view the U.S. as best positioned to benefit from AI because of its economic size; regulatory stance, which tends to be more flexible and less intrusive; dynamic private and public investment in research and development; and the quality of its higher-education system.[13] Importantly, the U.S. appears poised to retain its global technological leadership position not just in terms of AI technology innovation, but also in the way these innovations are disseminated throughout the economy (diffusion) and how quickly they are implemented by businesses and consumers (adaptability).

Key takeaways

Generative AI could materially lift U.S. productivity growth with an estimated 0.1% – 0.6% addition to the global economy's average annual productivity growth between now and 2040 (McKinsey & Company).

AI's support to productivity gains is coming at a crucial time — an aging workforce and slowing growth of labor supply are weighing increasingly on economic growth potential for the U.S. and global economies.

Improved competitiveness from AI-related productivity enhancements in advanced industries as well as in other industries where the U.S. holds a comparative advantage could support increasingly open trade by tempering the move toward protective industrial policies. Generative AI's boost to creative potential and productivity in knowledge-based industries could speed the economy's move up the value-add ladder, better insulating advanced economies from encroachment by lower-cost centers abroad. Ultimately, that could help take some of the edge off criticism of globalization's cost to employment, exports, and national income.

11. "The economic potential of generative AI: The next productivity frontier," McKinsey & Company, June 14, 2023.
12. For more on this topic, see the section below titled *Labor-market disruptions*.
13. "AI, Economies and Markets – How artificial intelligence will transform the global economy," Capital Economics, 2024.

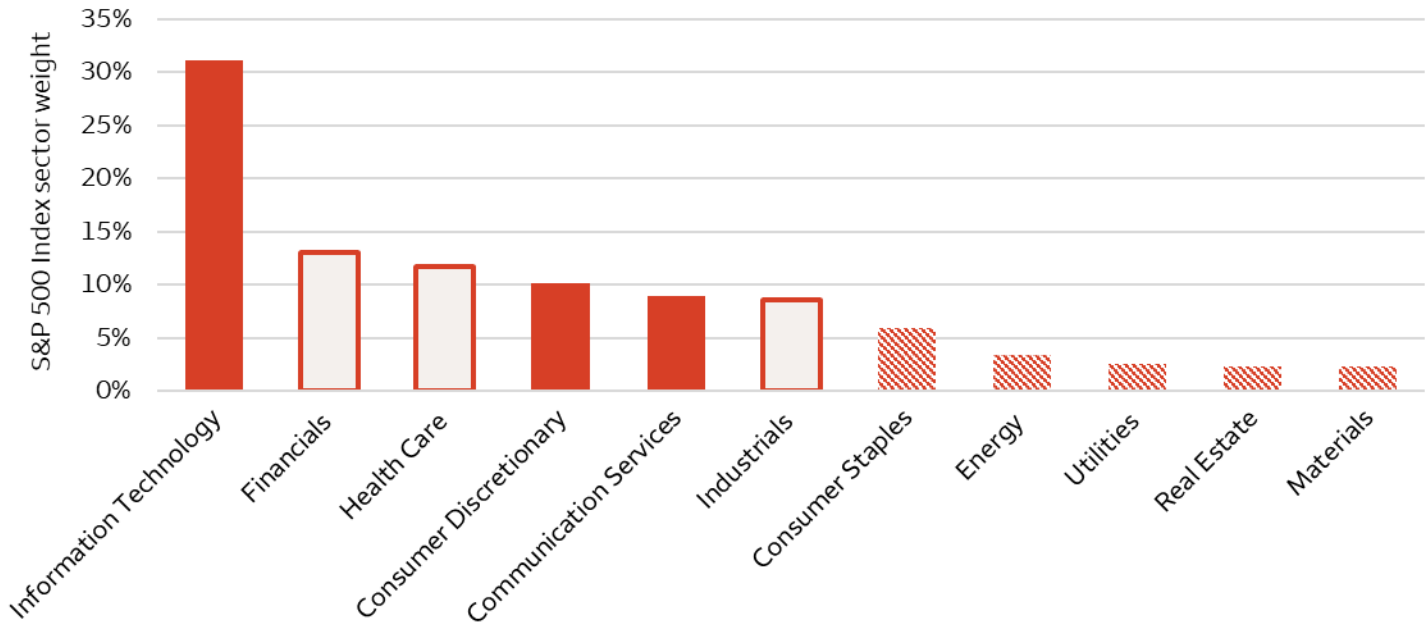
Sector implications of AI

We believe AI is likely to benefit revenue growth and overall profitability for several technology-focused industries. In addition, AI adoption has the potential to increase productivity and boost profit margins across all sectors to varying degrees. Investors may benefit from not only the global regions, industries, sectors, and companies that are driving the innovation today, but also from those areas with the greatest productivity potential as a result of AI adoption.

Sectors touched by generative AI

Potential AI beneficiaries are the companies at the forefront of developing and adopting these technologies as well as those that are supplying the necessary components. Many of these companies are constituents of the Information Technology, Consumer Discretionary, and Communication Services sectors, which together constitute about half of the S&P 500 Index (Chart 4). We believe exposure to these sectors is appropriate for long-term investors with an interest in AI. Our tactical guidance, which targets a 6 – 18 month timeframe as of this writing, includes a neutral rating on the Information Technology sector, a favorable rating on the Communication Services sector, and an unfavorable rating on the Consumer Discretionary sector. Looking ahead, we may prefer to increase exposures to these sectors if the pace of AI development accelerates, valuations become more attractive, or the risk-reward balance tilts more favorably in our view. However, we also expect that there will be periods when the enthusiasm for AI pushes valuations to levels we find expensive — at these times we may favor reducing exposure, at least temporarily, until more attractive opportunities arise.

Chart 4: S&P 500 Index is heavily weighted toward AI plays



Sources: Bloomberg, McKinsey, and Wells Fargo Investment Institute. Data as of October 1, 2024. Solid bars indicate the sectors most heavily involved in AI development. Outlined bars indicate the sectors that McKinsey studies indicate may stand to benefit most from AI-fueled productivity improvements. Striped bars indicate the sectors that McKinsey studies indicate may benefit to a lesser degree from AI. An index is not managed and not available for direct investment.

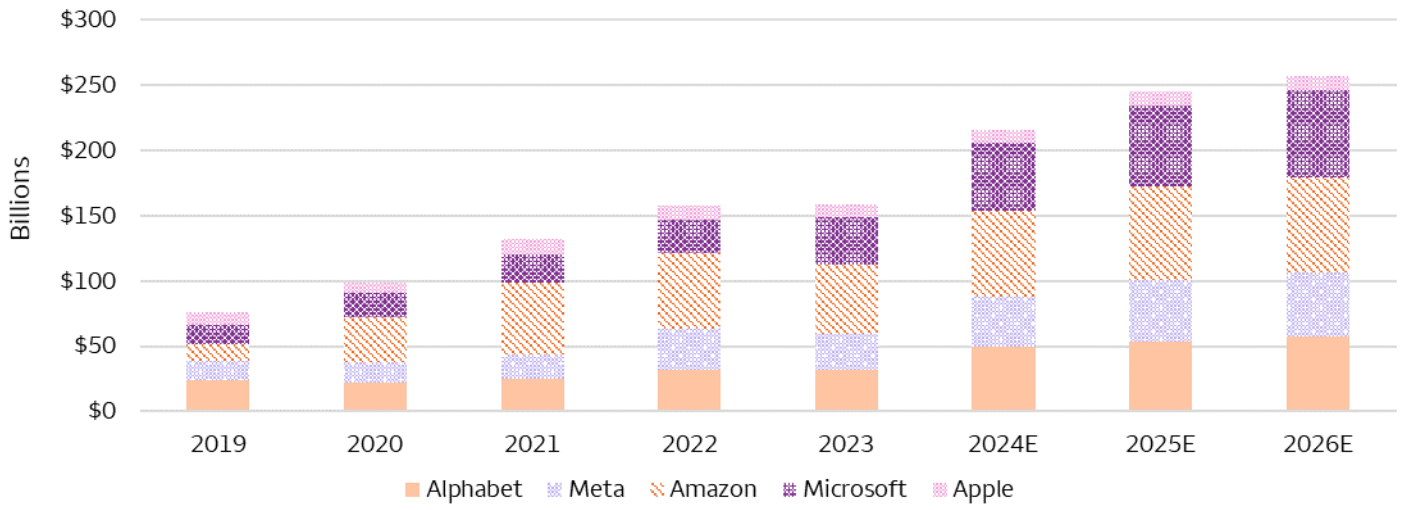
The remaining sectors we view as poised to benefit from AI are those that stand to gain from the implementation of AI products and services rather than the direct development of AI. In other words, second-order beneficiaries. These center mostly around opportunities to improve efficiencies in various areas, to include marketing and sales; customer operations; product development; research and development (R&D); software engineering; supply chain and operations; and risk and legal business processes.

Massive capex investment tailwind

Over the past two years, investor attention has largely been centered on the most visible beneficiaries of the investment phase of the generative-AI technology cycle and the material uptick in resources required to support the development of generative AI. Notably, the focus has been primarily around leading semiconductor firms (namely Nvidia) and a small number of hyperscale cloud providers. In our view, the scale of investment taking place has broader implications across the generative-AI investment landscape. However, we feel the range of companies is somewhat underappreciated.

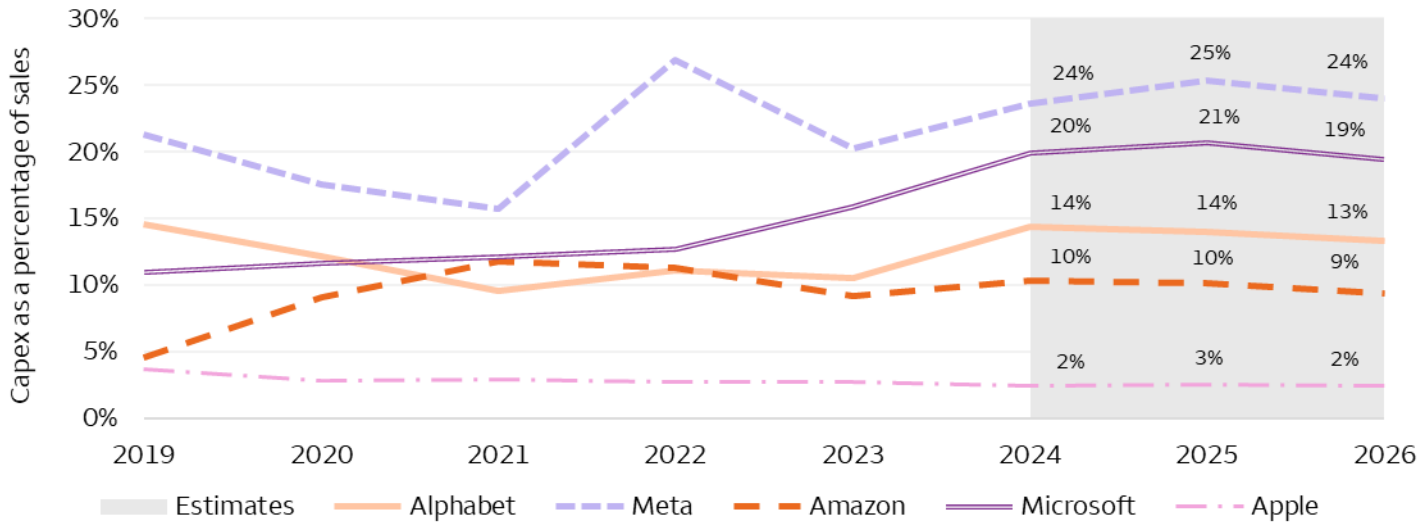
Capex spending has broadened beyond just semiconductors and software to include companies in the Industrials and Materials sectors as well as Real Estate and Utilities. That said, while year-over-year capex spending growth may have slowed from the fast pace seen over the past couple years, we believe the levels of capex spending will remain elevated for the foreseeable future (Chart 5). For 2024, on a percentage-of-sales basis, capex trends at the mega-cap technology companies that are also key hyperscalers (Amazon, Microsoft, and Alphabet) as well as Meta Platforms Inc (Meta) remain within what we see as a reasonable range, from 10% of sales on the low end to as high as 24% on the high end (Chart 6).

Chart 5: Mega-cap tech capex investment trend



Sources: FactSet and Wells Fargo Investment Institute. Data as of October 1, 2024. E = estimated. Estimates based on calendar year end consensus FactSet capex data.

Chart 6: Mega-cap tech capex trends as a percentage of sales



Sources: FactSet and Wells Fargo Investment Institute. Data as of October 1, 2024. E = estimated. Estimates based on calendar year end consensus FactSet capex data.

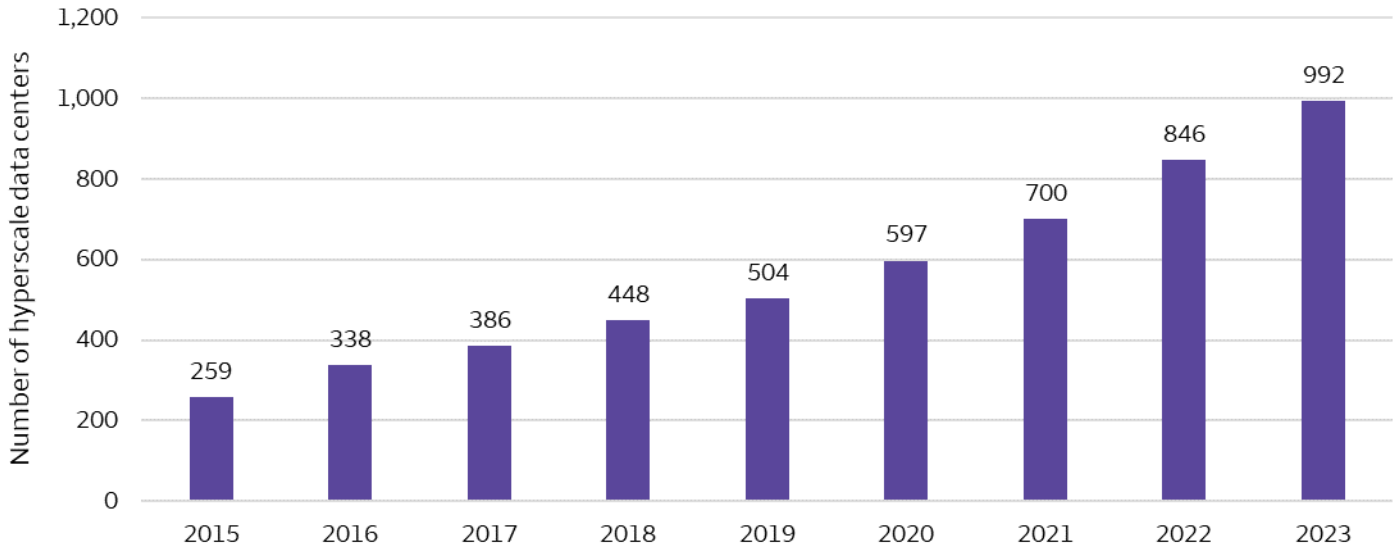
Finally, we would note that several management teams of technology companies, including hyperscalers, have indicated that they believe the industry is in the early stages of the AI capex cycle. Generally, commentary from these companies has indicated they would rather invest more capital early on and perhaps be a bit early rather than be late, with underbuilt infrastructure insufficient to support growing demand — the latter scenario would likely result in missed opportunities and losing out on potentially significant amounts of future AI-related revenue. However, there has been growing skepticism among the investment community around sufficient returns on generative-AI investments. Some technology veterans within the industry have drawn comparisons between the current AI technology cycle and the prior buildout of the desktop Internet in the late 1990s, noting returns from these revolutionary technologies could take time to develop and come to fruition. That said, we believe capex levels will likely remain elevated in the near term given the vast amount of computing resources required to operate the infrastructure to support current and future generative-AI use cases. We continue to believe in the long-term potential opportunities of generative AI, but we acknowledge that the path to meaningful returns on investment may not be immediately evident.

AI-focused data centers

AI-focused data centers typically use more expensive servers that are powered by leading-edge graphics processing unit (GPU) chips for training large language models compared to traditional enterprise servers, which are supported by a central processing unit (CPU) chip. The compute-intensive nature of generative-AI workloads compared to traditional information technology (IT) workloads is presenting new challenges for overall IT infrastructure, particularly in the form of higher levels of energy consumption. The power-hungry nature of these workloads requires significant amounts of computing, storage, and networking infrastructure.

In our view, multiple semiconductor, networking, storage, and hyperscale cloud companies will most likely be the ones helping to create the digital infrastructure necessary to support the modern data center. According to Synergy Research Group, the number of hyperscale data centers increased to 992 exiting 2023 and exceeded the 1,000 level in early 2024. The total number of hyperscale data centers doubled since 2019 (Chart 7). We believe there will continue to be significant data-center capacity brought online over the next few years, driven by the rapid growth of AI applications and sustainable data-center demand. According to research firm Synergy Research Group, hyperscale data-center capacity is expected to triple by the end of 2029, driven by high-compute AI-related applications. That expansion could take the form of new data centers or expanded (or retrofitted) locations to increase capacity and handle the high-intensity workloads that are typical with AI-related functionality.

Chart 7: Number of hyperscale data centers worldwide



Sources: Synergy Research Group, Statista 2024 and Wells Fargo Investment Institute.

Use cases will likely broaden

Adoption of generative AI has increased substantially in 2024, particularly among professional services industries. While most, if not all, sectors and industries will be noticeably altered by the implementation of generative AI, a few stand out. Regardless, companies across multiple industries continue to seek out expense optimization and improved productivity through the use of AI applications. The McKinsey study estimated that industries within the Health Care, Financials, and Industrials sectors could see the greatest value add through AI implementation.[14] For example, AI could deliver improvements for banks and other financial services firms within the Financials sector in product development and marketing, fraud detection, risk management, and customer interactions. Research, drug discovery and development, patient care, treatment, data management, and documentation are all likely to experience step-level improvements with the proper application of AI within the Health Care sector. Meanwhile, AI's largest potential benefit to companies in the Industrials sector will likely arise from supply-chain optimization, efficient warehousing, factory automation, improvements in marketing processes, software engineering, and R&D. This is not an exhaustive list as the potential applications are impressive (Table 1).

Table 1: Potential generative AI use cases and capabilities by industry

Industry	Use cases and capabilities
Automotive and transportation	Self-driving cars, more efficient car-sales process, connected vehicles, city of the future, ride sharing, and connected vehicles
Health care	Improved patient data sharing, smart implants, robotic surgeries, more personalized patient management and diagnosis, accelerated drug discovery and development, advanced data analysis, and point-of-service tools for physicians
Consumer goods	Inventory and labor-management efficiencies, improved target marketing, customer service enhancements, supply-chain efficiency, and higher customer engagement
Retail and restaurants	Improved customer demand tracking, inventory optimization, call-center virtual assistants, personalized customer product recommendations, automated service, and upsell products at point of service
Advertising, sales, and marketing	Customized advertising campaigns, content creation (including generation of graphics and images), voice synthesis, customer-facing chat bots, improved ad conversion, increased engagement, and video game development
Manufacturing, energy, and industrial	More robotics in manufacturing and distribution, supply-chain optimization, efficient warehousing, internet of things, factory automation, energy usage, pipeline data analysis, and repair and replacement of machinery
Financial services	High-level financial recommendations, faster data access, improved product development, fraud detection, improved risk management, fintech applications for personal finance and lending, and robo-advisors
Technology	Workflow optimization, generation of code, process automation, chat bots for customer support, transcription and summaries of meetings, proofreading, and suggestive correspondence
Education	Enhanced digital-learning capabilities, enhanced critical thinking from students, increased access to information, copyright and plagiarism detection, higher teacher-student engagement, and personalized tutoring
Entertainment	Music generation, video editing, content creation, and video-game interaction

Sources: Wells Fargo Investment Institute and McKinsey, 2024.

14. McKinsey & Company, "The Economic Potential of Generative AI: The Next Productivity Frontier," June 14, 2023.

The monetization of generative AI

As the generative-AI trend emerged, companies across several industries and sectors benefited from the initial wave and excitement over potential benefits. Much talk among investors has been around generative AI's potential to revolutionize industries and make workers more productive. The companies that emerged as early benefactors of the technology have included those that supply components to build out the infrastructure, to include semiconductor manufacturers (specifically GPUs); suppliers of hardware and equipment (such as servers and racks); and suppliers of heavy equipment (used for power generation and cooling). Data-center spending has continued to ramp up, driven by the ongoing development of AI applications. Mega-cap technology companies have allocated hundreds of billions of dollars in AI-related capital expenditures over the past five years. As capital spending remains elevated, investors are increasingly starting to scrutinize the path to sufficient returns on investment for these hyperscalers, specifically in the form of increased revenue contributions from AI applications.

While software companies initially benefited from the rollout of the generative-AI functionality, it became more evident that not all software firms would immediately benefit from the technology. The spending environment became very challenging as IT spending was scrutinized even further, the sales cycle elongated, contracts were adjusted by terms and duration of deals, and some deals were delayed and pushed out into subsequent quarters. We expect software companies to eventually monetize the technology in the form of increased revenue related to added AI capabilities, especially as enterprises optimize expenses and realize the benefits (productivity and efficiency gains) related to the premium services. In our view, the benefit to software companies may not be materially realized until at least 2025 (if not 2026) — this is largely a result of how revenue is recognized from a subscription business model, where year-over-year comparisons would not fully reflect the added revenue related to the premium AI content within new contracts. Further, if companies do not realize the productivity and efficiency gains from the increased expenses related to premium AI-capable software platforms, management teams may pull back on the spending and revert to legacy subscriptions without the AI capabilities as they optimize expenses.

Beneficiaries beyond Information Technology

Following more than a year of excitement, the attention around AI has expanded beyond just technology firms. We believe investor attention has been primarily focused on the most visible beneficiaries of the material uptick in investment required to support the development of generative AI — namely certain leading semiconductor firms and a small number of hyperscale cloud service providers (hyperscalers). The scale of investment taking place and its impact on the broader environment for a wide range of companies remains somewhat underappreciated, in our view. Further, ongoing interest in generative AI should continue to drive spending to build out the infrastructure to support it, namely data centers. The data-center footprint is expected to expand as more data is captured and utilized in AI-related workloads, and while equipment within the facility is necessary to operate the data center, we see two additional critical needs — reliable power and efficient cooling.

However, data centers that run the complex processes of AI applications are quite power hungry and resource intensive. AI-focused data centers typically use more expensive servers that are powered by leading-edge GPU chips for training large language models compared to traditional enterprise servers supported by a CPU chip. The compute-intensive nature of generative-AI workloads compared to traditional IT workloads is presenting new challenges for overall IT infrastructure, particularly in the form of higher levels of energy consumption. The power-hungry nature of these workloads requires significant amounts of computing, storage, and networking infrastructure. These applications are more complex and require significantly more computing power. We believe those increased needs translate into more of everything, including processors (GPUs and CPUs), servers, networking equipment, power generation, and land for data centers.

Global Securities Research

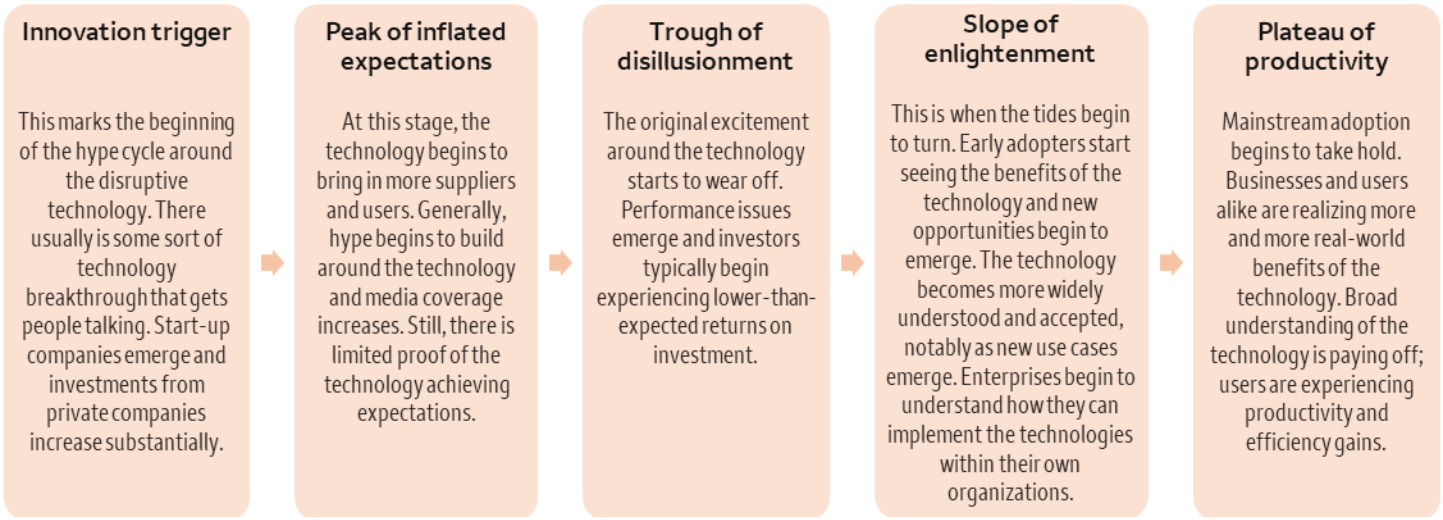
Media and investor excitement in perspective

The Information Technology sector is no stranger to economically disruptive technology and innovation cycles or to attention from investors and the media. Nevertheless, the typical technology innovation cycle can get ahead of reality in terms of attractive business models that work, unit economics that are profitable, and companies that can generate healthy amounts of free cash flow (amount of cash left after all expenses are covered) over the long run. As with past technology platform investment cycles, we believe investors tend to overestimate the near-term prospects of an emerging technology that has the potential to enormously impact society and to underestimate the long-term prospects of the technology's adoption as well as its ability to penetrate previously unforeseen end markets.

The Gartner Hype Cycle (the Cycle, shown in Chart 8) maps the path of potentially innovative and disruptive technologies. It tracks the path from the technology's development and introduction through mass acceptance and enterprise implementation, where businesses typically experience the benefits of the new technology. While the speed varies, it historically has taken about three to five years for a technology to move through the Cycle. We would note that not all technologies make it through all five phases of the Cycle. Some technologies fall off as enthusiasm simply fades away amid slow development of use cases or in the event that the technology is replaced.

On August 16, 2023, Gartner issued a press release confirming its view that we are currently within the "peak of inflated expectations" phase. While Gartner believes that generative AI is still in this stage of the Cycle, they believe it has passed the peak and is a bit further along on the curve. The number of generative-AI apps has increased substantially over the past year and a half, and interest in the technology remains elevated. Users continue to look for that "killer app" — an application deemed sufficiently necessary and desirable that users cannot live without it — and developers remain focused on creating a platform to increase productivity and efficiency. However, the focus for enterprises has now shifted to returns on investment for the capital being allocated to developing and implementing these new AI-capable software platforms.

Chart 8: Gartner Hype Cycle



Source: Gartner, 2023.

Questions around long-term sustainability of generative AI have also begun to bubble up, and the initial hype around generative AI has somewhat subsided. If it has not moved already, we believe generative AI is moving into the next phase of the cycle, the "trough of disillusionment". At this stage, widespread use cases continue to develop and are implemented on a larger scale. Although interest has not waned, we believe that management teams continue to balance expenses with productivity gains while also planning implementation on a larger scale. The movement into this next phase does not mean doom and gloom and certain abandonment of the technology. Quite the contrary, it is more of a rationalization for uses of the technology — users are seeking to develop further applications while also balancing the added expenses and resources

with the increased productivity. In essence, enterprise customers are seeking a minimum return on investment from the elevated levels of capital allocated to develop new AI applications. While there are many technologies that do not fully move through all five stages of the cycle, we believe that generative-AI technology is more in a phase of limbo. Excitement around the platform remains elevated, but at this point use cases for the technology are limited or at least have not reached peak potential.

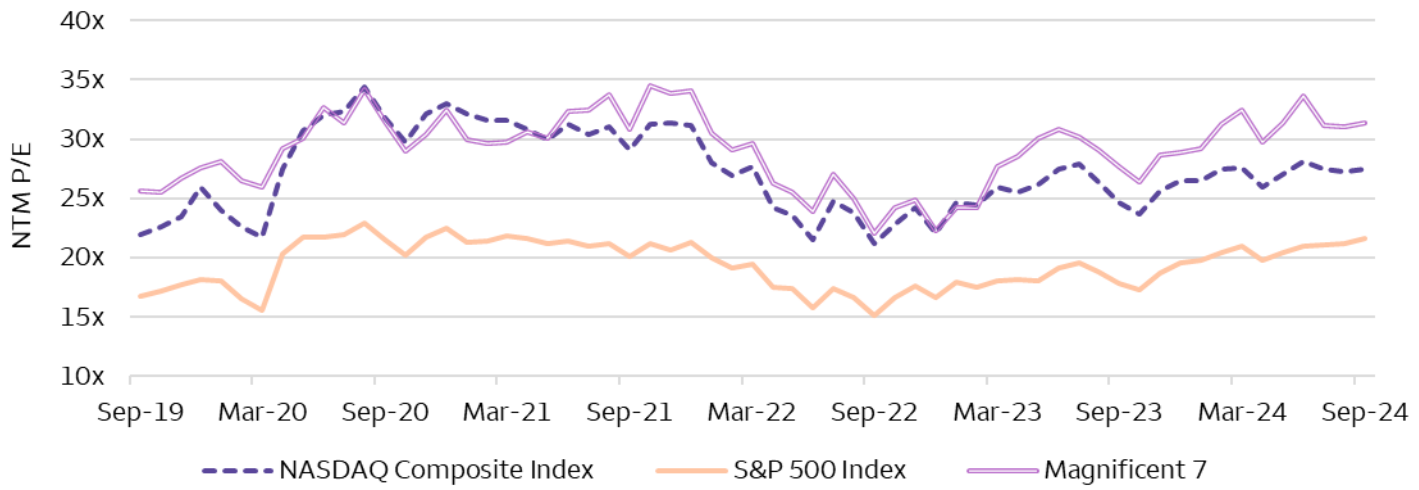
Amid the ongoing excitement, enterprises are now seeking those generative-AI applications that can drive sustainable returns on investment (ROI) over longer periods of time. As previously stated, Gartner believes that generative AI has moved over the "peak of inflated expectations" but still remains in that phase, just a little further along in the process. That said, we expect multiple applications to develop as the technology becomes even more widespread and ingrained into our everyday lives, similar to e-commerce and search. However, the pace at which those cutting-edge applications are developed will determine how long the technology stays within the "trough of disillusionment" phase. We believe that phase may be shorter than typical, particularly as the focus around the technology remains and capital continues to flow in to develop those applications. Yet, if the capital runs dry and app development slows to a crawl, widespread deployment of generative-AI uses could be at risk.

However, applications and use cases for the technology should develop over time. For example, we expect several companies to attempt to bring the technology closer to the end user (consumer). New handsets have been released that include an expanding range of AI capabilities, including Apple's next-generation iPhone 16 that was announced in September and Alphabet's updated Pixel 9 handset that was launched in August. Both feature generative-AI capabilities, bringing the power of large language models into the users' hands. Further, we believe we are in the early stages of the transformation of the PC market and expect laptop and desktop computer hardware to be embedded with AI functionality. This anticipated upgrade cycle follows slower demand and ongoing supply chain issues related to the pandemic in addition to slower PC upgrades over the past few years, due somewhat to a lack of innovation and new features.

Valuation snapshot

On October 1, 2024, the broader NASDAQ Composite Index traded at a next-12-months price-to-earnings (NTM P/E) valuation of approximately 27x (Chart 9). This represented a 23% premium to the approximate 22x NTM P/E valuation of the S&P 500 Index, much lower than the elevated 48% premium seen on July 28, 2023. The Nasdaq's NTM P/E valuation of 27x trades at a modest premium to the 25% calendar-year 2025 consensus earnings per share (EPS) growth rate of the NASDAQ Composite Index as of October 1, 2024 (according to FactSet data).

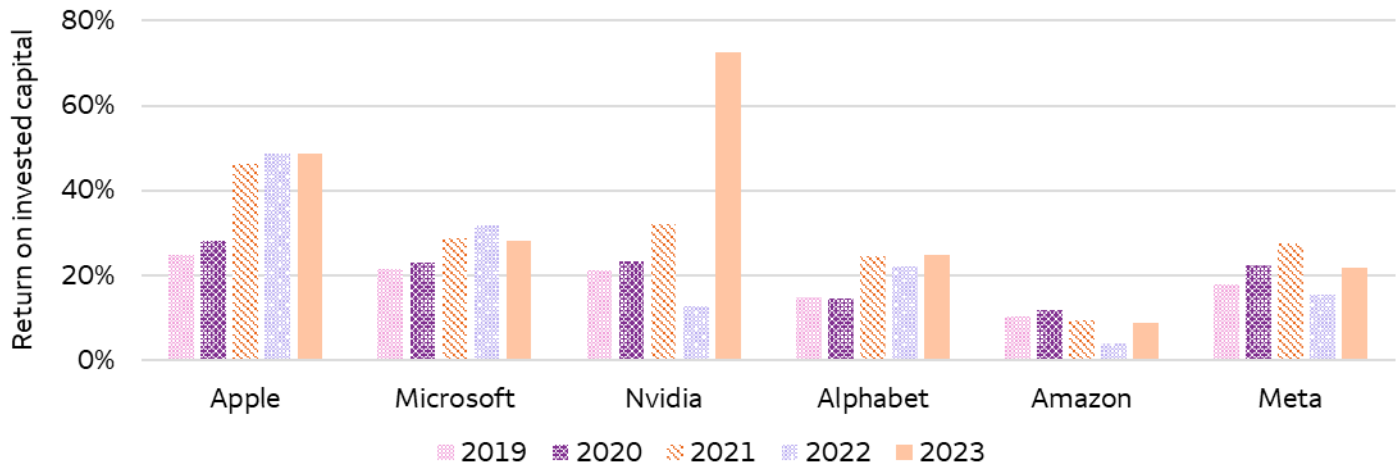
Chart 9: Valuation of the Magnificent 7 relative to the Nasdaq Index and S&P 500 Index



Sources: FactSet and Wells Fargo Investment Institute. Data as of October 1, 2024. An index is not managed and not available for direct investment. **Past performance is not a guarantee of future results.**

The narrow group of stocks often referred to as the Magnificent Seven (Alphabet, Microsoft, Nvidia, Meta Platforms, Amazon, Tesla, Inc., and Apple) have various amounts of exposure to generative AI and have benefited to various extents from the generative-AI trend over the past few years. According to our estimates, the Magnificent Seven's median NTM P/E of 31x traded at a premium to the Nasdaq Index's NTM P/E of 27x and the S&P 500 Index's NTM P/E of 22x. We do not view this valuation as egregious, and it is down from the peak median NTM P/E valuation of 34x on June 30, 2024. Further, we believe the premium valuation is warranted given the above-average return on invested capital seen in many of the Magnificent Seven companies (Chart 10). Ultimately, investors may extrapolate the growth potential for generative AI in a linear fashion out into the future, but we believe we remain in early innings of generative-AI technology deployments and the discovery of relevant use cases. In our view, the growth potential of the technology is large yet unpredictable, and performance could be choppy from quarter to quarter.

Chart 10: Above-average return on invested capital across most mega-cap tech companies



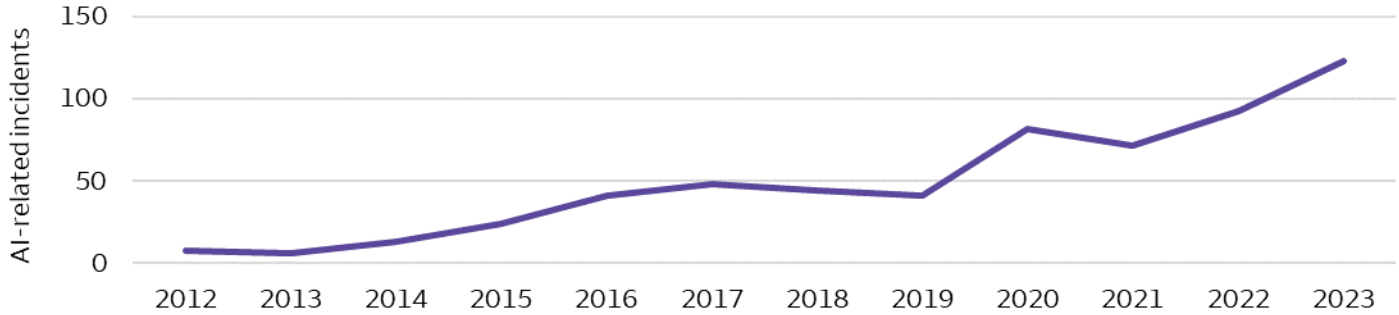
Sources: Bloomberg and Wells Fargo Investment Institute. Data as of September 18, 2024. **Past performance is no guarantee of future results.**

Global Securities Research and Global Investment Strategy

Potential pitfalls, challenges, and risks of AI

The rise of generative AI is similar to the development and advancement of other disruptive technologies — while the technology and infrastructure may be there, broader acceptance and scalability may still be lacking. The technology has the potential to be broadly transformative, but there are many outstanding questions and concerns that need to be addressed before it is widely accepted on a larger scale, evidenced by the increasing number of AI-related incidents (Chart 11). The AI Incident Database (AIID) tracks examples of ethical misuse of AI, including autonomous cars causing pedestrian fatalities or facial recognition systems leading to wrongful arrests.

Chart 11: Increase in the number of AI incidents from 2012 through 2023



Sources: Wells Fargo Investment Institute; AI, Incident Database (AIID), "The AI Index 2024 Annual Report," April 2024. Data through year-end 2023. The AIID is a public database that tracks instances of ethical misuse of AI.

From a higher level, obstacles related to the development, advancement, and widespread acceptance of AI include the cost of developing effective models, challenges ensuring accurate outcomes, and potential impacts on the workforce. There are also geopolitical and regulatory risks and challenges, potential impacts on society, behavioral issues, and concerns around potential infringement of intellectual property (for example, copyright and trademark infringement).

While difficult to predict, we also expect that security will likely be an issue, tied to the threat of new generative-AI capabilities being used to breach unsecured networks. Consequently, cyberattacks and data breaches could accelerate if generative-AI models are not secure and are accessible to bad actors. As such, cybersecurity firms will rely on data sharing, partnerships, and machine learning to uncover behavioral patterns in efforts to protect the network and sensitive data.

Labor market disruptions

Labor markets are among the areas most exposed to AI's potentially disruptive effects, in tandem with the potential lift to productivity. Generative AI's impact on the labor market likely will be more nuanced than more traditional AI systems. Earlier AI systems have been geared more toward automation that jeopardizes jobs in an array of labor-intensive services industries, from food services to office support to customer service and sales jobs, which are likely benefiting from more advanced generative AI as well. We expect generative AI's disruptive effect on the labor market to mirror other forms of automation — as in the past, its impact likely will be mitigated over time by new occupations spawned by the innovations themselves. If this seems difficult to envision, a recent MIT study estimated that 60% of U.S. workers are now employed in occupations that did not exist 84 years ago.[15] Adoption lags have steadily declined as technology has advanced, so we expect new industries and new roles to emerge faster this time.[16]

Sectors most exposed to generative AI's potential effects on the workplace include knowledge-based activities in financial services, such as trading and asset management, along with support workers in technology, professional services, and other knowledge-based industries. We see divergent impacts on individuals in different types of positions — for example, research project leaders who build and evaluate the models should find generative AI to be a valuable tool with the potential to increase the value of their work and their compensation. However, AI likely will reduce demand for professional-service support roles, such as research analysts or administrative assistant roles. This has already been observed, to some extent. For example, from 2012 to 2022, job growth for more cognitive-intensive positions (that is, information, financial, and business services) outpaced the overall total by 0.7%. However, the trend has already reversed with the introduction of AI — total nonfarm payroll growth outpaced more cognitive-oriented roles by 0.8% from July 2022 to July 2024.[17] The unequal boost from generative AI, which is skewed toward knowledge-based workers with higher pay, risks aggravating income inequality and inviting legislation slowing AI's absorption into the economy.

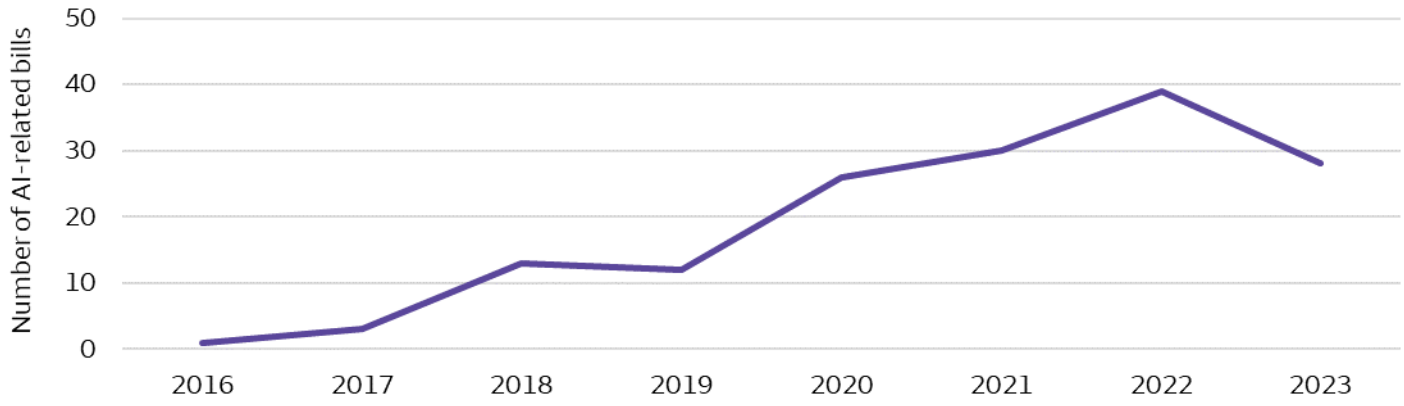
Government regulation

Government regulation is a second, highly visible uncertainty in the outlook for generative AI development and acceptance. Thus far, initiatives have ranged from industry pledges of voluntary safety guardrails in the deployment of new products to Federal Trade Commission requests for companies' details related to integration of AI into their operations. More importantly, exposure to copyright challenges could potentially impede the development of generative AI's large language models. The role of government regulation in addressing some of the risks discussed in this section continues to be debated. Governments around the world are becoming increasingly involved in the regulation of AI, based partly on concerns about societal impacts and data privacy.

15. Peter Dizikes, "Most work is new work, long-term study of U.S. census data shows," MIT News, April 1, 2024.
16. Ibid, Capital Economics.
17. Based on monthly nonfarm payrolls data from the Bureau of Labor Statistics.

As governments worldwide attempt to regulate AI, we think these efforts need to be balanced and measured appropriately to prevent any potential slowdown in the pace of innovation for generative AI going forward. According to Stanford University's AI Index (Chart 12), the total number of AI-related bills passed into law in select countries has shown a noticeable increase from only one bill passing in 2016 to 28 passing in 2023.

Chart 12. Number of AI bills passed into law in select countries (2016 – 2023)



Sources: Wells Fargo Investment Institute and Stanford University Institute for Human-Centered AI, "The AI Index 2024 Annual Report," April 2024.

The U.S. government is currently lagging the European Union in its AI-related legislation, partly because of partisan divisions and partly because of its caution in not impeding the development of emerging national champions. Slow legal action by the federal government has left an opening for more state laws to be passed in 2023 addressing perceived threats from automated systems. These laws have included restrictions on the use of AI in political advertisements, general advertisements, gambling, hiring, and other activities.

The Biden Administration has been working to update and expand upon its 2023 executive order on safe, secure, and trustworthy AI. Last year, the Biden Administration brought together seven leading AI companies, and each made a voluntary commitment to act responsibly in properly managing the risks of the new technology. The companies' pledges centered around making sure new AI-related products are safe before they are introduced to the public as well as investing in cybersecurity and proper safeguards to protect models — all working toward preventing harmful bias and discrimination and protecting privacy.[18]

Legislative action in the U.S. has shifted to individual states, including California and Colorado. On August 28, 2024, California's Democrat-controlled legislature passed the bill SB 1047, or the Safe and Secure Innovation for Frontier Artificial Intelligence Models Act. The bill is focused on ensuring AI developers meet strict safety criteria before training their large language models. The bill penalizes AI developers for adverse consequences that lead to death or bodily harm to another human, harm property, etc. On September 29, 2024, California Governor Gavin Newsom vetoed the SB 1047 bill.

The European Union (EU) published the final AI Act, effective August 1, 2024. The EU's AI Act is widely considered the most comprehensive piece of AI-related legislation. The AI Act buckets AI applications into three risk categories. The first risk category includes AI applications and systems that are deemed to create an unacceptable risk, such as government-run social scoring or manipulative AI. The second risk category includes high-risk applications, such as resume scanning tools that rank job applicants. The final risk category includes AI applications not banned or classified as a high-risk application, which are mostly left unregulated.

18. The White House, "Fact Sheet: Biden-Harris Administration Secures Voluntary Commitments from Leading Artificial Intelligence Companies to Manage the Risks Posed by AI," July 21, 2023.

China's regulatory framework concerning AI continues to evolve. Compared to the U.S., China has a more targeted and iterative approach to AI regulations. The first comprehensive set of finalized generative AI rules, referred to as the Interim Measures for Managing Generative AI Services, became effective on August 15, 2023. On December 1, 2023, measures for review of scientific and technological ethics (including businesses engaged in AI) became effective.

Escalating costs and energy requirements

Immediate issues in generative-AI implementation include both the computing power and cost of data-intensive model development. At the moment, the costs associated with developing, training, and managing generative-AI large language models effectively are fairly prohibitive as these models are very compute-, semiconductor-, networking-, and storage-intensive. The cost for training large language models is quite expensive, although less so for inference, which occurs when the already trained large language model is prompted for a response. Consequently, we believe there will be a significant increase in hardware demand, notably within the data-center environment, to accommodate the substantial increase in AI workloads. We do not believe that companies have reached the point of scaling the technology to be profitable. Currently, the costs per query on a platform like ChatGPT are multiples higher than well-established search engines like Google Search or Microsoft Bing. In our view, it may take a number of years to increase the operational efficiency of various large language models and decrease costs to a level more in-line with existing search engines. Elsewhere, data-center operators have begun to raise commercial lease rates to cover more limited computer capacity and added power costs of running energy-intensive AI-related workloads.

Power supply is key to operating a data center, so most facilities have redundancies in place to help avoid downtime. The causes of outages within data centers usually center around a few categories, including design; capacity issues; hardware failures (due to overheating or cooling issues); human error; environmental events; or even power disruptions. Power requirements for an AI-equipped data center have been compared to the power usage of a moderately sized city. As such, access to reliable, uninterrupted power is a requirement.

From a geographic perspective, data centers are fairly concentrated within the U.S. In fact, more than half of the data centers within the U.S. are located within a handful of states, including Virginia, California, Texas, Ohio, Illinois, and New York. Although data centers are currently located near major hubs around the country, we expect the coverage of data centers to expand geographically over time. Greenfield opportunities to expand the data-center footprint remain. Yet, as the opportunities to expand diminish, companies may revisit existing data-center locations to retrofit and upgrade hardware and infrastructure in support of the power and data-consumption needs of new AI technologies. A growing trend outside of the U.S. has been countries investing in sovereign AI, which refers to a nation's ability to utilize generative AI supported by localized data-center infrastructure investments, proprietary data, and networks to protect its national security.

Given the amount of data points and information collected as more and more devices are connected to the cloud, businesses have become dependent on data centers. Revenue may therefore be lost as a result of the outage, or data-center operators may even be required to reimburse customers for lost revenue while the outage occurred. Further, the data-center operator may be exposed to reputational risk in the event of an outage, possibly indicating a lack of adequate controls and measures to ensure security of information. Other potential types of risks or losses that could result from extended downtime include business interruption and lower productivity. Although eliminating outages altogether may be impossible, maintaining proper controls could help to mitigate the adverse impacts resulting from an outage.

Accuracy concerns

Issues have arisen around ChatGPT and other large language models providing answers with conviction that turn out to be inaccurate. Since the large language models were trained on the structure of language, these models are more focused on the structure of which word or what concept comes next and less focused on whether the answer is accurate. The risks

associated with hallucinations or inaccurate outcomes may be reduced with more high-quality parameters being entered into the large language model during the training phase — the model is only as useful as the quality of the data the model is using to produce an outcome.

Data quality is relevant because large language models are dependent on the quality and depth of the datasets they are utilizing to determine an output. As the saying goes: garbage in, garbage out. If the model is trained on stale or outdated data, the output will likely be poor and undependable as well. Consequently, it is vital to know how the model was trained and developed to better appreciate the outcomes the model produces. However, over time, we expect the accuracy of these large language models to improve as updated versions that incorporate a higher number of parameters manage to tweak the inaccuracies of prior versions.

Just a few years ago, models utilized millions of parameters when training their models. For example, the parameter count for Alphabet's Bidirectional Encoder Representations from Transformers (BERT) was 110 million in 2018. That figure has exploded, with the third version of OpenAI's ChatGPT (ChatGPT-3) utilizing more than 175 billion parameters during its training phase while it is estimated that the fourth version (ChatGPT-4) utilizes more than 1 trillion parameters. This hypergrowth of variable usage has resulted in a much more complex process to provide an outcome to an AI-related query. It has also contributed to GPUs becoming one of the most important components used for training generative-AI-based large language models.

Geopolitical risks

We have witnessed escalating trade tensions between China and the U.S. since 2018, and U.S. export controls for key semiconductor technology continue to escalate with the intent of limiting China's ability to build out its own independent semiconductor ecosystem. The ratcheted export restrictions since 2022 have limited China's access to critical next-generation semiconductor chips and equipment. However, this has led to China focusing its domestic investments in more localized companies at the expense of U.S.-based semiconductor suppliers.

Driven by concerns over national security, the U.S. restrictions, along with the Netherlands and Japan, have placed undue pressure on China's ability to compete and thrive in generative AI. On September 6, the U.S. Department of Commerce introduced new export controls for critical technologies, including quantum computing and semiconductor goods. The export controls cover quantum computers and components, advanced chipmaking tools, software related to metals and metal alloy, and high-bandwidth memory semiconductor chips used in generative-AI applications.

Other recent developments indicate similar tensions. For example, on September 6, the Dutch government said it will expand export-licensing requirements to China for ASML Holding NV's deep ultraviolet (DUV) immersion lithography tools, in line with export restrictions imposed by the U.S. last year. Earlier in September, Bloomberg reported China threatened material economic retaliation against Japan should Japan align with the U.S. and further restrict sales of critical semiconductor capital equipment to Chinese companies. China could react to the new stricter export controls by hindering Japan's access to critical minerals needed for automotive production. Additionally, last year, China imposed export restrictions targeting U.S. semiconductor companies for key minerals used in semiconductor and electric-vehicle production including gallium, germanium and graphite.

We believe the tense geopolitical environment between the U.S. and China as well as concerns over China's adverse use of AI for military purposes will contribute to headline risk, resulting in potential equity share-price volatility for AI-related semiconductor equities.

Overview of investment ideas

From a sector-level perspective, we expect the Information Technology and Communication Services sectors (rated neutral and favorable, respectively, by Global Investment Strategy) to benefit the most in the coming years from the modern evolution of AI, particularly within semiconductors and application software. Consequently, we upgraded the Semiconductors sub-sector to favorable in May and remain favorable on the Software sub-sector. Privacy and security issues around the technology also exist along with numerous obstacles the industry may need to overcome to get it to scale. However, these issues should increase focus around the cybersecurity names, notably those that are cloud native (that is, applications or business models suited to run on the cloud).

We also see opportunities among companies that focus on various product lines across multiple and converging AI trends. One important example is the convergence of augmented and virtual reality, the internet of things, and connected devices. In our view, companies that helped build out previous iterations of the internet are the most likely to create the infrastructure necessary to support the new and innovative technologies.

We also foresee that the companies with large pools of available cash and high-quality datasets should ultimately have the opportunity to outperform across multiple long-term technology trends. Many of these companies accumulated large datasets through their research and development efforts. We expect that software companies will make new investments that move quickly to include generative AI in their product sets.

AI-based deep-learning applications are compute-, network-, and semiconductor-intensive, and we favor semiconductor companies exposed to the development and implementation of AI. Modern advances in GPU architecture, such as parallel processing architecture, have been crucial in powering modern AI advancements. GPU chips are used to train the majority of deep neural networks used in deep learning tasks. Leading GPU chip suppliers appear well positioned to benefit from the proliferation of AI, and we expect leading semiconductor companies to benefit from supporting generative-AI models. We also expect generative-AI applications to help drive demand for semiconductor-related equipment in the coming years.

Some other sectors may be somewhat underappreciated in terms of generative-AI exposure, primarily the Industrials and Materials sectors. Materials may not be the first sector that comes to mind in relation to AI, yet there are a number of companies within the sector experiencing significant growth from the AI evolution. This includes increased demand for materials that are used in the production of semiconductor chips, water handling and recycling within data centers, and steel and construction materials used to build data centers.

Within Industrials, while data centers may not technically be a factory, the build and operation of the sites are quite similar. The uses of data centers continue to evolve, especially with the development and widespread acceptance of generative-AI applications. However, data centers are facing challenges related to energy consumption and heat dissipation, both of which are linked to the high-risk issue of power outages. To put it in perspective, Amazon recently purchased a 960 megawatt data center for $650 million, which is quite large relative to prior generations of data centers. We note that this figure only represents the cost of building the facility and basis utilities connections, but it does not include the filling of the facility with server racks and other equipment. We provide this example to give some scale to how large the capital investments will be to further build out the AI data-center landscape. Power disruption has often been cited as one of the leading causes to data center outages, so access to an uninterrupted, reliable source of power will also be necessary.

Ultimately, a single winner-take-all in the AI space is unlikely. Rather, we anticipate a handful of outperformers to emerge from a select group of companies with access to significant financial resources, high-quality datasets, and cutting-edge AI data scientists. Finally, specific investment ideas can be found in the following pages.

Global Securities Research

Individual equity investment ideas

Table 2: Companies with direct exposure to generative AI

Ticker	Company name	Market price	Market cap (billions)	Estimated NTM EPS	NTM P/E	Large language model and cloud infrastructure providers	Semiconductor, networking, storage, and AI server suppliers	Electronic design automation software	Enterprise software providers	Cybersecurity software providers
ADBE	Adobe Inc.	$503.80	$221.8	$20.2	24.98				X	
AMD	Advanced Micro Devices, Inc.	$162.85	$263.6	$5.0	32.69		X			
GOOGL	Alphabet Inc. Class A	$165.86	$2,041.7	$8.4	19.69	X				
AMZN	Amazon.com, Inc.	$181.96	$1,909.8	$5.6	32.56	X				
AAPL	Apple Inc.	$225.67	$3,431.1	$7.4	30.37	X				
AMAT	Applied Materials, Inc.	$199.59	$164.5	$9.6	20.69		X			
ANET	Arista Networks, Inc.	$390.11	$122.6	$9.1	42.72		X			
ASML	ASML Holding NV ADR	$832.41	$327.5	$29.4	28.30		X			
AVGO	Broadcom Inc.	$171.89	$802.8	$6.1	28.26		X		X	X
CDNS	Cadence Design Systems, Inc.	$265.79	$72.8	$6.7	39.92			X		
CHKP	Check Point Software Technologies Ltd.	$190.90	$21.0	$9.8	19.45					X
CSCO	Cisco Systems, Inc.	$52.43	$209.2	$3.6	14.48		X			X
CRWD	CrowdStrike Holdings, Inc. Class A	$283.75	$69.6	$4.1	69.97					X
HPE	Hewlett Packard Enterprise Co.	$20.35	$26.4	$2.1	9.67		X			
MRVL	Marvell Technology, Inc.	$72.24	$62.6	$2.2	33.33		X			
META	Meta Platforms Inc Class A	$582.77	$1,474.3	$23.5	24.78	X			X	
MSFT	Microsoft Corporation	$416.54	$3,096.2	$13.8	30.25	X			X	X
NVDA	NVIDIA Corporation	$122.85	$3,013.5	$3.6	33.72		X			
ORCL	Oracle Corporation	$166.86	$462.4	$6.6	25.37	X			X	
PANW	Palo Alto Networks, Inc.	$335.94	$109.4	$6.4	52.25					X
QCOM	QUALCOMM Incorporated	$168.92	$188.2	$11.2	15.11		X			
CRM	Salesforce, Inc.	$280.91	$268.5	$10.8	26.01				X	
NOW	ServiceNow, Inc.	$890.64	$183.5	$15.9	56.18				X	
SNPS	Synopsys, Inc.	$495.41	$76.1	$14.8	33.43			X		
TSM	Taiwan Semiconductor Manufacturing Co., Ltd.*	$179.48	$930.8	$7.9	22.68		X			
TSLA	Tesla, Inc.	$240.66	$768.8	$2.9	82.15	X				
WDAY	Workday, Inc. Class A	$240.94	$64.1	$7.9	30.39				X	

Sources: FactSet, Wells Fargo Investment Institute, company reports. NTM = next twelve months. EPS = earnings per share. P/E = Price to earnings. P/E ratio based on the next 12 months EPS. Prices and data as of October 3, 2024. Investments are subject to risk of loss, AI investment ideas are not comprehensive of all securities currently included on the GSR thematic Lists. See following page for description of each list referenced. *Sponsored ADR

Investment ideas constitute general information and are not tailored or directed to any particular investor and are not intended to be the sole basis for investment decisions. Individual equities listed may be held in portfolios independently developed by WFII's Managed Solutions and Global Portfolio Management. Holdings in these portfolios are subject to change at any time.

Table 3: Companies with indirect exposure to generative AI

Ticker	Company name	Sector	Market price	Market cap (billions)	Estimated NTM EPS	NTM P/E	Data center equipment	Related infrastructure
CAT	Caterpillar Inc.	Industrials	$391.09	$189.6	$22.7	17.22	X	X
ETN	Eaton Corp. Plc	Industrials	$326.96	$130.2	$11.7	27.91	X	X
HUBB	Hubbell Incorporated	Industrials	$425.90	$22.9	$17.4	24.53	X	X
TT	Trane Technologies plc	Industrials	$386.93	$87.3	$12.0	32.23	X	
EMR	Emerson Electric Co.	Industrials	$109.63	$62.8	$5.9	18.45		X
APH	Amphenol Corporation Class A	Information Technology	$62.07	$74.8	$2.0	31.24	X	
HPE	Hewlett Packard Enterprise Co.	Information Technology	$20.35	$26.4	$2.1	9.67	X	
DD	DuPont de Nemours, Inc.	Materials	$87.14	$36.4	$4.2	20.53		X
ECL	Ecolab Inc.	Materials	$250.77	$71.4	$7.3	34.40		X
MLM	Martin Marietta Materials, Inc.	Materials	$521.23	$31.9	$21.4	24.31		X
NUE	Nucor Corporation	Materials	$151.29	$35.9	$10.4	14.57		X
EQIX	Equinix, Inc.	Real Estate	$876.22	$83.2	$37.1	23.60		X

Sources: FactSet, Wells Fargo Investment Institute, company reports. NTM = next twelve months. EPS =earnings per share. P/E = Price to earnings. P/E ratio based on the next 12 months EPS. Prices and data as of October 3, 2024. Investments are subject to risk of loss, AI investment ideas are not comprehensive of all securities currently included on the GSR thematic Lists. See following page for description of each list referenced. *Sponsored ADR

Investment ideas constitute general information and are not tailored or directed to any particular investor and are not intended to be the sole basis for investment decisions. Individual equities listed may be held in portfolios independently developed by WFII's Managed Solutions and Global Portfolio Management. Holdings in these portfolios are subject to change at any time.

Global Manager Research

Mutual fund, SMA, and ETF investment ideas

Equity mutual fund, separately managed account (SMA), and exchange-traded fund (ETF) investment ideas are provided by Global Manager Research.

Table 4: Mutual fund, SMA, and ETF investment ideas

Name	Vehicle	Symbol[1]	Symbol[2]	Assets (billion)[3]	Asset group	Asset class
JPMorgan Large Cap Growth Fund	Mutual Fund	SEEGX	JLGMX	$94.1	Global Equity	Large Cap Growth
JPMorgan Large Cap Growth SMA	SMA			$147.2	Global Equity	Large Cap Growth
Harbor Capital Appreciation Fund	Mutual Fund	HACAX	HNACX	$30.0	Global Equity	Large Cap Growth
Jennison Large Cap Growth Equity SMA	SMA			$91.9	Global Equity	Large Cap Growth
Xtrackers MSCI USA ESG Leaders Equity Fund	ETF	USSG	USSG	$1.0	Global Equity	Large Cap Core
MFS Technology Fund	Mutual Fund	MTCIX	MTCLX	$2.0	Global Equity	Sector — Information Technology
iShares U.S. Technology Fund	ETF	IYW	IYW	$20.0	Global Equity	Sector — Information Technology

Sources: Morningstar and Wells Fargo Investment Institute. 1. Fund is offered by Wells Fargo Advisors 2. Fund is offered by Wells Fargo Bank, N.A. 3. Data as of June 30, 2024. Investments are subject to risk of loss. See end of report for important disclosures. Investment ideas constitute general information and are not tailored or directed to any particular investor and are not intended to be the sole basis for investment decisions.

U.S. Large Cap Equities

JPMorgan Large Cap Growth Fund (SEEGX, JLGMX)* and JPMorgan Large Cap Growth SMA

The JPMorgan Large Cap Growth Fund (the Fund) is a large-cap growth fund with a moderately higher risk profile than the GMR benchmark, the Russell 1000 Growth Index, but has a record of performing well across various market environments. It seeks stocks with sustainable competitive advantages in large addressable markets undergoing change. The Fund views change and the resulting improvement in financial performance as a leading catalyst for stock outperformance. Price momentum of stocks is also a factor used. Despite this, the Fund exhibits low turnover and seeks to minimize downside risks. We believe it is well positioned around AI, the current predominant investment theme in technology. At the time of this writing, the Fund owns several AI-focused stocks that are highlighted in this report. We believe the Fund expects to own companies across various industries that it believes will be beneficiaries of the adoption of AI in the long term.

The JPMorgan Large Cap Growth SMA is managed in a similar fashion to the Fund by the same team led by the lead portfolio manager since 2005.

*SEEGX is offered by Wells Fargo Advisors and JLGMX is offered by Wells Fargo Bank, N.A.

Harbor Capital Appreciation Fund (HACAX, HNACX)* and Jennison Large Cap Growth Equity SMA

The Harbor Capital Appreciation Fund (the Fund) is a large-cap growth fund with a moderately higher risk profile than the GMR benchmark, the Russell 1000 Growth Index, but has a record of performing well across economic cycles. The Fund has tended to outperform when growth is in favor and underperformed when value is in favor. Jennison Associates (Jennison) has served as sub-adviser to the Fund since 1990. The seasoned management team averages more than three decades with Jennison, primarily as portfolio managers (PMs) on the Fund. The PMs balance owning both faster-growing companies and stable growth companies while maintaining a long-term time horizon and monitoring and investing in secular trends such as AI. At the time of this writing, the Fund owns several AI-focused stocks that are highlighted in this report. It tends to seek above-average growers, so it sees AI as a key growth driver over time for many of its holdings.

The Jennison Large Cap Growth Equity SMA is managed in a similar fashion to the Fund by the same long-tenured team.

*HACAX is offered by Wells Fargo Advisors and HNACX is offered by Wells Fargo Bank, N.A.

Xtrackers MSCI USA ESG Leaders Equity Fund (USSG)

The Xtrackers MSCI USA ESG Leaders Equity Fund (the Fund) tracks a modified market-cap index that provides exposure to companies with high environmental, social, and governance (ESG) performance relative to their sector peers. The Fund's underlying index is the MSCI USA ESG Leaders Index (the Index), which uses MSCI ESG Ratings to determine its constituents. Companies are rated based on how well they manage their ESG risks and opportunities; those with the highest ratings are included in the Index. The Fund employs a full replication methodology in seeking to track the Index, meaning that it generally invests in all the securities comprising the underlying index in proportion to their weightings in the underlying index. The index that the Fund tracks is designed for investors seeking a broad, wide-ranging sustainability benchmark with relatively low tracking error (how closely the fund follows its index) to the underlying equity market. The Fund is a diversified portfolio consisting of approximately 275 securities; its size and trading volume allows it to have a high liquidity. It is invested primarily in large-cap companies, with its top ten holdings representing a very large percentage of the portfolio. The Fund's underlying holdings represent companies that focus on transformational growth and intellectual property across the globe. It may have limited direct exposure to AI companies, but it has strong exposure to companies that may be beneficiaries of the adoption of AI in the long term.

Information Technology sector

MFS Technology Fund (MTCIX, MTCLX)*

The MFS Technology Fund (the Fund) is a sector fund with a moderately lower risk profile than the S&P 500 Information Technology Index. The Fund seeks to identify stocks with accelerating revenue growth or margin expansion opportunities that are attractively priced. It has a broad and flexible mandate which allows fund assets to be allocated across industries, market capitalizations, styles, and geographies while typically avoiding extremely cyclical stocks. Given its inherent focus on technology and innovation, it will own stocks involved in AI. The PM has also been the lead technology sector analyst for MFS Investment Management for more than two decades. It is focused on technology across all industries, many of which we expect should benefit from the continued adoption of AI. It tends to own many of the large AI-focused stocks that are highlighted in the report. The Fund may also own stocks focused on innovation and change, like AI, that may offer above-average growth prospects.

*MTCIX is offered by Wells Fargo Advisors and MTCLX is offered by Wells Fargo Bank, N.A.

iShares U.S. Technology Fund (IYW)

The iShares U.S. Technology Fund (the Fund) tracks a modified market-cap index that provides exposure to U.S. equities in the Information Technology sector. It employs a full replication methodology in seeking to track the underlying index, meaning that it generally invests in all the securities comprising the underlying index in proportion to their weightings in the underlying index. The Fund seeks to provide broad exposure to technology companies with a diversified industry allocation. It is a diversified portfolio consisting of approximately 140 securities; its size and trading volume allows it to have high liquidity. The Fund is invested primarily in large-cap companies, with its top ten holdings representing a very large percentage of the portfolio. Underlying holdings represent companies that focus on transformational growth and intellectual property across the globe. The Fund may have limited direct exposure to AI companies, but it has strong exposure to companies that may be beneficiaries of the adoption of AI in the long term.

Definitions:

An index is unmanaged and not available for direct investment.

MSCI USA ESG Leaders Index is a free float-adjusted market capitalization-weighted index designed to represent the performance of companies that are selected from the MSCI USA Index based on Environmental, Social and Governance (ESG) criteria.

NASDAQ Composite Index measures the market value of all domestic and foreign common stocks, representing a wide array of more than 5,000 companies, listed on the NASDAQ Stock Market.

Russell 1000® Growth Index measures the performance of those Russell 1000 companies with higher price-to-book ratios and higher forecasted growth values. Russell 1000® Index measures the performance of the 1,000 largest companies in the Russell 3000 Index, which represents approximately 90% of the total market capitalization of the Russell 3000 Index. Russell 3000® Index measures the performance of the 3,000 largest U.S. companies based on total market capitalization, which represents approximately 98% of the investable U.S. equity market.

S&P 500 Index is a market capitalization-weighted index composed of 500 widely held common stocks that is generally considered representative of the US stock market.

S&P 500 Information Technology Index comprises those companies included in the S&P 500 that are classified as members of the GICS® information technology sector.

Stanford University AI Index tracks, collates, distills, and visualizes data relating to artificial intelligence.

Mutual funds and exchange traded funds are sold by prospectus. Please consider the investment objectives, risks, charges and expenses carefully before investing. The prospectus, which contains this and other information, can be obtained by contacting the fund company. Investors should read it carefully before investing.

IMPORTANT DISCLOSURES

Global Securities Research Analyst or household member owns a long common equity position in AAPL and ORCL.

One or more members of Global Securities Research leadership owns a long common equity position in AAPL, AMZN, AVGO, CSCO, EMR, MSFT, NVDA, and TSLA.

Analyst Certification: The analyst who prepared this report hereby certifies that the views expressed in this report accurately reflect his/her personal views about the subject companies and their securities. The analyst also certifies that he/she has not been, is not, and will not be receiving direct or indirect compensation for expressing the specific recommendation(s) or view(s) in this report.

WFII analysts receive no compensation in connection with the firm's investment banking, sales and trading, or principal trading revenues. Analysts may be eligible for annual bonus compensation based on the overall profitability of the firm, which takes into account revenues derived from the firm's business activities, including its investment banking business, sales and trading, and principal trading.

Important Disclosures relating to Wells Fargo Clearing Services, LLC and Wells Fargo Advisors Financial Network, LLC as broker-dealers distributing Wells Fargo Investment Institute prepared research reports:

Wells Fargo Clearing Services, LLC (WFCS) and Wells Fargo Advisers Financial Network, LLC (WFAFN) provide their customers with access to third-party research, including this report, which is produced by Wells Fargo Investment Institute, Inc.

To review important information about certain relationships and potential or actual conflicts of interest that may exist between WFCS, WFAFN, their affiliates, and any company that may be the subject of or part of a list that is the subject of this report, please visit the Research Disclosure page of wellsfargoadvisors.com as provided below.

https://www.wellsfargoadvisors.com/disclosures/research.htm

WFCS and/or WFAFN trades or may trade as principal in fixed-income and preferred securities (or in related derivatives).

Disclaimers

There is no guarantee the Funds or Strategies will meet their investment objectives. All investing involves risk including the possible loss of principal.

All investments are subject to market risk, which means their value may fluctuate in response to general economic and market conditions, the prospects of individual companies, and industry sectors due to numerous factors, some of which may be unpredictable.

Be sure you understand and are able to bear the associated market, liquidity, credit, yield fluctuation, and other risks involved in an investment in a particular strategy.

Equity securities are subject to market risk which means their value may fluctuate in response to general economic and market conditions and the perception of individual issuers. Investments in equity securities are generally more volatile than other types of securities. An investment that is concentrated in a specific sector or industry increases its vulnerability to any single economic, political or regulatory development affecting that sector or industry. This may result in greater price volatility.

Risks associated with the Technology sector include increased competition from domestic and international companies, unexpected changes in demand, regulatory actions, technical problems with key products, and the departure of key members of management. Technology and Internet-related stocks, especially smaller, less-seasoned companies, tend to be more volatile than the overall market.

There are no guarantees that growth or value stocks will increase in value or that their intrinsic values will eventually be recognized by the overall market. The return and principal value of stocks fluctuate with changes in market conditions. The growth and value type of investing tends to shift in and out of favor.

Investing in foreign securities presents certain risks not associated with domestic investments, such as currency fluctuation, political and economic instability, and different accounting standards. This may result in greater share price volatility. These risks are heightened in emerging markets.

'Sustainable' or 'Social Impact' investing focuses on companies that demonstrate adherence to environmental, social and corporate governance (ESG) principles, among other values. There is no assurance that social impact investing can be an effective strategy under all market conditions or that a strategy's holdings will exhibit positive or favorable ESG characteristics. Different investment styles tend to shift in and out of favor. In addition, an investment's social policy could cause it to forgo opportunities to gain exposure to certain industries, companies, sectors or regions of the economy which could cause it to underperform similar portfolios that do not have a social policy. Risks associated with investing in ESG-related strategies can also include a lack of consistency in approach and a lack of transparency in manager methodologies. In addition, some ESG investments may be dependent on government tax incentives and subsidies and on political support for certain environmental technologies and companies. The ESG sector also may have challenges such as a limited number of issuers and liquidity in the market, including a robust secondary market. There are many factors to consider when choosing an investment portfolio and ESG data is only one component to potentially consider. Investors should not place undue reliance on ESG principles when selecting an investment.

Global Securities Research (GSR) and Global Investment Strategy (GIS) are divisions of Wells Fargo Investment Institute, Inc. (WFII). WFII is a registered investment adviser and wholly owned subsidiary of Wells Fargo Bank, N.A., a bank affiliate of Wells Fargo & Company.

The information in this report was prepared by Global Securities Research (GSR). Opinions represent GSR's opinion as of the date of this report and are for general information purposes only and are not intended to predict or guarantee the future performance of any individual security, market sector, or the markets generally. GSR does not undertake to advise you of any change in its opinions or the information contained in this report. Wells Fargo & Company affiliates may issue reports or have opinions that are inconsistent with, and reach different conclusions from, this report. Past performance is no guarantee of future results.

The information contained herein constitutes general information and is not directed to, designed for, or individually tailored to, any particular investor or potential investor. This report is not intended to be a client-specific suitability or best interest analysis or recommendation, an offer to participate in any investment, or a recommendation to buy, hold, or sell securities. Do not use this report as the sole basis for investment decisions. Do not select an asset class or investment product based on performance alone. Consider all relevant information, including your existing portfolio, investment objectives, risk tolerance, liquidity needs, and investment time horizon. The material contained herein has been prepared from sources and data we believe to be reliable, but we make no guarantee to its accuracy or completeness.

Global Securities Research works with information received from various resources including, but not limited to, research from affiliated and unaffiliated research correspondents as well as other sources. Global Securities Research does not assign ratings to or project target prices for any of the securities mentioned in this report.

Global Securities Research receives research from affiliated and unaffiliated correspondent research providers with which Wells Fargo Investment Institute has an agreement to obtain research reports. Each correspondent research report reflects the different

assumptions, opinions, and the methods of the analysts who prepare them. Any opinions, prices, or estimates contained in this report are as of the date of this publication and are subject to change without notice.

Global Securities Research publishes several theme-based lists of recommended equity securities. Each list is based on a specific investment objective and time horizon which may be different from the other lists. This may cause Global Securities Research to recommend an equity security to be added to one list and removed from another list. Thus, one list may contain different recommendations or conclusions that could result in short-term price movements contrary to the recommendations in another list.

Bank products and services are available through Wells Fargo Bank, N.A.

Wells Fargo Advisors is registered with the U.S. Securities and Exchange Commission and the Financial Industry Regulatory Authority but is not licensed or registered with any financial services regulatory authority outside of the U.S. Non-U.S. residents who maintain U.S.-based financial services account(s) with Wells Fargo Advisors may not be afforded certain protections conferred by legislation and regulations in their country of residence in respect of any investments, investment transactions, or communications made with Wells Fargo Advisors.

Wells Fargo Advisors is a trade name used by Wells Fargo Clearing Services, LLC and Wells Fargo Advisors Financial Network, LLC, Members SIPC, separate registered broker-dealers and non-bank affiliates of Wells Fargo & Company.