

Transformation

The AI evolution: Reality justifies the hype

03 November 2023

Key takeaways

- The newest wave of artificial intelligence - generative AI - will likely catalyze a corporate efficiency and productivity evolution that touches every sector globally over the next 5 to 10 years. Past disruptive technologies emerged over 15 to 30 years, but AI-driven efficiencies and revenue may appear as soon as the next 3 to 5 years - a faster pace than many expect.
- A survey of over 100 BofA Global Research equity analysts on AI's financial impact for the 3,500 companies covered globally found that analysts expect that three-quarters of covered companies will experience mild-to-strongly positive AI-driven financial impact over the next five years and 60% will implement strategies targeting operational efficiencies, followed by revenue enhancement (29%) and transformation (5%).
- The survey also found that AI implementation strategies are expected to drive operating margin expansion across 24 of 25 industry groups over the next five years with Tech Hardware (+5%), Telecom (+5%) and Semis (+5%), most likely to experience the largest operating margin expansion. However, while the transformative nature of the newest AI wave is clear, it's impossible to foresee the long-term implications of this nascent technology.

AI's newest wave has arrived

The newest artificial intelligence (AI) models powering generative AI (GenAI) applications represent a paradigm shift in corporate efficiency and productivity in line with past disruptive technologies like the telephone, automobile, personal computer and internet.¹ As discussed in [Me, Myself and AI: What you need to know](#), past disruptive technologies have historically reached mainstream adoption after 15 to 30 years, but AI-driven efficiencies and incremental revenue may appear across sectors as soon as the next 3 to 5 years, a faster pace than many may expect.

Over the last few decades, companies have integrated AI and machine learning (ML) into processes and products; however, the foundation models powering the newest GenAI applications emerged only five years ago and are still immature. Because of this, it's difficult to overstate how transformative the GenAI applications that have only just emerged could be, not to mention the thousands that have yet to be created. However, BofA Global Research expects that over the next 5 to 10 years increasingly large foundation models that power GenAI applications will catalyze a technological evolution across every sector globally.

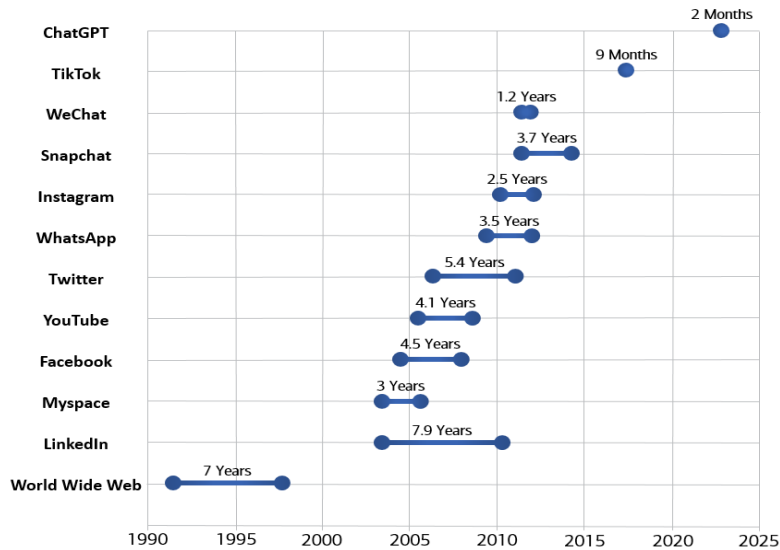
And it's not just tech companies that will benefit from this new wave. GenAI beneficiaries are likely to emerge across every sector globally as corporate AI investment and adoption accelerate. Although these beneficiaries are unlikely to occur nearly as fast as public ChatGPT adoption (Exhibit 1), BofA Global Research expects corporate adoption to progress rapidly as initial implementation strategies focused on operational efficiency and revenue enhancement ultimately drive business transformation. We still have a long way to go before reaching artificial general intelligence (AGI), but the transformative nature of the newest AI wave is clear.² The reality justifies the hype.

¹ Generative AI (GenAI) is a field of AI that uses foundation models trained on unlabeled data to produce original, often creative, content in various forms (text, image, video, audio). In contrast, traditional AI uses models trained on labeled data to produce (unoriginal) outputs based on predefined rules.

² Artificial General Intelligence (AGI) refers to AI systems with human capabilities (or more).

Exhibit 1: Time required for various applications to reach 100 million users

ChatGPT reached 100 million users in record time



Source: BofA Global Research

AI Development: Not a straight line

In the 1940s, AI systems were leveraged as a tool for codebreaking and progressed in the 1950s with Alan Turing's *Computing Machinery and Intelligence*, but development over the next 80 years has not been smooth sailing. In the 1950s, data storage and processing requirements were inadequate to support the technology's development, access to computers was limited, and leasing costs of ~\$200k per month were prohibitive.

In the 1960s, incremental AI advances were frequently hindered by inconsistent funding and the continued upper bounds of data storage and processing requirements. In 1966, following the peak of the Cold War, the infamous ALPAC (Automatic Language Processing Advisory Committee) report by the US government determined that it was faster to use human translators and that substantial government investment in AI for machine translation, specifically translation of Russian to English, had led to limited return. The Lighthill report for the British government in 1973 was similarly pessimistic. As a result, US and British funding for AI decreased significantly and interest in the field waned.

However, despite some significant AI advances, breakthroughs were largely uninspiring to the public. The AI Effect – the tendency to discount AI advances after the fact and for reality to seemingly never meet expectations – ensued and led to the “AI Winter” in the mid-1970s. Advances in the 1980s led to corporate adoption of expert systems, but excitement dissipated once again until IBM's Deep Blue chess-playing AI application beat Garry Kasparov in 1997.³

Removed constraints power AI liftoff

AI advances increased in the 1990s, but more powerful chips emerged in the mid-2010s that exponentially raised the upper bounds of data storage and processing following years of research & development (R&D) from chipmakers. Chip advances and accelerating private investment removed some prior constraints to model development, but headwinds remained due to the high cost and extensive time required to train and fine-tune foundation models as a result of inefficient data storage and compute.⁴

However, Google Brain's 2017 paper “Attention is All You Need” proposed a new neural network architecture called the Transformer, which improved upon recurrent neural network architectures, such as long short-term memory.⁵ Transformer architecture utilizes a self-attention mechanism that allows for parallel processing, which enables more efficient data storage and computation and reduces the time and cost of training and fine-tuning foundation models.⁶ BofA Global Research's view is

³ *Across the Board: The Payoff from Expert Systems* (1989). Expert systems apply if/then rules to data to generate new insights and were implemented by companies like Texas Instruments, which improved productivity and efficiency by making some processes 20x faster and reducing expenses by \$2mn/year on average by reducing cost overruns and preparation expenses. American Express increased the efficiency of its credit authorizers by 45-67%.

⁴ Fine-tuning refers to the process of training a pre-trained model with structured data to produce a specialized application with improved performance for specific tasks relative to the original model.

⁵ Transformer models also improved the functionality of AI applications as neural networks, essentially the brain of a foundation model, were able to better contextualize language. For example, “bank” may mean a financial institution or the side of a river, but it's helpful to look for context before and after a word in a sentence to determine the meaning. Transformer models determine the meaning of “bank” by looking for context using all words in a sentence, instead of just words that came before. Put another way, the model looks for context bidirectionally, which is what the “B” in “BERT” stands for. BERT stands for Bidirectional Encoder Representations from Transformer and is a neural network architecture.

⁶ *Attention Is All You Need* (2017)

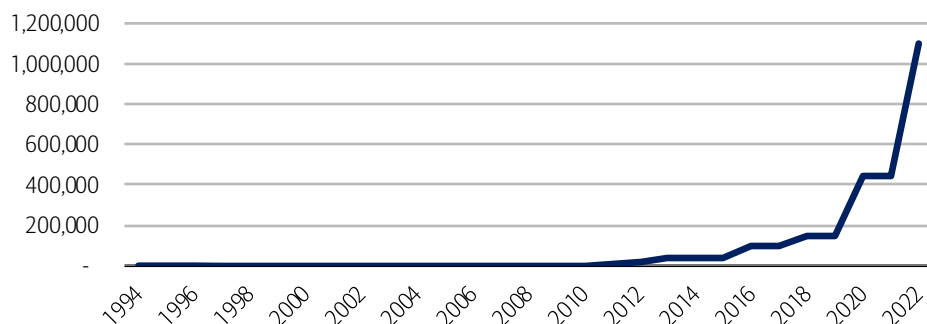
that the introduction of Transformers unlocked the current AI wave by spurring renewed interest in research that led to new advances in computer vision and pattern recognition, such as generating increasingly natural-looking images, and driving the size and performance of foundation models, such as BERT and GPT, to increase exponentially.^{7, 8}

Computational capacity in 2022 had accelerated by more than 3,000 percent relative to capacity in 2015 (Exhibit 2). Government funding was largely replaced by private investment, which reached ~\$70 billion in 2021, representing a 1,000+% increase relative to 2015 investment (Exhibit 3). Newly funded AI companies emerged as private investment accelerated with the number globally receiving \$1.5 million+ in funding reaching 1,669 in 2021, representing a 143% increase relative to newly funded AI companies in 2015 (Exhibit 4).

As private investment accelerated, new startups began to emerge and, ultimately, the creation of increasingly large foundation models. However, a 34% year-over-year (YoY) drop in private investment in 2022 reflects the challenging macro environment, but also indicates that investors may be waiting for clarity on AI monetization strategies. The rapid adoption of ChatGPT was a public phenomenon, but corporate AI adoption and the resulting return on investment (ROI) remain to be seen.

Exhibit 2: Computational capacity of the fastest supercomputer (teraFLOPS) from 1994-2022

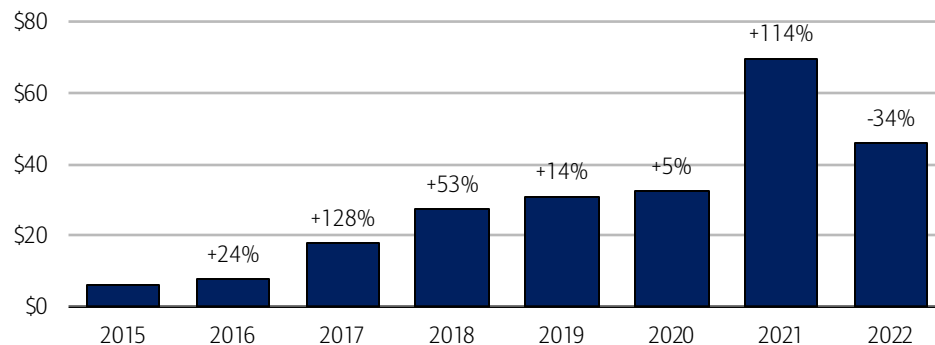
Computer processing power jumped 3,145% from 2015 to 2022



Source: Our World in Data: TOP500 Supercomputer Database (2023)
 FLOPS = floating-point operations per second. 1 teraFLOPS = 1,000 gigaFLOPS = 1,000,000,000,000 FLOPS.

Exhibit 3: Private AI investment globally (\$bn) from 2015-2022

Private AI investment in 2021 rose 114% YoY to \$69.7 billion, but fell 34% YoY in 2022



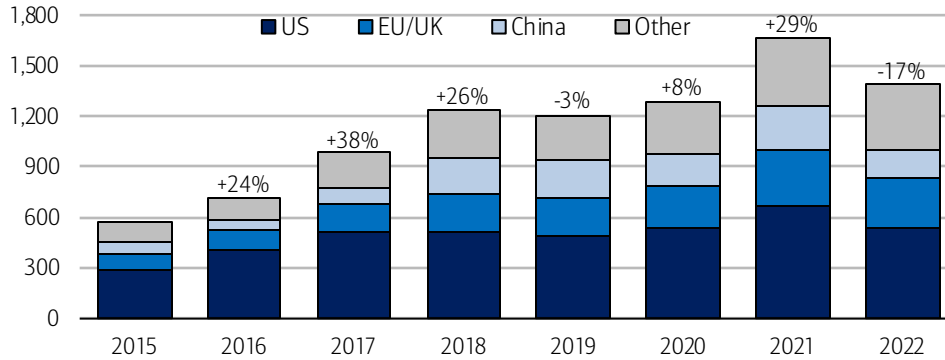
Source: CB Insights, BofA Global Research
 Data labels indicate the percentage change YoY in global private AI investment.

⁷ Image Transformer (2018)

⁸ BERT performance improved as measured by performance indicators, including the General Language Understanding Evaluation (GLUE) score, Multi-Genre Natural Language Inference (MultiNLI) accuracy, and Stanford Question Answering Data (SQuAD) question answering.

Exhibit 4: Newly funded AI companies globally that received a \$1.5mn+ investment from 2015-2022

Newly funded AI startups peaked in 2021 following accelerating funding in Q4'20



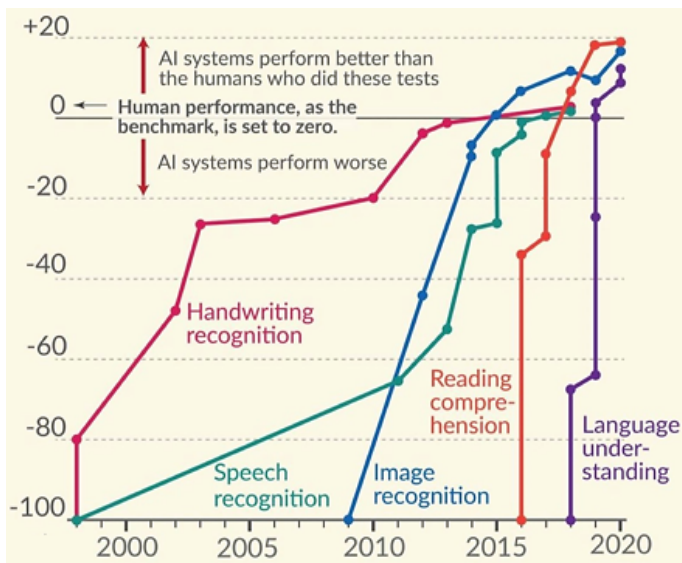
Source: NetBase Quid (2022) via the AI Index 2023 Annual Report, AI Index Steering Committee, Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2023
Data labels indicate the percentage change y/y in the total number of newly funded AI startups globally that received a \$1.5mn investment.

Further advances required

AI advances may seem to have emerged miraculously, but they follow long-term investments and resulting development that occurred even before the term “artificial intelligence” was coined in 1956. Since then, AI applications have beaten world champion Garry Kasparov in a game of chess (IBM Deep Blue, 1997) and former champion Ken Jennings in Jeopardy! (IBM Watson, 2011), won art contests and outperformed humans on standardized tests (Exhibit 5). However, while current foundation models and GenAI applications remain immature and can be viewed as “version 1.0,” BofA Global Research expects advances to occur rapidly.

Exhibit 5: Test scores of AI applications relative to human performance

AI system capabilities have improved rapidly



Source: Our World in Data: Kiela et al. (2021) - Dynabench: Rethinking Benchmarking in NLP

Immature apps likely slow corporate adoption

Foundation models that power chatbots excel at creative tasks; generating images; analyzing data and documents and translating languages but are less proficient at non-creative tasks like math and perform poorly on exams like AP Calculus BC.⁹ Chatbots also produce outputs that are frequently inaccurate and biased, as well as prone to hallucinations, which are responses that are seemingly made up and not supported by training data.

BofA Global Research’s view is that advances in foundation model and application performance will ultimately improve responses for non-creative tasks, as well as mitigate concerns around inaccuracies and hallucinations. For example, GPT-4 is 82% less likely to respond to requests for disallowed content and 40% more likely to produce factual responses than GPT-3.5, according to OpenAI’s internal evaluation. However, regarding biased responses, AI model outputs reflect societal views and stigmas that were “learned” from training data, which is oftentimes pulled from the internet. Additionally, BofA Global Research

⁹ OpenAI: GPT-4 Capabilities and Exam Results

expects advancing model development, potentially through reinforcement learning from human feedback in which humans rate chatbot responses to prompts, to mitigate concerns.

Transparency and repeatability are required

Lack of response transparency and repeatability are also factors that must be overcome prior to mainstream corporate adoption. AI models may deliver accurate outputs 80-90% of the time, but outputs may be seemingly ridiculous 10-20% of the time, limiting usefulness for edge cases without additional training data and fine-tuning. The public may be unaffected by inaccurate or insulting chatbot responses, given that the consequences are likely insignificant, but many corporate use cases for AI applications require precision and polite responses. However, as mentioned above, advances in foundation model and application performance are likely to mitigate these concerns.

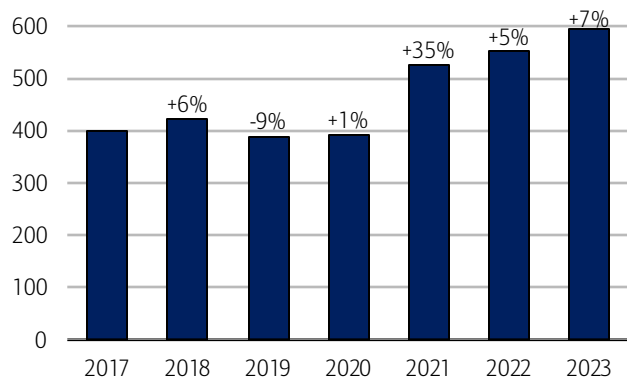
Robot takeover isn't coming (yet)

While robot functionality has certainly improved over time, the shift has not happened as rapidly as portrayed in movies. Some manufacturers are getting closer to “lights out” or, rather, the ability for their warehouses to operate without lighting because robots have replaced workers, but further advances are needed. Robots are unlikely to displace a significant number of workers in the near or intermediate term. But over the next 5-10 years, BofA Global Research expects advancing functionality and decreasing costs to drive adoption and new use cases that accelerate AI-driven efficiencies and productivity.

Industrial robots and drones are capable of tasks like operating forklifts, doing laundry, inspecting and repairing infrastructure, and even making deliveries, but are still largely deployed within the manufacturing sector for heavy lifting. As a result, installations have not accelerated significantly, illustrated by the ~553,000 industrial robot installations in 2022, only 38% higher than in 2017 (Exhibit 6). Installations have been largely driven by demand in China, which accounted for 52% of 2022 installations, indicating that adoption globally may appear more widespread than aggregate installations suggest (Exhibit 7).¹⁰ There were 12.8 million workers within the US manufacturing sector at the end of 2022, which accounts for 7.8% of non-farm payroll employment, but only ~39,600 industrial robots installed in the US – which could indicate that widespread job displacement and corporate efficiencies generated by replacing workers with tech is unlikely in the near or intermediate term.¹¹

Exhibit 6: Industrial robot installations globally (in thousands) from 2017-2023

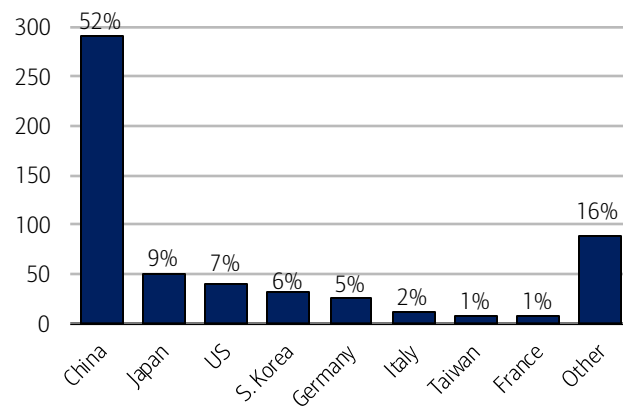
Industrial robot installations are not accelerating rapidly



Source: International Federation of Robotics
Industrial robot installation stat for 2023 is an estimate. Data labels indicate the percentage change YoY in the total number of newly installed industrial robots globally.

Exhibit 7: Industrial robot installations (thousands) by country

China installed 52% of all industrial robots globally in 2022



Source: International Federation of Robotics
Data labels indicate the percentage of total industrial robot installations globally attributed to the specific country.

Chatbot-embedded robots expand disruption potential

BofA Global Research’s view is that chatbots may eventually displace many workers that perform non-physical labor, but recent advances in robot functionality, specifically regarding dexterity, may drive expanding use cases and accelerating installations. Significant improvements are likely needed before collaborative industrial robots (cobots) work alongside humans outside of the factory, but GenAI embedded robots could expand functionality significantly over the next 5 to 10 years and accelerate AI-driven operational efficiencies for companies. However, BofA Global Research also notes that robots embedded with chatbots that include conversational features could displace “front of house” workers in restaurants and retail stores, as opposed to just in a kitchen or factory.

¹⁰ International Federation of Robotics

¹¹ Employment Projections program, U.S. Bureau of Labor Statistics

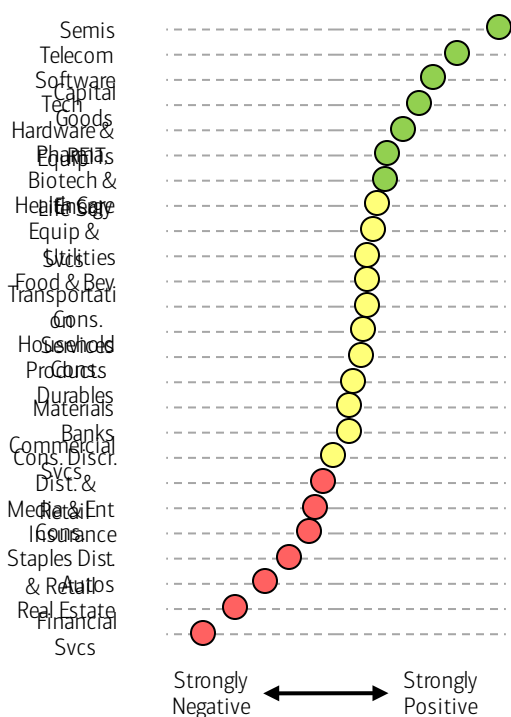
Sector breakdown: Who's affected?

Recently, BofA Global Research examined AI's impact across sectors globally through a survey of 114 BofA Global Research fundamental equity analysts ("Analysts") (see methodology). The survey found that Analysts expect about three-quarters of the ~3,500 covered companies by market cap globally to experience mild-to-strongly positive AI-driven financial impact over the next five years.¹² According to the survey, the industry groups most likely to be positively affected are Semis, Telecom, Software, and Capital Goods, while those most likely to be negatively affected are Real Estate and Autos (Exhibit 8). Interestingly, Analysts expect Financial Services to be the most negatively disrupted industry group in the Americas, but the most positively disrupted in Asia Pacific (APAC).

They also expect covered companies' AI implementation strategies to skew toward operational efficiencies/cost savings (60%), followed by new revenue streams (29%) and transformative strategies (5%). However, survey responses show that 35% of covered companies' prior AI investments resulted in both operational efficiencies and incremental revenue. Notably, only 6% of covered companies have not articulated an AI strategy (Exhibit 9).

Exhibit 8: Global AI disruption potential by industry group

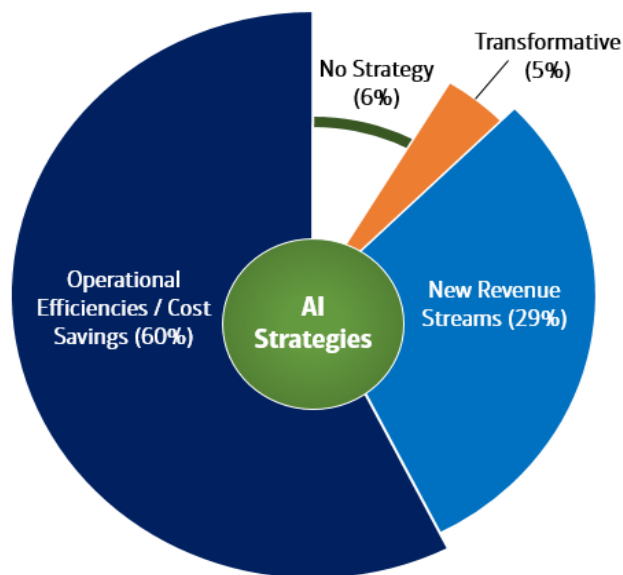
Most Positive: Semis, Telecom, Software | Most Negative: Financial Svcs, Real Estate, Autos



Source: BofA Global Research
Green/red shading indicates the top/bottom 25% of industry groups most likely to be positively/negatively disrupted by AI. Results are based on survey responses.

Exhibit 9: AI strategies skew toward operational efficiencies

Only 6% of covered companies do not have an AI strategy in place



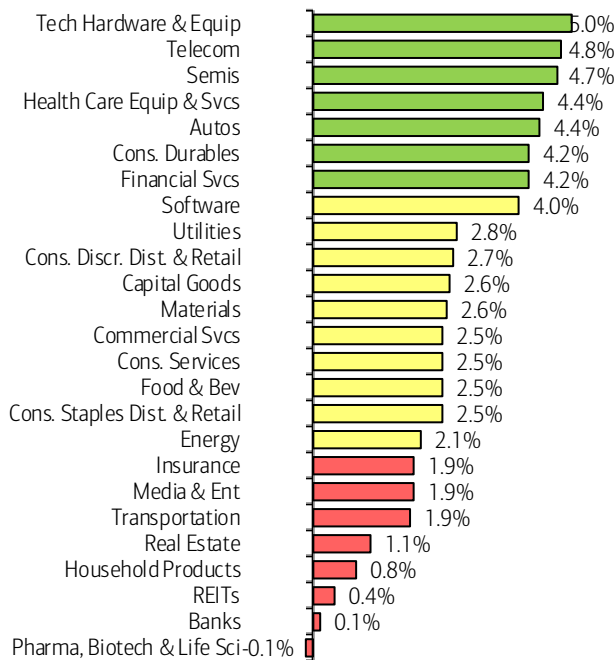
Source: BofA Global Research. Results are based on survey responses.

Additionally, analysts expect covered companies' AI implementation strategies to drive operating margin expansion across 24 of 25 industry groups over the next five years (Exhibit 10). The industry groups most likely to experience the largest operating margin expansion are Tech Hardware (+5%), Telecom (+5%) and Semis (5%), while those most likely to experience the smallest percentage increase in operating margin expansion are Banks (+0.1%), REITs (+0.4%) and Household Products (+0.8%). Pharma, Biotech & Life Sci is the only industry group that Analysts expect to experience operating margin contraction due to AI implementation.

¹² The ~75% of covered companies globally that our analysts expect to experience mild-to-strongly positive AI-driven disruption have an aggregate market cap of ~\$53tn.

Exhibit 10: Global AI-driven operating margin expansion/contraction (% change)

AI likely to drive margin expansion for 24 of 25 industry groups



Source: BofA Global Research

Note that 5% indicates operating margin expansion from 20% to 21%. Green/red shading indicates the top/bottom 25% of industry groups by expected operating margin expansion/contraction. Results are based on survey responses.

Exhibit 11: Corporate revenue derived from AI products as a % of revenue

Only Semis (6%), Cap Goods (6%) and Software (4%) derive a significant % of rev from AI

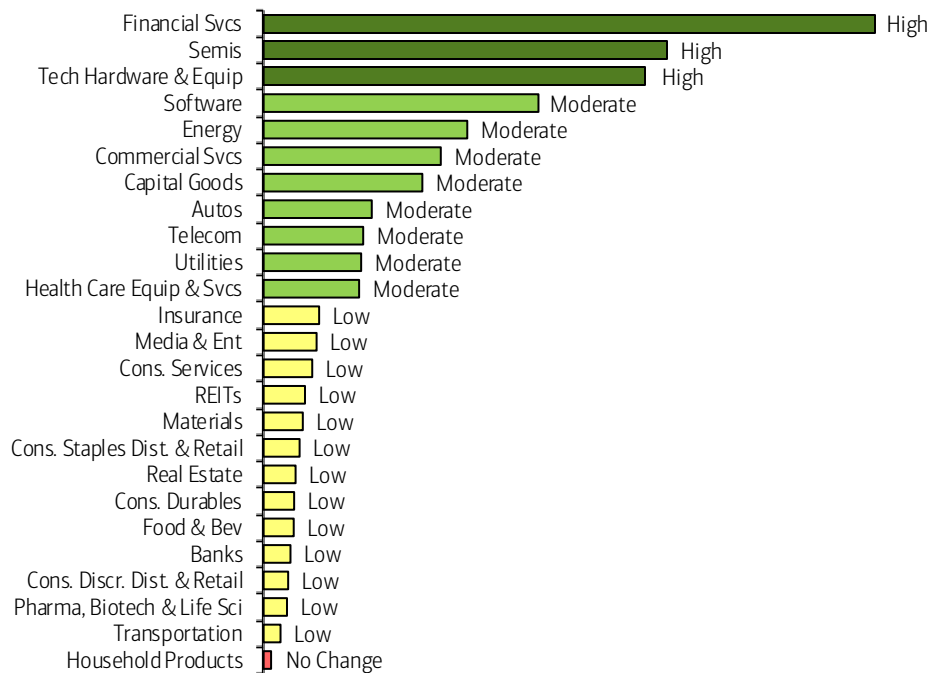
Industry Group	% Rev from AI
Semis	Moderate
Capital Goods	Moderate
Software	Low-to-Moderate
Health Care Equip & Svcs	Low
Tech Hardware & Equip	Low
Household Products	Low
Materials	Low
REITs	Low
Banks	Low
Commercial Svcs	Low
Cons. Durables	Low
Cons. Services	Low
Energy	Low
Food & Bev	Low
Cons. Staples Dist. & Retail	Low
Media & Ent	Low
Pharma, Biotech & Life Sci	Low
Real Estate	Low
Telecom	Low
Transportation	Low
Utilities	Low
Autos	Low
Financial Svcs	Low
Cons. Discr. Dist. & Retail	Low
Insurance	Low

Source: BofA Global Research

Moderate = 6-20% of revenue from AI, Low = 0-5% of revenue from AI. Results are based on survey responses.

Exhibit 12: Global AI revenue potential over the next 5 years, High / Moderate / Low Increase = +21-50% / +6-20% / +1-5%

AI-driven revenue may increase significantly for some industry groups



Source: BofA Global Research. Results are based on survey responses.

Analysts also expect today’s low AI-driven revenue from covered companies to increase significantly for some industry groups over the next five years. The industry groups that derive a meaningful amount of revenue from AI products and services are Semis (6% of revenue), Capital Goods (6% of revenue) and Software (4% of revenue) (Exhibit 11). The industry groups most likely to drive significant revenue growth from AI products and services over the next five years are Financial Services (41% increase), Semis (27% increase), Tech Hardware (26% increase) and Software (18% increase) (Exhibit 12).

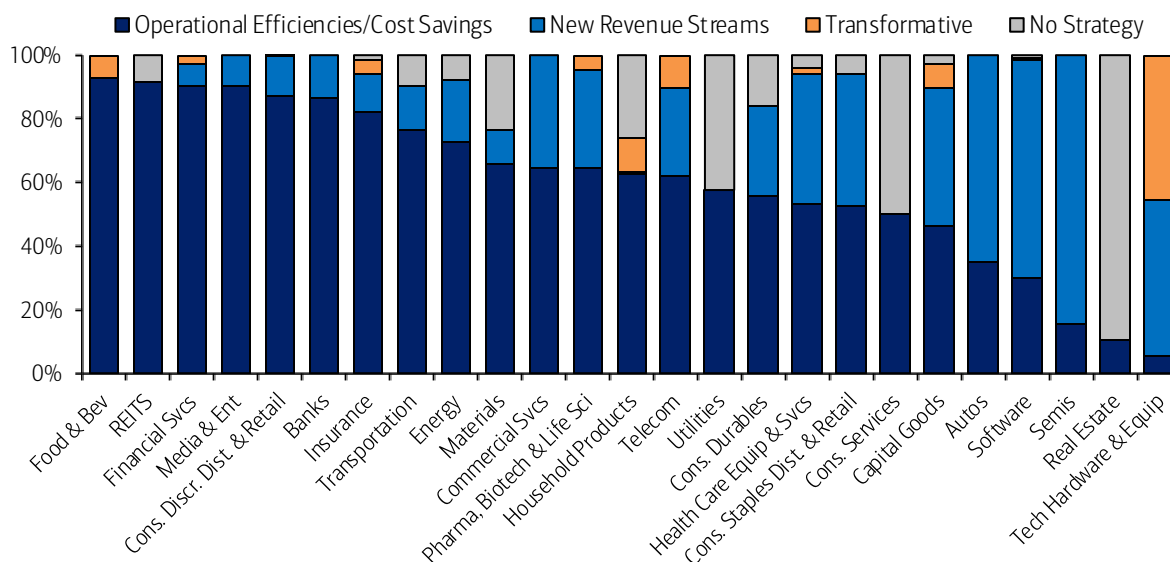
Corporate Adoption: “When” not “if”

While the newest foundation models and GenAI applications are likely to require further development and advances before the full implications of corporate adoption are felt, the disruption potential of the current foundation models and GenAI applications should not be ignored. When discussing primary strategies of covered companies, responses by surveyed Analysts fell into three distinct categories (Exhibit 13).

- **Operational efficiencies / cost savings:** Companies may implement AI strategies that drive efficiencies and productivity by optimizing processes and reducing labor costs. Analysis and optimization of current processes may lead to increased productivity, as well as to replacing labor with tech to augment or automate processes, which may result in headcount reductions. This strategy is likely a natural extension of current operational efficiency strategies to be implemented within the next three years.
- **Incremental revenue opportunities:** Companies may implement AI strategies that drive incremental revenue or new revenue streams by embedding GenAI into both legacy and new products. Embedding AI into legacy products may result in incremental revenue through “AI upgrade” fees, while new AI products may drive entirely new revenue streams through competitive advantages that produce product differentiation and market share capture. Analysts expect companies to implement this strategy over the next three to five years.
- **Business Transformation:** Companies may implement AI strategies that drive transformation by refocusing the business around products and services that leverage AI. This strategy does not apply to AI startups, given that their business strategies were originally focused on AI. Analysts expect companies to implement this strategy gradually over the next five to ten years and note that transformation strategies will likely be costly and take time to implement.

Exhibit 13: Corporate strategies to leverage AI may target new revenue streams initially but ultimately transform businesses

Semis, SW and, to a lesser extent, Capital Goods most likely to leverage AI to generate new revenue streams



Source: BofA Global Research. Results are based on survey responses.

For every negative, there’s a positive

New occupations may emerge as foundation models and GenAI applications advance and as companies implement AI tools into processes and products, but the pace of disruption is likely to be faster than disruptive technologies of the past. BofA Global Research notes that new GenAI-driven jobs are unlikely to emerge fast enough to offset GenAI-driven job displacement. And while Analysts don’t expect the newest GenAI applications to result in large-scale labor displacement in the near term, the net

effect of GenAI on labor over the longer term remains to be seen. However, it's also important to note that ~60% of jobs in 2018 were in occupations that didn't exist in 1940.¹³

BofA Global Research expects customer service roles to be largely automated within the next three years as companies look to reduce the ~\$118.6 billion in annual costs paid to ~2.9 million customer service agents in the US.¹⁴ After all, human customer service agents can't speak to more than one customer at a time or remember every detail across hundreds of customer calls. In contrast, customer service chatbots can speak to an unlimited number of customers at a time, communicate in almost every language and remember every detail across hundreds of calls in perpetuity. They can also work 24/7. This same thought experiment can be aligned to many other occupations in which workers may find it difficult to compete with bots, including coders, data analysts, marketing professionals, paralegals, medical scribes and translators.

Solving the world's largest challenges

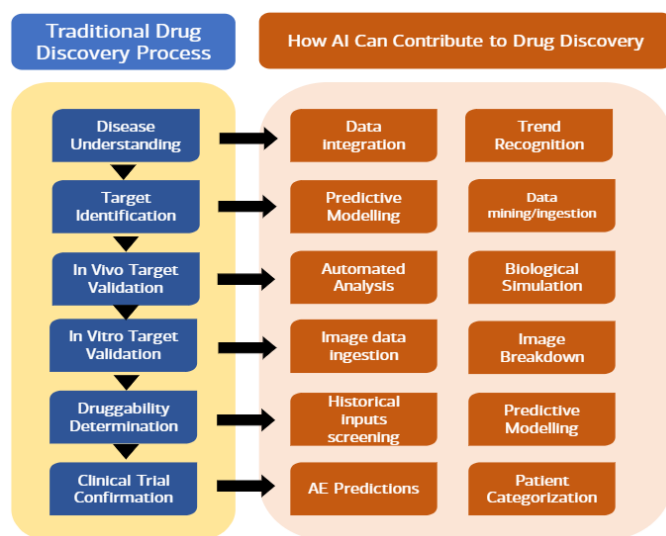
Overall, AI models and applications represent a paradigm shift in corporate efficiency and productivity and could boost S&P operating margins by 250bps, equivalent to ~\$65 billion in cost savings over the next five years. And as we've noted in prior publications – AI could potentially contribute up to \$15.7 trillion to the global economy by 2030 (source: PwC), but implications of this nascent technology extend beyond the economy.

GenAI applications have already resulted in tools that transform the drug discovery process, empower paralyzed individuals to communicate through digital avatars via brain implants that decode and translate thoughts into speech, detect life-threatening health problems like cancer or sepsis and predict the molecular structures of proteins (Exhibit 14). The potential uses are plenty – GenAI applications may analyze data generated from drones to prevent or mitigate wildfires, assist law enforcement in catching violent criminals and identify unexploded munitions in developing countries.

How companies implement GenAI applications into their processes and products is likely to play out over the next 5 to 10 years, but GenAI is a neutral technology that is not inherently good or bad. BofA Global Research understands why outsized attention is focused on potential job displacement and the dystopian, seemingly imminent, "robot takeover," however, over the longer term, the newest foundation models have the potential to power applications that may solve some of the world's largest challenges. In the meantime, one thing is clear: while a new era of corporate efficiency and productivity has arrived, it has only just begun.

Exhibit 14: How GenAI applications may improve the drug discovery process

GenAI may drive optimized clinical trials and healthcare systems



Source: BofA Global Research

¹³ NBER: *New Frontiers: The Origins and Content of New Work, 1940–2018*

¹⁴ Bureau of Labor Statistics: *Occupational Employment and Wage Statistics (May'22)*

BofA Global Research Analyst Survey Methodology

In this report, we include results from a survey of 114 of BofA Global Research fundamental equity analysts (“Analysts”) on corporate AI strategies across ~3,500 covered companies with an aggregate market capitalization (cap) of ~\$72tn across the 25 GICS2 Industry Groups. Respondents answered 20 survey questions, which focused on 1) corporate strategies for AI implementation, 2) the potential implications of these strategies on the operating and financial performance of their covered companies over the next 5 years, 3) the degree to which specific industry groups are likely to be positively or negatively disrupted over the next 5 years and 4) risks that may slow corporate AI adoption.

Note that percentages throughout this report that originate from survey responses refer to the aggregate market cap of specific covered companies relative to the aggregate market cap of all covered companies.

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