

The Effect of AI Development on Stock Prices

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Abstract

The period from 2019 to 2024 has been marked by tremendous progress in AI. During the late 1990's and the 2000s, there was a '.com' bubble: excitement about the rise in internet led to the stock prices of US tech companies to rise tremendously. Eventually, this bubble burst, leading to huge losses. 2023 saw a similar rise in the share prices of AI companies. This led to people speculating whether an 'AI bubble' is forming, similar to the '.com bubble' of the 2000s. Therefore, to investigate this phenomenon, the paper will compare stock price movements for companies that develop AI products and those that don't. For this purpose, the stock prices of the top 25 companies from the S&P 500 have been selected based on their index weight, after which the companies were classified as AI companies and non-AI companies. Then, the graphs were drawn using the R programming language to compare the stock prices. From this, it was seen that companies that have been classified as AI saw a boost in their stock prices due to AI-related products, mergers, acquisitions, development of generative AI, and dependence on technology during the COVID-19 pandemic, as compared to the stock prices of non-AI companies.

Keywords

Robotics and Intelligent Machines; Machine Learning; Artificial Intelligence; Stock Market; Quantitative Economics

Introduction

By the summer of 2023, America's S&P 500 index of leading shares had risen by 28% from the autumn of 2022. Analysts explain the reason for this was because of the 'Magnificent Seven.' The 'Magnificent Seven' are the top seven tech giants- Alphabet, Amazon, Apple, Meta, Microsoft, Nvidia, and Tesla- acting as if they had a market of their own. While higher interest rates caused turmoil everywhere, these companies were thriving. By the start of June, the S&P 500 had risen by 12%. Analysts believe this rise was because of the big seven tech giants, while all the other 493 companies were stagnant or dropping. By late October of 2023, these seven companies had added \$3.4 trillion to the combined market value since the start of the year while all the other 493 companies had lost \$ 1 trillion. However, these seven companies' bull run as a pack ended on the 27th of October 2023. The share prices of Alphabet and Apple had underperformed and that of Tesla had completely dropped. However, the remaining four have beaten the index, but by different amounts. While Microsoft has done only slightly better than the average S&P 500 member, Nvidia's shares have increased by 129%. While AI or AI Stock Companies are seeing a boom in their stock prices, there is some irrationality that these companies are causing due to which investors are becoming confused. Generative AI had excited investors and were assumed to be the winners by default in the stock markets. While investors might be excited about AI, they seem willing to be skeptical too. ⁵³

A similar phenomenon was seen previously when the Internet was discovered. The announcement of name changes in which '.com' was put in front of the company name was associated with significant increases in stock prices and trading activity.⁸⁶

Between 1995 and 2000, excitement about the rise of the internet led to US tech stock prices increasing exponentially, but by the first two years of the 21st century all these gains were wiped out.⁵⁷

According to Bratton and Nguyen, Investors invested huge proportions of their money in risky startups, such as "Pets.com — pushing their stocks far above levels justified by their underlying businesses. Eventually it all came crashing down, with the bubble burst leading to trillions in lost market cap before the early-2000s recession."⁵⁴

The founder of Research Affiliates and 'Godfather of Smart Beta' investing, Rob Arnott, says that similar to how in the 2000s investors were excited about the development of the internet during the dot-com bubble and invested a huge amount of money only for the gains to be completely wiped out, today investors are getting ahead of themselves when it comes to the speed of transformation taking place in AI as a result of technology.⁵⁵

The enormous valuations of companies like Nvidia show investors the excitement about AI. They are sure of the fact that it will supercharge productivity, power transformative products and services, and radically change the global economy. Furthermore, the difference between the dot-com bubble and the AI mania which is going on right now is that the companies during the dot-com bubble were mostly small startups. Thus, they did not have massive shareholder bases so once the dot-com bubble ended in the 2000's it was only the foolish investors that were hurt. However, the leaders of the AI stocks are established companies such as Microsoft, NVIDIA, and Alphabet, and they make up a large chunk of the US's stock market's value and are mainstays of pension funds and retirement portfolios. So, once the AI Mania comes to an end, then the company can lose billions of dollars but will never go broke. However, lots of investors will suffer losses.⁵⁶

Now, with the rapid rise of AI is it possible that investors associate those companies that manufacture AI products as ones that have higher stock prices and therefore shall help them earn more returns, leading to AI stocks being overvalued?

Capital Group published a research note that stated that the tech-heavy NASDAQ 100 index currently has an average price-to-earnings ratio of about 32.5 fold. At the peak of the dot com boom, NASDAQ 100 had a price-to-earnings ratio of 90.1 fold. This suggests that the stocks were significantly more overvalued during the dot com boom as compared to the market leaders are now.⁵⁷

Even AI bubble believers think that AI is not like the dot-com bubble. According to Richard Windsor, "the internet bubble bursting [was] worse than the AI bubble bursting" will be. That's partly because even in its "immature form" today, AI is capable of generating substantially greater revenues than the internet was in the 1990s and early 2000s. The internet in the 1990s was "super slow," he said, "and it took a long time to realize" its full potential.⁵⁴

Therefore, I aim to investigate the performance of the stock prices of AI companies against non-AI companies.

Methods

To investigate how AI development affects the stock prices of companies, data has been collected from Yahoo! Finance on the stock prices of the top twenty-five companies from the S&P 500 Index based on their index weight from the past five years on a weekly basis from 1/7/2019 to 24/6/2024. 2019 to 2024 is an era marked by tremendous growth and evolution in AI.

In 2019, AI was in an accelerated growth phase. It was focused on making advancements in machine learning, data analytics, and process automation. Generative AI was also in its initial stages of development. Healthcare, automotive, financial services, and customer care have all adopted AI technologies in their industry, through chatbots, recommender systems, and predictive analytics. Fast-forward to 2024, AI has made remarkable transformations and is now integrated into every aspect of business and life. Generative AI has made advancements, especially with the introduction of GPT-4. It now allows us to interact with technology differently due to its advanced capabilities in text, image, and audio generation. Multimodal models, which combine data such as texts, images, and voice, have also made advancements, providing the user with a more personalized experience. On a customer call, AI can make use of visual and auditory cues such as voice tone and facial expressions and analyze financial documents to provide more personalized financial advice to customers. The adoption of natural language interfaces in digital products and services has improved business-to-business interactions and accelerated software development. Companies are now incorporating tailored generative AI applications that provide more efficient and personalized AI-based business solutions according to the needs of the business. Chatbots and virtual assistants provide personalized responses to customers 24/7, helping to improve customer satisfaction and loyalty.⁵⁸

Due to such rapid transformations in AI, companies that manufacture and produce AI products may have increased Year-On-Year (YOY) profits causing investors to buy more of their stocks. Therefore, 2019 to 2024 is an important period to study the effect of the development of AI on the stock prices of companies due to such rapid advancements in AI.

The companies have been categorized as AI and non-AI companies based on whether they manufacture and produce AI products. In other words, those companies that are involved in the manufacturing and producing of AI products and are called as AI stocks have been categorized as AI companies and those companies that aren't involved in the manufacturing and producing of AI products and aren't called as AI stocks have been categorized as Non-AI companies. After this, the line graphs of the opening stock prices of AI companies and Non-AI companies and the differences between the opening stock prices of AI and Non-AI companies were drawn using R programming language.

The categorization of companies as AI companies and non-AI companies is given in Table 1.

Table 1. Categorization of companies as AI and Non-AI companies.

COMPANY	AI OR NOT	REASON
Microsoft	AI	Microsoft stands at the forefront of AI innovation, seamlessly integrating AI into its vast array of products and services. Microsoft's Azure AI platform, a cornerstone of its AI strategy, collaborates with OpenAI to offer businesses and developers access to advanced AI models such as GPT-3. Through these initiatives, Microsoft exemplifies its role as a leading AI company, driving innovation and practical applications across diverse sectors. ⁵⁹
Apple	AI	Apple is integrating AI across its products to enhance functionality and user experience. Siri, Apple's voice assistant, uses AI to understand and predict user needs through voice commands, with plans to improve its conversational abilities and add features like auto-summarizing notifications, providing quick news synopses, and transcribing voice memos. Furthermore, Apple is collaborating with OpenAI to integrate a chatbot into iOS 18, enhancing its AI capabilities and user interactions. Through these advancements, Apple demonstrates its commitment to integrating AI as a core component of its products, focusing on improving user experience and maintaining privacy standards. ⁶⁰
Nvidia	AI	Nvidia's shares have been rising since 2023 due to its pivotal role in the artificial intelligence industry. The company is a leading supplier of graphics processing units (GPUs), which are essential for training and deploying AI models. As AI technologies are being increasingly used across various industries, the demand for powerful GPUs has increased, boosting NVIDIA's sales and stock value. ⁶¹



Amazon	AI	Amazon Web Services is a part of Amazon Inc's stock. Amazon Web Services AI provides a wide range of services to develop and expand AI applications for numerous uses. For example, Amazon Code Guru Security helps detect, monitor, and fix code security exposures. Amazon Fraud Detector helps in detecting online fraud and enhances detection models. Amazon Monition helps in detecting infrastructural issues before they even occur. Amazon Recognition helps in automating, streamlining, and calling image recognition and video analysis. Amazon Extract helps in extracting printed text, analyzing handwriting, and automatically capturing data from any document, and Amazon Transcribe helps in converting speech to text, extracting key business insights from video files and improving business outcomes. ⁶²
Meta	AI	Meta is using AI to optimize advertisement targeting and recommendation systems to boost engagement and advertisement revenue. Meta AI makes use of Meta Llama 3 an open-source AI model. It is an intelligent assistant that is capable of complex reasoning, following instructions, victualing ideas, and solving nuanced problems. It also has image generation technology that helps in putting your ideas into AI-generated images. ⁶³
Alphabet	AI	Alphabet underscores its commitment to leading in AI innovation and application through its innovations. Alphabet is advancing its AI capabilities with the Gemini AI chatbot, and the upcoming Gemini Pro 1. In the realm of search, Google is integrating AI to refine search results for dining, recipes, and eventually, books, movies, and other content in the US. ⁶⁴
Berkshire Hathaway Inc	Not AI	Berkshire Hathaway Inc is a holding company that owns subsidiaries in a variety of business sectors. It mainly conducts insurance business across the USA on a primary basis and worldwide on a reinsurance basis. Its operations also include a railway company, a specialty chemical



		company, and an international association of diversified businesses. ⁶⁵
Broadcom Inc.	AI	Broadcom Inc. develops chips that help in processing massive data sets and designs chips that facilitate communication between multiple AI chips using network technology. For example, to its flagship networking chip Trident 5-X12, a portion of the silicon in networking processors is devoted to AI which improves the chip's efficiency, boosts performance, alleviates network traffic congestion, and can handle tasks such as network security. ⁶⁶
Eli Lilly and Company	Not AI	Eli Lilly and Company is a pharmaceutical company that focuses on manufacturing drugs in the key areas of Alzheimer's, pain, cancer, immunology, diabetes, and obesity. ⁶⁷
JP Morgan Chase and Co	Not AI	JP Morgan Chase and Co is an investment banking company that operates in the business areas of asset and wealth management, commercial banking, consumer and community banking, corporate and investment banking, and has technologists who provide cutting-edge solutions for organizations. JP Morgan serves prominent corporations, governments, and institutional investors, while Chase serves customers through consumer and commercial banks. ⁶⁸
Tesla	AI	Elon Musk, the CEO of Tesla, calls it an "AI and Robotics Company". Tesla has taken the initiative to introduce AI-powered products, such as the Optimus-Bipedal robot. Furthermore, the Dojo AI supercomputer collects, analyzes, and will become the compute engine for all of the data from the Tesla sled-driving software suite. ⁶⁹



Exxon Mobil Corporation	Not AI	Exxon Mobil Corporation delivers industrial solutions to provide essential energy and chemical resources to power businesses, facilitate construction, and support manufacturing. Furthermore, they meet global transportation needs, and provide various materials that help in the efficient functioning of materials in our day-to-day life, such as lightweight plastics for smartphones, Electrical vehicles, and medical devices; fuels for aircraft; lubricants for wind turbines; and flexible films for food preservation. Lastly, they also focus on providing energy supply. ⁷⁰
United Health Group Inc.	Not AI	United Health Group Inc. is a health care and well-being company that consists of two businesses- Optum and UnitedHealthcare. ⁷¹ Optum makes use of local medical groups, ambulatory care systems, products and services, data, analytics, research, consulting services, technology, and pharmacy healthcare services to make healthcare affordable and help patients achieve better health. ⁷² -UnitedHealthcare provides affordable health coverage to persons of various age groups to simplify healthcare and provide access to high-quality health care for all. ⁷³
Visa	Not AI	Visa is a global digital payment technology company that provides its services to various individuals such as merchants, government, individual and commercial clients, entities and financial institutions. Furthermore, they have a transaction processing network that helps ink leering, authorizing, and settling payment transactions. Additionally, it provides services such as payment cards, mobile payments, commercial payments, transaction processing services, and other digital solutions. ⁷⁴
Procter and Gamble Company	Not AI	Procter and Gamble Company is responsible for providing consumer goods worldwide. It provides products in five segments- beauty, grooming, healthcare, fabric and home care, and baby and feminine and family care. ⁷⁵



Mastercard Inc.	Not AI	Mastercard Inc. is a technology company that provides payment-related services to consumers, businesses, financial institutions, merchants, and governments. It provides payment products and services for deferring payments, accessing funds in deposit and other accounts, prepaid program services, and commercial credit, debit, and prepaid payments. It also provides cyber and intelligence solutions, insights and analytics, consulting services, and other such services to e-commerce merchants. ⁷⁶
Johnson & Johnson	Not AI	Johnson & Johnson manufactures healthcare products and provides related services such as medical devices to consumers, pharmaceuticals, and diagnostic markets. It sells skin and hair care products, pharmaceuticals, diagnostic equipment, acetaminophen products, and surgical equipment in countries around the world. ⁷⁷
Home Depot Inc.	Not AI	Home Depot Inc. is a home improvement retail that sells building materials, home improvement products, lawn and garden products, home decor products, and facilities to maintain, repair or improve the operations of products. ⁷⁸
Merck & Co.	Not AI	Merck & Co. is a pharmaceutical company that functions in two segments- pharmaceutical and animal health. In the pharmaceutical segment, it provides pharmaceutical products for humans in the areas of oncology, diabetes, hospital acute care, immunology, neuroscience, virology, cardiovascular, and vaccines. Under animal health, it provides pharmaceutical products for animals for example vaccines, veterinary pharmaceuticals, and health management solutions and services. ⁷⁹
Costco	Not AI	Costco is a membership warehouse club that sells a variety of products such as food, toys, automotive supplies, hardware, sporting goods, jewelry, electronics, apparel, health and beauty products, etc. ⁸⁰



Chevron Corporation	Not AI	Chevron Corporation engages in the operations of integrated energy and chemicals. The Upstream segment focuses on the research and development and production of crude oil and natural gas; liquefied natural gas operations; crude oil transportation via major international pipelines; processing, transporting, storage, and marketing of natural gas; and a gas-to-liquids plant. The Downstream sector involves converting crude oil into petroleum products, selling crude oil and refined products, transporting them using various methods, and producing and selling commodity petrochemicals, industrial plastics, and fuel and lubricant additives. ⁸¹
AbbVie Inc.	Not AI	AbbVie Inc. is a research-based biopharmaceutical company that also develops and sells pharmaceutical products. It focuses on developing products and services that help in treating chronic autoimmune diseases, virology, neurological disorders, metabolic diseases, and many other health conditions. ⁸²
Salesforce	AI	Salesforce Inc. is an AI company through its integration of artificial intelligence into its customer relationship management services. Its flagship AI tool, Einstein, encompasses natural language processing, machine learning, and predictive analytics, empowering companies to automate processes, gain insights for swift decision-making, and enhance customer experiences. Einstein Analytics enables the analysis of data from various sources, while Einstein Language combines natural language processing with AI to analyze customer interactions and deliver personalized experiences, thus boosting customer engagement through tailored responses. Salesforce Einstein Intent further provides insights into customer interactions, solidifying Salesforce's position as a leader in leveraging AI to improve business operations and customer relations. ⁸³

Advanced Microdevices	AI	Advanced Microdevices (AMD) designs and sells GPUs and accelerators used for AI. For example, AMD CDNA is built to accelerate computer-intensive IA and HPC workloads, AMD Instinct Accelerators offer large on-chip memory ideal for GenAI, and AMD Ryzen processor consists of built-in AI engines. ⁸⁴
Bank of America	Not AI	Bank of America is a bank and financial holding company that operates in the sector banking and bank financial services. It provides services in consumer banking, global wealth and investment management, global banking, global markets, and others. ⁸⁵

Results

Figure 1 shows the average of the opening stock prices on a weekly basis from 2019 to 2024 for AI companies and non-AI companies. 'Is AI' is the average of the opening prices of the AI companies, while 'Not AI' is the average of the opening prices of the non-AI companies. Through this graph, we can see that during the year 2020-2021 'Is AI' dipped early in 2020 but recovered easily. In 2021, there is a continuous growth trend in 'Is AI' graph. Again, in 2022, 'Is AI' sees a dip. Finally, from 2023 till well into 2024, 'Is AI' graph sees a continuous growth trend.

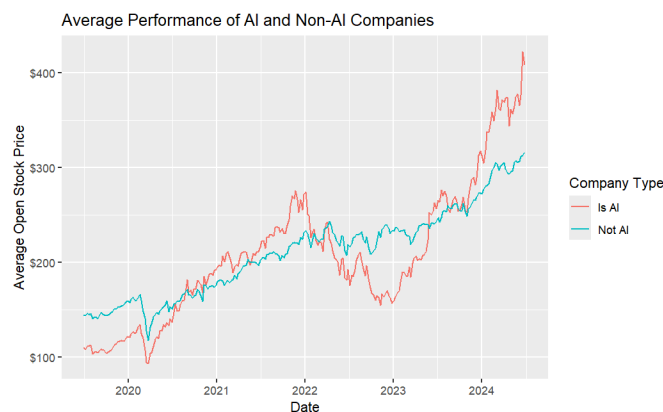


Figure 1. Average performance of AI

and Non-AI Companies

Figure 2 shows that the difference in the opening stock prices of AI companies and non-AI companies increased from 2020 to 2021. Then, in 2021 to 2022 it predominantly continued increasing. In 2022 to 2023, it decreased, and in 2023 to 2024, it again picked up an increasing trend.

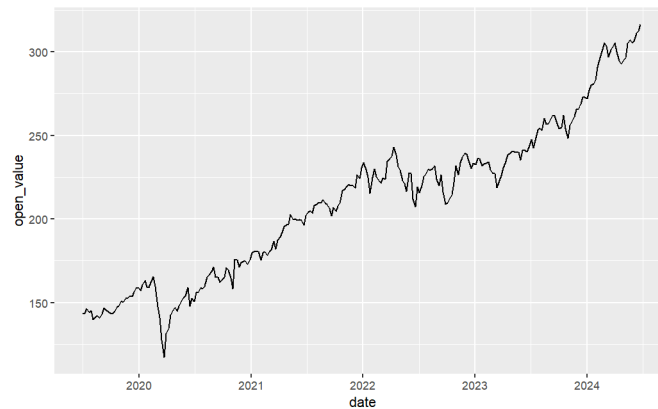


Figure 2. Difference in opening stock prices of AI and Non-AI companies.

Discussion

To analyze the reason the average of the opening stock prices of AI companies saw a growth trend or a decline or both in a particular year, I will be studying it in five phases. Phase I is the period from 2020-21, Phase II is the period from 2021-22, Phase III is the period from 2022-23, Phase IV is the period from 2023-24, and Phase V is the year of 2024.

PHASE I:

In 2020, according to Rotblut and Hageman, “technology stocks helped to propel the S&P 500 index to new highs. Technology stocks had gained 38.5% in the first eight months of 2020, compared to the S&P 500 gain of 10.6% over the same period.”¹

In fact, 41% of companies increased their use of AI strategies in 2020, and according to Reynolds, “three-quarters of organisations surveyed in the State of AI Report cite AI as critical to their success in 2020, and many are already benefiting from the results.”²

The reasons for this gain in the tech stocks is due to the COVID-19 pandemics stay-at-home orders, forced business closures and quarantining that boosted the demand for workplace collaboration software, communication services, online learning tools, telehealth, e-commerce platforms, and delivery offerings.³

Furthermore, AI powered change across various industries. Retail outlets started using computerized designs to layout their stores, monitor stocks, and create automated stores. In education, advances were made in AI-powered smart-learning tech. Many teachers began using AI in their curriculums. For example, one school used AI to automate its roll-call process and has seen greater attendance and data accuracy since. In the healthcare industry, AI-powered contactless check-in points were introduced for in-person visits, but due to the increase in demand for virtual options, companies are now improving telehealth services. For instance, healthcare organizations are utilizing chatbots to address basic patient queries, and AI is helping in the rapid detection and diagnosis of COVID-19 through MRI and other imaging systems.²

According to Markowicz, “While many businesses struggle to survive under the global lockdown, the largest technology companies remain afloat and in some cases are even thriving. Microsoft has reported a surge in usage of its cloud computing service Azure, as millions of people work from home. Amazon is hiring an additional 75,000 workers, on top of the 100,000 it hired last month, to cope with increased demand for its online delivery service. The number of video calls and messaging on Facebook has exploded, while a record number of gaming apps were downloaded in China on Apple’s app store. YouTube Kids, owned by Google, was the most streamed app in the first quarter of 2020 according to a report by Apptopia and Braze, following the closure of most nurseries and schools.” Specifically, ‘FAMAG’ stocks (Facebook, Amazon, Microsoft, Apple, and Google) significantly outperformed broader market indices due to stay-at-home orders.” For example, Amazon was up by 28.5% and Microsoft was up by 13.3%, in 2020, while the S&P 500 was down by 11%. In 2020, businesses were forced to close due to which their sales literally collapsed to zero. Therefore, a company having stockpiled enough cash to survive during lockdown was more important than the revenues made by the companies. On the basis of this, the FAMAGs were ahead. According to Markowicz, “most of them have above-average cash buffers, relatively few short-term liabilities and strong cash generation capabilities.” For example, Microsoft had \$134 billion of cash and cash equivalents. According to Markowicz, “this is significantly higher than the median \$6 billion cash balance and cash cushion of 0.88 years (10.5 months) for the S&P 500.” Additionally, Microsoft is also better at translating sales into cash, collecting \$38 for every \$100 of sales, while the S&P 500 collects only \$22. At the same time, according to Markowicz, “although Amazon has a substantial amount of cash on hand, it is dwarfed by its relatively high operational costs and near-term liabilities. But given the surge in its stock price this year, investors are not placing much weight on this.” Furthermore, in 2020, US equity returns became dependent on the largest tech companies. According to Markowicz, “since the outbreak of the virus, however, most share prices have fallen off a cliff while the FAMAGs have held up much better. As a consequence, their combined market-cap weight has more than doubled from roughly 8% of the S&P 500 Index in 2015 to nearly 20% today.”⁴

PHASE II:

In 2021, Microsoft announced the launch of the Azure OpenAI service through which customers will be able to access OpenAI's GPT-3 language model along with features of security, reliability, compliance, data privacy, and other enterprise-grade capabilities.⁵

Furthermore, according to Langston, Microsoft's Turing Universal Language Representation Model (T-ULRV5) was "at the top of the Google XTREME public leaderboard. The Cross-lingual TRansfer Evaluation of Multilingual Encoders (XTREME) benchmark covers 40 typologically diverse languages that span 12 language families and includes nine tasks that require reasoning about different levels of syntax or semantics. The languages in XTREME are selected to maximize language diversity, coverage in existing tasks, and availability of training data."⁶

According to Alvi, Microsoft introduced the "DeepSpeed- and Megatron-powered Megatron-Turing Natural Language Generation model (MT-NLG), the largest and the most powerful monolithic transformer language model trained to date, with 530 billion parameters." It performs "tasks such as completion prediction, reading comprehension, commonsense reasoning, natural language inferences, and word sense disambiguation with extreme accuracy."⁷

These events resulted in a positive financial year for Microsoft. In the fiscal year 2021, Microsoft delivered \$168 billion in revenue, up 18% Year-on-Year. Operating income grew by 32% to \$70 billion. LinkedIn and Microsoft's other security business both passed \$10 billion in annual revenue for the first time.⁸

In 2021, NVIDIA announced that they would be incorporating their critically acclaimed AI infrastructure Ampere Architecture into laptops.⁹

NVIDIA, in collaboration with VMware, also announced NVIDIA AI Enterprise. It is an AI-Ready Enterprise platform that provides enterprise-grade AI tools and frameworks. This was introduced to virtualize AI workloads. According to Nvidia, It allows enterprises to "develop a broad range of AI solutions, such as advanced diagnostics in healthcare, smart factories for manufacturing, and fraud detection in financial services."¹⁰

In 2021, Amazon announced Amazon DevOps Guru for RDS, a new addition for Amazon DevOps Guru. According to Villalba, "it allows developers to easily detect, diagnose, and resolve performance and operational issues in Amazon Aurora. Hundreds of thousands of customers nowadays are using Amazon Aurora because it is highly available, scalable, and durable."¹¹

Apart from this, according to aws (Amazon Web Services), Amazon HealthLake "enables healthcare providers, health insurance companies, and pharmaceutical companies to securely store, transform, query, and analyze health data at petabyte scale. HealthLake transforms unstructured data using specialized machine learning models, like natural language processing, to automatically extract meaningful medical information from the data, which can then be queried and searched."¹²

Possibly, because of these innovations, Amazon saw a strong financial year. Amazon's net sales increased significantly, reaching \$469.8 billion in 2021, up from \$386.1 billion in 2020. This represents a 22% increase year-over-year. The company's operating income was \$24.9 billion in 2021, compared to \$22.9 billion in 2020. This increase was supported by the growth in AWS, which has higher margins compared to Amazon's retail operations. Furthermore, Amazon Web Services (AWS) experienced an increase of 37% in its year-over-year revenue.¹³

In 2021, Meta launched the Ray-Ban Stories: smart glasses, built in partnership with EssilorLuxottica. According to Microsoft, it has “dual integrated 5MP cameras let you capture life's moments as they happen from a unique first-person perspective.” This can be done “the capture button or hands-free with Facebook Assistant voice commands.” Ray-Ban Stories feature “open-ear speakers” and a “three-microphone audio array delivers richer voice and sound transmission for calls and videos.” According to Microsoft, “Beamforming technology and a background noise suppression algorithm provide for an enhanced calling experience like you'd expect from dedicated headphones.”¹⁴

Google had also launched smart glasses in 2014 called Google Glass. However, it failed as it wasn't deemed fashionable or comfortable to wear. Furthermore, the product did not address consumer demand, and it had a high price point, making it unaffordable for an average consumer. In contrast to this, Ray-Ban Stories surpassed Google Glass. It is more fashionable and seems to be more beneficial and useful to the users. It also addressed the issue of privacy by having an LED light go on whenever the camera is in use.¹⁵

In 2021, Google built its very own System on a Chip (SoC) to power its mobile phone Pixel 6 to bring innovative AI and machine learning to Pixel users. This SoC was called Tensor. Tensor enables high-quality photos and video, powerful security and performance, and more intelligent speech recognition that makes Pixel more personalized and helpful to users. It delivers complex artificial intelligence and machine learning processes on the phone itself, bringing the power of cloud computing to one's phone. These algorithms run on a device rather than running through a network or server making the phone work faster.¹⁶

Google introduced LaMDA (Language Model for Dialogue Applications) that can engage in free-flowing conversations, unlocking more natural ways of interacting with technology. It is built on Transformer architecture that produces a model that can be trained to read many words, understand the relationship between the words, and then predict what word or words will come next. LaMDA was trained in dialogue. It provides responses in a conversation that are sensible and specific to the context of the conversation.¹⁷

At I/O Developers Conference 2021, Google announced MUM (Multitask Unified Model) that allows users to ask questions across different types of information. It is 1000 times more powerful than BERT (a technology that enabled users to train their own question answering system). It is able to understand and generate language. It is trained across 75 different languages and can perform many different tasks at the same time, allowing it to develop a deeper understanding of information than previous models. Since it is multimodal, it is able to understand information across texts and images.¹⁸

Google had a strong financial year. A factor that contributed to this increase could possibly be the innovations and announcements made by Google in 2021. Alphabet's total revenue for 2021 was \$257.6 billion, a significant increase from \$182.5 billion in 2020. This represents an increase of \$75.1 billion or approximately 41%. The operating income for Alphabet in 2021 was \$78.7 billion, up from \$41.2 billion in 2020. This marks an increase of \$37.5 billion or about 91%. The operating margin improved from 23% in 2020 to 31% in 2021. Alphabet's operating cash flow in 2021 was \$91.7 billion, compared to \$65.2 billion in 2020, indicating an increase of \$26.5 billion or roughly 40.7%.¹⁹

In 2021, Tesla unveiled its Dojo supercomputer technology. It is a training system designed to handle large-scale AI workloads, particularly for training neural networks used in Tesla's autonomous driving systems.²⁰

In 2021, Salesforce completed the acquisition of Slack Technologies, Inc., a software company. Through this acquisition, Salesforce will be able to create a modern workspace that enables collaborations, communities, communications, CRM (Customer Relationship Management) functionality, customer experience, and AI into an ecosystem to welcome other integrations to extend enterprise.²¹

PHASE III:

In Phase III, we see that the graph of 'Is AI' saw a more significant dip as compared to the graph of 'Not AI'. The common reason for the dip in the aggregate of their opening stock prices is the war between Russia and Ukraine. According to Q.ai, "oil prices and inflation increased, wages remained low for many workers, interest rates rose, and many feared the beginning of a recession". Now, the reason the trend of 'Is AI' saw a more significant dip was because, according to Q.ai, "the number of IPOs were down and IPOed businesses often lost as much as 80% of their value, and tech companies and start-ups relied on the cheap money that interest rates of almost 0% provided now.". The Federal Reserve also increased their interest rate to between 4.25% and 4.5%, a 0.5% increase. As rates rose, investors stopped putting their money in businesses for returns and rather sought immediate cash generation. Due to this dire situation, tech businesses began downsizing and cutting jobs. According to Q.ai, "costs for many goods and services had increased and transportation saw significant volatility due to shifting oil prices." Many tech companies rely on advertisement for a large portion of their revenue. Other companies had cut down on advertising in their budgets in the fear of a recession. Due to this, companies such as Alphabet, Meta, and Twitter saw their advertisement revenues fall. The US dollar had also strengthened. According to Q.ai, due to this, "Multinational Companies brought in less money from overseas business, significantly impacting major tech firms. As a result of all of this, tech stocks fell more than 30% in 2022, and the overall market saw a drop of 20%. The

S&P 500 ended the year with an overall market drop of more than 20%. Dow Jones Technology Index was also down more than 35% and the NASDAQ was down over 33%.”⁽²²⁾

PHASE IV:

In Phase 4, we see that the 'Is AI' graph sees a significant recovery in the average of their opening prices.

In November of 2022, ChatGPT was launched by OpenAI and reached one million users in five days. According to Lawlor and Chang, “ ChatGPT enables machines to engage in coherent and context-aware conversations.” As a result of this huge breakthrough in technology, Alphabet, Meta, and Amazon.com started announcing milestones in AI in the battle for the AI supremacy. For example, according to Lawlor and Change, “Meta’s Llama (Large Language Model Meta AI) is a collection of state-of-the-art foundation language models and was a turning point in open-source AI development. Though its foundational models are smaller than those of GPT-3 and others, it achieves comparable results with much less computational power. In 2023 at Snapdragon Summit, we achieved the world’s fastest Llama 2-7B on a phone, demonstrating chat with an AI assistant that runs completely on the device.” Google made PaLM (Pathways Language Model) was made public in 2023.his model was a major breakthrough in natural language processing (NLP) as it was able to scale up to an astonishing 540 billion parameters. Google also introduced Gemini, an AI model that can help one with writing, brainstorming, learning and more. It was designed for different sizes and can understand and combine different modalities. It came in three different sizes: Ultra, Pro, and Nano, allowing it to be used with different devices.²³

As a result of this Generative AI wave, technology stocks were responsible for more than 70% of the S&P 500’s total return of 26.3 % in 2023.²⁴

Investors, led by Microsoft’s multibillion-dollar bet on OpenAI, invested \$27 billion into generative AI startups in 2023.²⁵

PHASE V:

Continuing the growth trend in 2023, 'Is AI' graph saw a growth trend in 2024, as well.

In 2024, Microsoft launched the dynamics 365 contact centre. It is a service that integrate Copilot to offer comprehensive and composable solutions. It makes use of engaging, context-aware chatbots and virtual assistants powered by generative AI and provides a modern conversational IVR (Interactive Voice Response) that recognizes caller intent and complex instructions, using Nuance’s technology.²⁶

Microsoft announced the launch of Microsoft Copilot for Security. This is the industry’s first generative AI solution which uses copilot to strengthen security at the scale and speed of AI and transform security operations.²⁷

Azure, Microsoft's cloud computing platform, has been a primary beneficiary of AI initiatives. In the fiscal third quarter of 2024, Azure revenue surged 31%, with AI services contributing 7 percentage points to this growth. According to Seiler, "Microsoft said that more than 65% of Fortune 500 companies now use Azure OpenAI services, while deals are also getting larger." The introduction of AI-powered Copilot assistants has boosted adoption of Microsoft's productivity tools. Microsoft 365 revenue grew by 14%, partly driven by Copilot integration.²⁸

As a result of this, for the quarter ended March 31, 2024, Microsoft's revenue was \$61.9 billion and had increased by 17%. Its Operating Income was \$27.6 billion and increased by 23%, its Net Income was \$21.9 billion and increased by 20%. and Microsoft Cloud revenue was \$35.1 billion, up by 23% Year on Year.²⁹

In 2024, NVIDIA acquired Brev.dev (a San Francisco-based startup that provides an AI and machine learning development platform for building, training and deploying models on CPU- and GPU-based cloud instances). Earlier, it acquired an Israel-based startup that worked in AI infrastructure management called Run:ai. The deal was valued at \$700 million. It also acquired a California-based startup called Shoreline.io that provided software for automatically fixing issues in data centre infrastructure. The deal was valued at \$100 million.³⁰

NVIDIA Healthcare launched Generative AI microservices. According to Nvidia, "they offer advanced imaging, natural language and speech recognition, and digital biology generation prediction and simulation. Researchers, developers and practitioners can use the microservices to easily integrate AI into new and existing applications and run them anywhere — from the cloud to on premises — equipping them with copilot capabilities to enhance their life-saving work. These include screening for trillions of drug compounds to advance medicine, gathering better patient data to aid early disease detection and implementing smarter digital assistants."³¹

According to Nvidia, It also unveiled "Project G-Assist- an RTX-powered AI assistant technology demo that provides context-aware help for PC games and apps." Furthermore, Nvidia also states that it takes "voice or text inputs from the player along with contextual information from the game screen, and runs the data through AI vision models." Finally, it provides a response based on the information collected in the form of text or speech.³²

As a result of this, 2024 was a record-breaking year for NVIDIA. According to Jennewine, "Nvidia shares have surged 150% this year alone, accounting for nearly one-third of the gains in the S&P 500."³³

In 2024, Amazon announced the launch of Rufus. It is an AI-powered expert shopping assistant trained on Amazon's product catalogue and information from across the web to answer customer's questions on shopping needs, products, comparisons between products, and recommendations based on context.³⁴

According to Bodas, "AWS Supply Chain recently launched a new generative AI-powered data onboarding agent built on Amazon Bedrock to seamlessly integrate data from disparate sources. This onboarding agent increases the speed and ease of onboarding customer data by

eliminating the need to manually transform data from its native format into the AWS Supply Chain Data Lake (SCDL) canonical data model format.”³⁵

In the second quarter ending June 30, 2024, according to Amazon, “Net sales increased 10% to \$148.0 billion in the second quarter, compared with \$134.4 billion in second quarter 2023. AWS segment sales increased 19% year-over-year to \$26.3 billion. Operating income increased to \$14.7 billion in the second quarter, compared with \$7.7 billion in second quarter 2023. AWS segment operating income was \$9.3 billion, compared with operating income of \$5.4 billion in second quarter 2023.”³⁶

The reason for Amazon’s second quarter to have a good performance could be because of the AI-related innovations introduced by Amazon.

In 2024, Meta launched Meta AI. It is one of the world’s leading assistants that can be used on Facebook, Instagram, WhatsApp, and Messenger. It was built using LLaMA 3. You can use Meta AI in feed, chats, search and more across our apps to get things done and access real-time information, without having to leave the app you’re using. You can also generate images on Meta AI. An image starts appearing as you start typing so you can watch Meta AI bring your vision come to life.³⁷

Meta saw a strong second quarter in 2024 and is on track to make Meta AI the most used AI assistant in the world by the end of 2024. Meta saw an increase in their revenue of 22% (in Q2 of 2024, it was \$ 39,071 million and in Q2 of 2023, it was \$31,999 million).³⁸

In 2024, Google introduced Gemini 1.5. It was more capable and had been built to be multimodal. It can generalize and easily understand, operate across, and combine different types of information such as text, code, audio, image, and video.³⁹

Google introduced Gemma, a family of light, state-of-the-art open models. It is built from the same research and technology used to create Gemini models.⁴⁰

It was designed to be smaller and more resource- efficient compared to the other models, making it suitable to be used on various platforms. Since it was open-source, developers can inspect and fine-tune the model according to specific tasks that need to be performed. It also supported many popular frameworks such as PyTorch and Hugging Face Transformers. It also aimed to mitigate biases and promote responsible model behaviour through techniques such as automated filtering and RLHF (human feedback reinforcement learning).⁴¹

Google introduced AlphaFold 3. It is an AI model developed by Google DeepMind in collaboration with Isomorphic Labs that can accurately predict the structure of proteins, DNA, RNA, ligands, etc, and how they interact to transform humans understand of the biological world and potentially help with drug discovery. Isomorphic Labs is using AlphaFold3 to accelerate and improve the success of drug design by helping to understand how to approach new disease targets, and developing new ways to pursue existing ones that were previously out of reach.⁴²

Google saw a strong performance in second quarter of 2024. This shows Google's strength in Search and momentum in Cloud, by innovating at every layer of AI stack. As a result of this, Google's revenue for second quarter was up by 14%, when compared to the revenue earned in second quarter of 2023.⁴³

Elon Musk announced on social media that Tesla is constructing an AI supercluster, which is projected to be the world's largest, requiring over 500 megawatts of power and utilizing a combination of Tesla's own AI hardware and third-party chips from Nvidia and others. This facility is crucial for Tesla's advancements in self-driving technology and humanoid robotics, as it will provide the necessary computing power to support these innovations.⁴⁴

In 2024, Salesforce announced the Salesforce Zero Copy Partner Network. This allows organizations to access data from where it exists and when there is a change in the source data, the data is immediately updated at every location. According to Salesforce, it allows organizations to take action "on data from anywhere in the flow of work." Further, Salesforce also states that "it also allows you to share valuable insights back into these systems", without needing to make copies of the data. According to Salesforce, "this lets customers deploy trusted, relevant generative AI across all Salesforce applications without having to fine-tune an off-the-shelf LLM."⁴⁵

Salesforce introduced Slack AI. It is an intuitive generative AI which is available in Slack itself. It is an AI-powered search that allows users to ask questions and get an answer based on relevant Slack messages, making it personalized and intelligent responses to any question. This allows users to access information faster. It allows users to get a summarization of unread messages, messages sent in the past seven days, or messages sent according to a custom range date set by the user. It also provides summaries of long conversations, and clear sources are included in each summary, allowing users to dive deeper into a highlight. Users can save an average of 97 minutes per week by using Slack AI features.⁴⁶

Salesforce being the number one AI CRM, with industry leading clouds, Einstein, Data Cloud, MuleSoft, Slack, and Tableau, all integrated into one platform, they believe they are leading their users into a new era of AI. Their second quarter revenue of 2024 was of \$8.60 billion, up 11% year-over-year.⁴⁷

In 2024, at the Computex technology trade show in Taipei, AMD introduced the MI325X accelerator. This accelerator is designed to compete with Nvidia's offerings and support complex AI applications in data centres.⁴⁸

AMD introduced AMD Ryzen AI 300 series processors. These processors designed for AI PCs that enhances the AI computing performance of the PCs. It improves laptop computing by delivering lightning-fast performance for multitasking, immersive gaming, and content creation, allowing users to tackle difficult tasks with ease. It increases the battery life of laptops and efficient processing of AI workloads. Acer, ASUS, HP, Lenovo, and MSI are announcing more

AI PCs enabled by AMD Ryzen AI 300 Series processors. AMD also introduced Ryzen 9000 series processors. This was introduced for desktop PCs aimed at high performance for gaming content creation, and productivity. It offers cutting-edge computing power and reliability and delivers an average 16% better IPC (Inter Process Communication) than the prior generations of Ryzen processors.⁴⁹

In 2024, China's ByteDance worked with the chip Designer Broadcom to develop an advanced AI processor. It is a 5-nanometre customised product known as an application-specific integrated chip.⁵⁰

According to Zacks Equity Research, Broadcom also “announced significant advancements in its optical interconnect solutions tailored for AI and machine learning (ML) applications.” Broadcom released the 200-Gbps per lane (200G/lane) electro-absorption modulated laser designed to complement next-generation GPUs. It also introduced the industry's first 200G/lane vertical-cavity surface-emitting laser (VCSEL), and a continuous wave (CW) laser optimized for silicon photonics (SiPh) modulation at 200G. This will aid in revolutionizing high-speed interconnects within AI compute clusters, facilitating front-end and back-end networks. Furthermore, according to Zacks Equity Research, “Broadcom's continued investment in VCSEL, EML and CW laser technologies underscores its commitment to delivering disruptive innovations in bandwidth, power efficiency and latency optimization for optical interconnects.” As a result of these developments, Broadcom's share has gained 12.7% year to date. According to Zacks Equity Research, “AVGO is benefiting from the robust adoption of AI and the strong deployment of generative AI. In the first quarter of 2024, under its semiconductor segment, AI revenues quadrupled year on year to \$2.3 billion despite sluggish enterprise and telcos end markets. Broadcom now expects fiscal 2024 AI revenues of roughly \$10 billion (higher than previous guidance of \$7.5 billion) and to account for 35% of semiconductor revenues (higher than previous guidance of 25%). Networking revenues are expected to rally 35% year over year, driven by the accelerating deployment of networking connectivity and the expansion of AI accelerators within hyperscalers.”⁵¹

Conclusion

In Phase I, we see that due to the COVID-19, dependence on technology increased, and there was an increase in AI-powered solutions in education, retail, and education. Due to this, AI or technology stocks performed better than non-AI stocks.

In Phase II and Phase V, innovations, products, acquisitions, mergers, and contracts that were entered into or introduced by AI companies, and the strong financial performance by AI companies during those time periods could have led to investors having positive sentiments towards AI companies, possibly leading a boost in the stock prices of the AI companies.

In Phase III, the AI companies saw a dip in their stock prices because of increase in the interest rates, downsizing, significant increase in the costs of goods and services and transportation, and other firms cutting down their advertisement expenses.

In Phase IV, the rise of generative AI because of ChatGPT and companies such as Alphabet, Amazon, and Meta making advancements in AI, the S&P 500 market saw an increase in their

total returns. This could have led to investors having positive sentiments towards AI companies, leading to a boost in the stock prices of AI companies.

In conclusion, companies that are involved in the manufacturing and production of AI-related products, mergers and acquisitions have favorable investor sentiments and have had a strong financial performance from 2020-2024.

However, recently there has been speculation regarding whether the AI ‘bubble’ may be about to burst. It is said that AI could add about \$15 trillion to the value of the global economy, but recent earning reports show that Google and Tesla haven’t had a strong financial performance, leading to a dip in their share prices. Moreover, there are reports stating that the public is becoming more distrustful of AI, and businesses are finding it difficult to make money from it. At the same time, there is another viewpoint that believes that the AI revolution isn’t about to come crashing down, having a drastic impact on the global economy. During the dotcom bubble the hundreds of companies that had failed weren’t very profitable. They weren’t set up to survive even a temporary dip in the market. However, companies that are the leaders in the AI race (Microsoft, Nvidia, Alphabet, and Meta) are already hugely profitable. They have proven business models and reliable revenue streams that won’t dry up even if the AI bubble was to burst. They also have huge user bases and vast amounts of proprietary data that serves as a protection against upstarts hoping to sneak in and launch competing AI services under their noses. But it does not mean that the AI giants aren’t immune to external pressures. For example, the ongoing antitrust cases against Google and Nvidia would not just impact these two companies, but also have far-reaching implications for other major players in the AI industry.⁵²

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