PERFORMANCE
EQUITY MANAGEMENT

Generative AI

A PEM Tech Trend Overview

June 2023

Image created using Generative AI via Midjourney using the following prompt, "Create a collage of an investor navigating a web of artificial intelligence, big data, innovation using pale blue, black and white in dynamic and bright style."

ChatGPT is the AI heard around the world. A new computing platform has been invented. The iPhone moment of AI has started.

Jensen Huang, CEO of NVIDIA,
March 24, 2023

I have always thought of AI as THE most profound technology that humanity is working on. More profound than fire or electricity or anything we have done in the past.

Sundar Pichai, CEO of Google,
April 17, 2023

The development of AI is as fundamental as the creation of the microprocessor, the personal computer, the Internet, and the mobile phone

Bill Gates, founder of Microsoft,
March 21, 2023

INTRODUCTION

Wow. AI as more profound than the discovery of fire or electricity?!? The iPhone moment?!? As fundamental as the PC or the Internet?!? Clearly, these technology leaders are excited. But should investors be? How can one distinguish signal from the deafening AI noise of the moment?

As with every exciting innovation wave or "sky is falling" black swan event, investors may wish to first calibrate to the facts, use historical frameworks and balance rewards with risks. This Tech Trend Overview will briefly touch on these three dimensions to aid in investor education and awareness. While it's impossible to cover every detail of this rapidly evolving field, this market brief aims to serve as a starting point. A resource section is included at the end to facilitate further learning for readers to go deeper, if they would like (please see End Note 2).

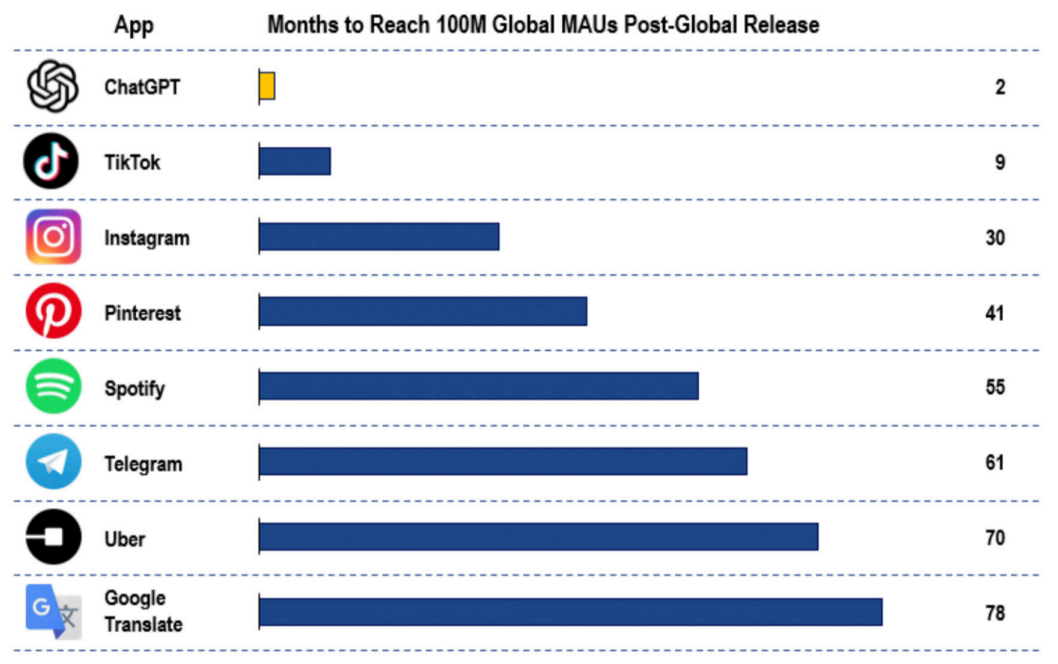
In summary, investors will be faced with how to best capitalize on this mega trend in the short term. Is it through collaborations with venture capital funds that partner with entrepreneurs? Or is it through mega cap public equity exposure via a Microsoft or Nvidia? Time will tell, but either way, PEM expects this will be a long journey over multiple phases.

CALIBRATE TO THE FACTS:

Recent excitement around artificial intelligence (AI), has been driven by advancements in the burgeoning category of "Generative AI". Whereas traditional AI is focused on deep analysis of existing data to glean insights, generative AI uses existing data sets to create novel content including text, images, audio, code, video, etc. Moreover, generative AI poses a paradigm shift in human / machine interactions, bridging communication gaps by allowing individuals to use everyday language, rather than programming languages to automate complex tasks.

Leading the charge is OpenAI's ChatGPT, a simple to use chat-based interface that generates long form text responses to user-initiated prompts. GPT-3.5 has seen an unprecedented quick rise, faster than any consumer web app ever, reaching over 100M monthly unique users in less than two months post-release as seen in the chart below.[1]

From Zero to 100M: ChatGPT's Meteoric Rise



Source: UBS Research | For illustrative purposes only.

CALIBRATE TO THE FACTS (cont.)

Other marquee products include image-based generative AI frameworks such as Midjourney (used to generate the cover of this paper), Stable Diffusion, and OpenAI's DALL-E 2. Despite the tremendous progress made, the industry consensus view is that the current wave of generative AI companies may only be scratching the surface of what could be possible in the coming years and decades.

Many venture capital funds seem to agree with this view. Since ChatGPT's release, venture funding has surged into generative AI startups as firms try to stake their claims within the rapidly evolving landscape, sometimes at startlingly high 2021 type valuations.[2] This has led many skeptics to declare generative AI the latest "hype wave."[3] However, as history has shown, hype often does not predict failure. PEM believes institutional investors consider siding with venture capitalists to build some exposure should generative AI emerge as the next great growth investment sector.

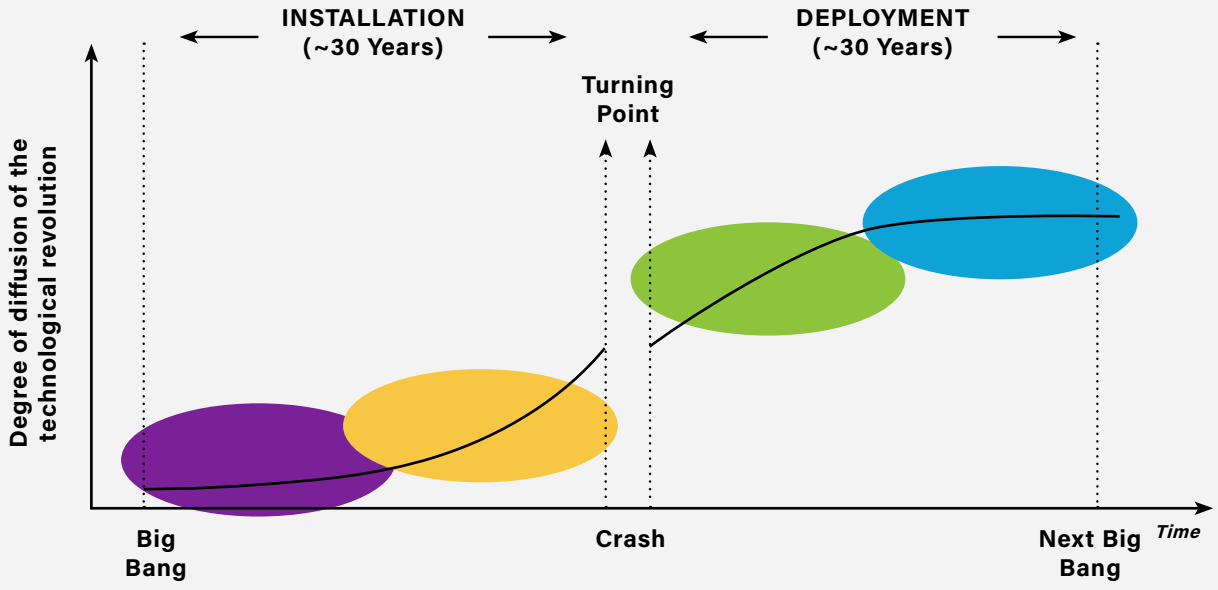
Given the rapid pace of change surrounding AI, one should examine this trend through the lens of broader technology adoption cycles. PEM believes that Carlota Perez's lifecycle of innovation as outlined in her book, "Technological Revolutions and Financial Capital" is a useful framework.

USE HISTORICAL FRAMEWORKS:

Perez assesses innovation as a series of overarching technological revolutions defined as clusters of novel technologies that bring about new products, industries, and capabilities. These, in turn, significantly transform society and the broader economy. In her book, Perez identifies five historical examples of technological revolutions, ranging from the Industrial Revolution of the 18th century to the Information and Telecommunications ("ICT age") of the late 20th century to present.[4]

Without going into detail, it is worth noting that each innovation cycle has common characteristics: interrelated technologies typically anchored by common low-cost inputs and infrastructure, cycles that last approximately 50 years, and cycles that progress in an S-curve fashion. The below graphic illustrates this S-curve, with the "Installation Phase" taking place over the first two to three decades, followed by an inflection, or "Turning Point" with the "Deployment Period" occurring over the next two to three decades.

The Installation Period begins with a "big bang" event that introduces new technological capabilities. This typically stimulates the imagination of entrepreneurs who begin to incubate and start new companies. Investors and entrepreneurs lean into these new technologies, leading to significant financial inflows



Source: Carlota Perez, Technological Revolutions and Financial Capital, The Dynamics and Bubbles of Golden Ages | For illustrative purposes only.

* Technological revolutions and techno-economic paradigms: Paper from Carlota Perez that outlines many of these same ideas outlined in her book "Technological Revolutions and Financial Capital."

and the rapid expansion of new firms, products, and services. This is happening today with generative AI. Eventually, the new technological paradigm matures as a new status quo until a new revolution is sparked.

In previous technological revolutions, the seeds for the next innovation wave have been sown well before its big bang. Often, inputs and products have existed for a considerable time, either in a minor economic role or as a complement to existing industries. For instance, computers had been incubated and utilized in academic and military contexts for decades before Moore's Law took hold with the 1971 release of the Intel 4004, which made personal computers technologically and commercially feasible. The same goes for the Internet.

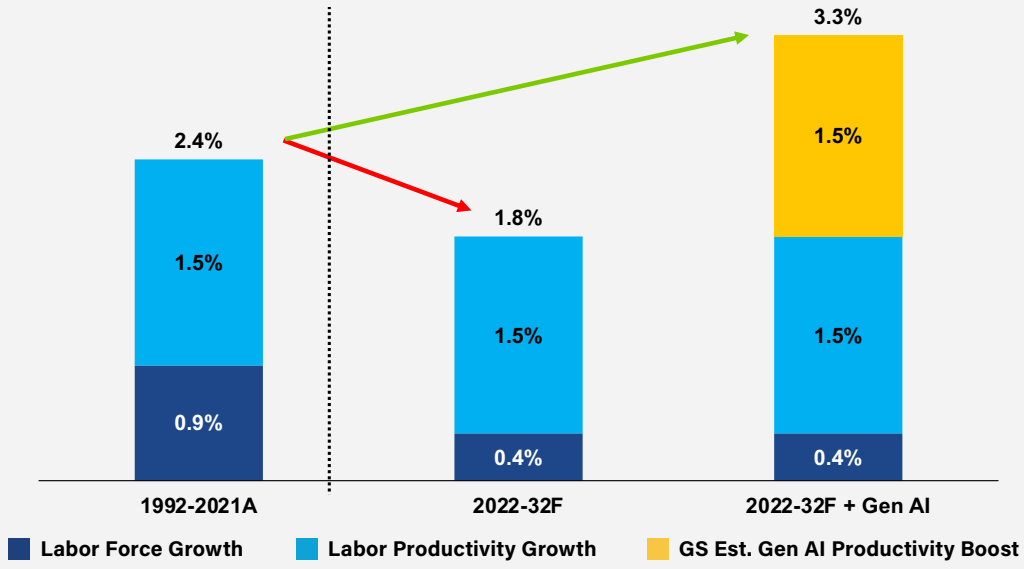
Hence, AI itself is not new. The seeds of AI via machine learning algorithms and neural networks have been rapidly evolving as compute power has become ubiquitous and training data sets have exploded. As a result, AI has already been used to conquer Chess (Deep Blue in 1997), Jeopardy (Watson in 2011), and Go (AlphaGo in 2016). AI algorithms are incorporated into TikTok feeds, Snapchat filters, Amazon recommendations, Uber pricing, Gmail spam filters, and more.

But just as the Intel 4004 ushered in the ICT age, Google Brain's 2017 paper, "Attention is All You Need," may in the future be considered the "big bang" event that sparked the Age of AI. This paper introduced the Transformer architecture (the "T" in the product name of "Chat GPT") – the breakthrough that enabled products based on Large Language Models (LLMs) viable (e.g., ChatGPT and DALL-E).[5] This is enabled through a mathematical focus on "attention" by novel statistical algorithms to replicate the human cognitive capability to formulate and predict the best matched response as an output to a prompt.[6]

UNDERSTANDING RISK / REWARD:

As we look towards the future, many experts predict that the Age of AI will usher in significant innovations and transformative changes in society and the economy. Bill Gates envisions AI as akin to having a white-collar worker at one's disposal, while Microsoft CEO Satya Nadella describes the emerging human-AI relationship as "moving from autopilot to co-pilot."[7] The productivity increase from generative AI has the potential to be a major economic catalyst. Goldman estimates that generative AI could contribute an incremental $150 billion to the global software market of $685 billion and deliver approximately $7 trillion of incremental global economic growth driven by a ~1.5% boost to real GDP. As seen in the chart below, such a net labor productivity increase would almost double the long term forecast of the Congressional Budget Office and could usher in what Perez would classify as a new "Golden Age".[8]

Annual US Real Potential GDP Growth



Source: PEM Analysis; Congressional Budget Office (CBO) - see www.cbo.gov/publication/57971#data; Briggs, Kodnani, et al. "The Potentially Large Effects of Artificial Intelligence on Economic Growth." Goldman Sachs Global Investment Research. March 26, 2023. For illustrative purposes only. Real values are nominal values that have been adjusted to remove the effects of inflation. Potential GDP is the maximum sustainable output of the economy as calculated by the CBO. GS Est. Gen AI Productivity Boost represents their baseline estimate which incorporates that about 7% of workers are fully displaced but that most are able to find new employment in only slightly less productive positions, that partially exposed workers experience a boost in productivity consistent with five academic sturdies cited by GS in their report, and that effects are realized over a 10-year period that starts around the time when roughly half of businesses have adopted generative AI. Note displayed bar values may not add to the total due to rounding.

UNDERSTANDING RISK / REWARD: (cont.)

Despite the economic promise, there are key concerns about generative AI. It remains uncertain whether generative AI will act as a substitute or as a complement to human labor. Goldman's report estimates that one-fourth of current work tasks could be automated, while two-thirds of current occupations could be partially automated, with a bias towards white-collar fields. Consequently, generative AI poses a significant disruption risk to the labor supply.

Data governance and security are also central concerns. Recently, there were reports of Samsung employees using ChatGPT leaking crucial trade secrets.[9] Another growing risk is the spread of misinformation and AI "hallucinations" propagated by AI. ChatGPT has been characterized as a pathological liar[10], and many are concerned about generative AI's potential use in propagating propaganda through deepfakes.

Furthermore, critics argue that the capital-intensive nature of developing large language models (LLMs) inherently favors oligopolistic market structures.[11] OpenAI CEO Sam Altman recently disclosed that GPT-4 cost over $100 million to train, with some speculating that its daily operating expenses exceed $100,000.[12]

While these concerns are valid, it is essential to recognize that many technological revolutions bring not only tremendous opportunities but also risks that need to be managed and mitigated. This is not unique to generative AI, as similar concerns emerged during past innovation driven revolutions. Both the age of mass production and the internet spurred significant GDP growth through increased productivity but also significantly transformed the labor market. Despite the risks, Generative AI holds immense potential to drive a transformative paradigm shift in society and the global economy.

In summary, as we continue to parse the tsunami of AI headlines and proclamations, PEM believes this cycle aligns well with Carlota Perez's framework, with the Transformer as the catalyst for the next technological Generative AI driven paradigm shift. In this context, we are likely within the first half of the Installation Period. With an eye toward opportunities within this stage, PEM believes it is beneficial to pay attention to experts and companies who possess technical proficiency in the field, maintain connections with knowledgeable engineers and founders, and demonstrate track records in navigating hyper growth. Venture capital funds and mega cap public companies are all racing to seize this opportunity.

PEM compiled the following curated set of additional resources. This field is rapidly evolving and has no shortage of coverage. We hope this provides a good launching off point to go deeper. Please see End Note 2.

CHATGPT RELATED:

- **The inside story of ChatGPT (January 25, 2023):** Fortune longform piece on Sam Altman and OpenAI.
- **ChatGPT, AI Technology, and the Rise of Techno-Humanism (January 2023):** Atlantic piece written by Reid Hoffman of Greylock on the techno-humanist case for generative AI
- **I Tried Microsoft's New AI-Powered Bing Search, and I Will Never Be the Same (February 7, 2023):** WSJ article providing a firsthand account of using Microsoft's AI-powered Bing search
- **Google CEO Sundar Pichai on Artificial Intelligence, Bard Hallucinations, and the Unsolved (April 17, 2023):** Interview with Google CEO Sundar Pichai, discussing the challenges and future of AI
- **The False Promise of ChatGPT (March 8, 2023):** Noam Chomsky's critique on the limitations and risks of generative AI.

EMERGING USE CASES AND APPLICATIONS:

- **The Age of AI has begun (March 21, 2023):** Bill Gates explains why AI is as revolutionary as personal computers, mobile phones, and the Internet, and he gives three principles for how to think about it.
- **ChatGPT Can Decode Fed Speak, Predict Stock Moves From Headlines (April 17, 2023):** Bloomberg article summarizing findings from two new papers applying ChatGPT to finance use cases.

- **Generative AI Makes Headway in Healthcare (March 21, 2023):** WSJ article highlighting how providers are tapping ChatGPT technology to summarize patient visits, assist in research.
- **Five Predictions for the Future of Learning in the Age of AI (February 8, 2023):** a16z blog post from partner Anne Lee Skates covering her predictions on how generative AI will disrupt the education industry.
- **OpenAI Cookbook:** Github repository with code for accomplishing tasks with OpenAI's APIs.

AI MARKET PRIMERS FROM SELECT VENTURE CAPITAL GPS:

- **AI Canon (May 25 2023)** and **Who Owns the Generative AI Platform (January 19, 2023):** a16z thought leadership piece on the AI stack and where value will accrue.
- **The 2023 MAD (ML/AI/Data) Landscape (Feb 21, 2023):** Interactive market map of the ML/AI/Data landscape created by Firstmark Capital.
- **AI Primer (March 2023):** AI market report from IVP that provides the technical basics of AI technology for the layman audience as well as a brief history of AI.
- **The Seven Generative AI Building Blocks for the Next Generation of Consumer Technology Companies (April 27, 2023):** Menlo Ventures outlines key AI building blocks that consumer companies will use.
- **The New Generative AI Infra Stack (May 19, 2023):** Post from Cowboy Ventures regarding the infrastructure tools needed to enable Generative AI.

LARGEST AI / LLM VC FINANCINGS ANNOUNCED YTD AS OF MAY 2023 (SOURCE: CRUNCHBASE):

- **Adept:** raises $350M in a Series B co-led by Spark and General Catalyst
- **Anthropic:** raises $300M in a Series C led by Spark
- **Asimov:** raises $200M in Series B led by CPP
- **Character.AI:** raises $150M in a Series A led by a16z

AI RESEARCH PAPERS:

- **Attention is all You Need by A Vaswani et al. (2017):** Google Brain paper that introduced the Transformer network architecture which now underpins many prominent LLM
  - Link to paper - Summary / Media Coverage
- **Generative Agents:** Interactive Simulacra of Human Behavior by JS Park et al. (April 2023): Stanford / Google paper that trained AI Agents to emulate human interactions in a closed-world sandbox.
  - Link to paper - Summary / Media Coverage

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3 Clark, Peter Allen. "Generative Artificial Intelligence Is Driving Tech's Latest Hype Wave." Axios, January 10, 2023. https://www.axios.com/2023/01/10/artificial-intelligence-hype-explosion-generative-ai-chatgpt.

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8 "Generative AI Could Raise Global GDP by 7%" Goldman Sachs. April 5, 2023. https://www.goldmansachs.com/insights/pages/generative-ai-could-raise-global-gdp-by-7-percent.html.

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12 Knight, Will. "OpenAI's CEO Says the Age of Giant AI Models Is Already Over." Wired. April 17, 2023. https://www.wired.com/story/openai-ceo-sam-altman-the-age-of-giant-ai-models-is-already-over/.

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Jeffrey Barman
CHIEF INVESTMENT OFFICER
jbarman@peqm.com

John Clark
PRESIDENT
jclark@peqm.com

Marcia Haydel
MANAGING DIRECTOR
mhaydel@peqm.com

Jeffrey Reals
MANAGING DIRECTOR
jreals@peqm.com

Lawrence Rusoff
MANAGING DIRECTOR
lrusoff@peqm.com

James Tybur
MANAGING DIRECTOR
jtybur@peqm.com

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