Future Digital Technologies and Artificial Intelligence

Open Access Journal

May 2025| Volume 01 | Issue 01 | Pages 01-07

https://doi.org/10.55670/fpll.fdtai.1.1.1

Journal homepage: https://fupubco.com/fdtai

Future Publishing LLC

Article

From hype to bubble: a historical analysis of technology trends and the case for artificial intelligence

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ARTICLE INFO

Article history:
Received 25 January 2024
Received in revised form
28 February 2025
Accepted 11 March 2025

Keywords:
Artificial Intelligence; Technology Advancement, AI Butterfly Theory, Technology Trends, AI Future

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DOI: 10.55670/fpll.fuen.1.1.1

ABSTRACT

Technological advancements often undergo a hype cycle that initial enthusiasm and heavy investment lead to inflated expectations, followed by eventual market corrections. This article examines historical cases of technology hype and decay, including the dot-com bubble, Google Glass, and 3D televisions, drawing parallels to the current surge in artificial intelligence (AI). With generative AI experiencing unprecedented investment and integration across industries, concerns arise regarding its long-term viability and realistic impact. Through the AI Butterfly Theory, this study highlights the stages of AI evolution, emphasizing the need for balanced expectations and strategic investment to avoid repeating past technology booms and busts.

1. Introduction

Technological advancements have consistently sparked waves of excitement and heavy investment, fundamentally reshaping industries, economies, and daily life. However, history demonstrates that not every breakthrough technology lives up to its initial expectations. Periodically, emerging technologies experience a "hype cycle" in which enthusiasm and market speculation drive rapid growth and adoption. Yet, as limitations, implementation challenges, or shifting consumer interests become evident, these technologies sometimes fail to meet their transformative promises. This article examines several prominent historical cases where technological trends initially gained rapid traction but ultimately faded. From the dot-com boom to Google Glass, these examples reveal how overestimated potential, lack of market readiness, or technical challenges can lead to technology's decline. The global AI market has experienced explosive growth in recent years, with investments reaching staggering levels. In 2023, the global AI market size was estimated at $142.3 billion, and it is projected to grow at a compound annual growth rate (CAGR) of 37.3% from 2023 to 2030, potentially reaching $1,811.8 billion by 2030 [1]. This remarkable growth trajectory is fueled by substantial investments from both the private and public sectors. Major tech companies are leading the charge in AI investments. In 2022, global corporate investment in AI reached $92 billion, a six-fold increase compared to 2016. Tech giants like Amazon, Google, Microsoft, NVIDIA, and Salesforce have secured two-thirds of the $27 billion raised by emerging AI companies in 2023. OpenAI, a prominent AI research company, has received $14 billion in capital through partnerships with Microsoft and other leading investors [2]. The AI startup ecosystem is also experiencing significant growth. In the second quarter of 2024, investment in AI startups reached $24 billion, more than doubling from the previous quarter. AI became the largest sector for startup funding for the first time, driving overall startup funding to $79 billion in Q2 2024. The United States leads in AI investment, with nearly $250 billion invested in 4,643 companies cumulatively since 2013 [3]. Companies across various industries are increasingly integrating AI into their operations. According to

an EY AI Pulse Survey, 95% of senior leaders report that their organizations are currently investing in AI. The number of companies investing $10 million or more in AI technology is set to nearly double from 16% to 30% in the coming year. Furthermore, 88% of senior leaders at organizations investing in AI now spend 5% or more of their total budgets on AI investments, up from 51% three years ago. Half of the surveyed senior leaders stated they would dedicate 25% or more of their total budgets toward AI investments in the coming year [4]. AI investment and adoption vary across different regions. The United States AI market size accounted for $103.7 billion in 2022 and is estimated to reach around $594 billion by 2032, growing at a CAGR of 19.1% from 2023 to 2032. China's AI market is expected to reach $196.6 billion in 2023 and is projected to grow at a CAGR of 37.3% from 2023 to 2030, potentially reaching $1,811.8 billion by 2030. Other countries, including the United Kingdom, Israel, Canada, France, India, Japan, Germany, and Singapore, are also among the top countries leading in AI research and technology in 2023. Companies investing in AI are already seeing tangible benefits. Among senior leaders whose organizations are investing in AI, about three-quarters are experiencing positive ROI in areas such as employee productivity, cybersecurity, and product innovation. Organizations investing 5% or more of their total budgets in AI saw higher rates of positive return compared to those spending less than 5%. Additionally, 83% of companies claim that using AI in their business strategies is a top priority, and 87% plan to invest in AI in 2023 [5].

2. Historical cases of hype and decline

2.1 The dot-com boom and bust

The dot-com boom of the 1990s is perhaps the most prominent example of technology hype gone wrong. The internet was rapidly transforming communication and commerce, and companies without substantial products or profits were valued at billions of dollars. As the Harvard Business Review notes, in the early 2000s, the overvaluation led to the dot-com bust, with thousands of internet startups collapsing, wiping out billions in investments. The dot-com bubble burst because of unsustainable business models and overvaluation. Many internet startups lacked viable products or revenue, and once investors realized this, the value of these companies plummeted. Although the Internet itself became a critical infrastructure, the speculative investment frenzy around “dot-com” companies created a bubble that burst when profits didn’t materialize [6].

The Dot-Com Boom and Bust of the late 1990s and early 2000s provide a striking example of technology hype leading to unsustainable investment and subsequent market collapse. The number of tech IPOs on American exchanges skyrocketed during the boom, increasing from 205 in 1995 to a peak of 371 in 1999 [7]. This rapid increase in public offerings demonstrates the intense investor interest in internet-based companies. The NASDAQ Composite Index, heavily weighted towards tech stocks, rose from 751.49 in January 1995 to a peak of 5,048.62 on March 10, 2000 - an increase of 582% in just over five years [8]. This dramatic rise reflects the enormous valuations placed on tech companies during the boom. By 1999, 39% of all venture capital investments were directed toward Internet companies [9]. When the bubble burst, the consequences were severe. The NASDAQ fell by more than 75% between March 2000 and October 2002, wiping out more than $5 trillion in market value [10]. Many high-profile dot-com companies went bankrupt or saw their valuations plummet. For example, Pets.com saw its market capitalization fall from over $300 million to zero in less than a year [11]. The number of companies going public dropped dramatically after the bubble burst, from 380 in 2000 to only 80 in 2001 [7]. The NASDAQ did not regain its March 2000 peak until April 2015, 15 years after the bubble burst [8]. While many companies failed, some survived the burst and went on to become tech giants. Amazon's stock price, for instance, fell from around $100 during the bubble peak to just $7 after the burst before rebounding dramatically in subsequent years [9].

2.2 Virtual worlds and second life

Second Life, launched in 2003, was envisioned as the future of digital interaction. Media and businesses rushed to establish virtual presences, but by 2007, interest waned as the platform failed to sustain user engagement. Academic studies highlight that technology wasn’t ready to create immersive virtual environments and that social and cultural factors limited mainstream adoption. While Second Life was initially hyped as the future of digital interaction, it failed to keep users engaged long-term. Key barriers included limited technology for creating immersive experiences and difficulties in maintaining a large, consistent user base. This lack of mainstream appeal led to a decline in interest among both users and businesses, who saw diminishing returns on virtual world investments.

Virtual Worlds and Second Life experienced significant investment and attention during their peak but ultimately failed to maintain widespread user engagement and business interest. In 2006, Second Life's user base grew from 100,000 to 2 million registered users. By January 2008, residents were spending a total of 28,274,505 hours "inworld" and on average 38,000 residents were logged in at any moment [12]. Major companies invested heavily in Second Life during its peak. For example, IBM spent $10 million on its Second Life presence, including virtual real estate and employee time [13]. At its height, Second Life had a thriving virtual economy. In 2015, Second Life users cashed out approximately $60 million, and the platform had an estimated GDP of $500 million. Despite initial success, user engagement declined significantly. By 2017, the active user count had fallen to "between 800,000 and 900,000" [12]. Many companies that invested heavily in Second Life eventually abandoned their virtual presence. For instance, American Apparel closed its Second Life store in 2007, just a year after opening it [14].

2.3 Segways and personal transportation

Launched in 2001, the Segway was billed as a game-changing mode of personal transport, with its inventor predicting it would replace walking in cities. However, its high price, practical limitations, and niche appeal meant that it never reached the transformative impact it was expected to achieve. As transportation expert Pourmand [15] describes, it ultimately failed to align with mainstream commuting needs. The Segway's failure to revolutionize personal transportation is evident in its sales figures and financial performance. The company invested over $100 million in development costs, yet by 2009, it had only reached annual sales of about $25 million [16, 17]. This poor market performance led to multiple ownership changes, with the company eventually being acquired by Ninebot in 2015 for an undisclosed amount, likely to be far below its peak valuation [17]. The product's limited success is further highlighted by its discontinuation in 2020, nearly two decades after its highly anticipated launch.

2.4 Televisions and entertainment

With the success of films like Avatar, 3D televisions were launched around 2010 with the promise of an enhanced home viewing experience. Major manufacturers quickly jumped on the trend, but the excitement was short-lived. 3D televisions saw a surge in popularity following the release of 3D films, but they quickly fell out of favor. Viewers were deterred by the discomfort of wearing 3D glasses, high costs, and a lack of engaging 3D content. Manufacturers stopped production within a few years, and consumers shifted back to regular HD and 4K viewing options, which were more convenient and affordable [18]. The 3D television market experienced a brief surge followed by a rapid decline. In 2010, 3D TV sales reached 3.2 million units worldwide, with expectations of growth to 91 million units by 2014. However, these projections proved overly optimistic. By 2012, only 41% of U.S. consumers who owned 3D TVs used the 3D feature. Major manufacturers like Vizio discontinued 3D TV production in 2014, and by 2017, industry leaders Sony and LG had completely abandoned the technology [19]. The failure of 3D TVs resulted in significant financial losses for manufacturers who had invested heavily in technology, with some estimates suggesting that the industry lost billions of dollars on research, development, and marketing of 3D TVs [20].

2.5 QR codes and the slow path to resurgence

Initially introduced in the early 2000s, QR codes were touted as a bridge between the digital and physical worlds. Despite initial excitement, QR codes failed to gain traction in everyday use. They were seen as cumbersome, requiring specialized apps to scan, and didn’t offer enough value to consumers. Although they saw a resurgence during COVID-19 due to their use in contactless transactions, they are still not seen as an essential technology in everyday life and face competition from other contactless solutions like NFC [21]. QR codes experienced a rollercoaster journey in terms of adoption and investment. In 2011, 14 million U.S. consumers scanned a QR code, but by 2015, only 9.76% of consumers were actively using them [22]. Major companies invested heavily in QR technology, with Snapchat reportedly spending $54 million on QR code startup Scan.me in 2014 [23]. However, the COVID-19 pandemic sparked a resurgence, with QR code scans increasing by 94% from 2018 to 2020 [24]. Despite this growth, QR codes still face challenges, as evidenced by a 2021 study showing that only 45% of U.S. consumers felt comfortable using QR codes for payments [25]. This demonstrates the technology's struggle to achieve widespread adoption despite significant investments and periodic surges in popularity.

2.6 Google glass and the promise of wearable AR

Google Glass generated immense excitement as a wearable augmented reality device in 2013, with plans to revolutionize how people interacted with digital information. However, it was met with privacy concerns, high costs, and limited functionality, ultimately failing to gain mainstream consumer acceptance. Studies on the societal response to Google Glass indicate that consumer discomfort with intrusive technology was a major factor in its decline [26]. Google Glass's journey illustrates the challenges of introducing revolutionary technology to the consumer market. The project reportedly cost Google between $500 million to $1 billion in development [27]. Despite this significant investment, sales were disappointing. While exact figures weren't disclosed, estimates suggest that only about 10,000 units were sold during its initial "Explorer" phase [28]. The device's $1,500 price tag was a major barrier to adoption. A 2013 survey found that 79% of Americans were unwilling to pay more than $300 for a wearable device. Privacy concerns were also significant, with 72% of Americans citing privacy as their biggest concern about Google Glass. These factors contributed to Google discontinuing the consumer version in 2015, just two years after its limited release, marking a notable failure in terms of both financial investment and market acceptance [27, 28].

2.7 Blockchain beyond cryptocurrency

Blockchain was heralded as a revolutionary technology capable of transforming industries, from finance to supply chain management. While blockchain remains relevant in certain areas, like cryptocurrency, attempts to apply it broadly across industries have often failed. Many blockchain initiatives encountered issues with scalability, complexity, and high costs. For numerous applications, blockchain was not the best technological solution, leading to disillusionment and the closure of many blockchain-based projects outside of crypto [29]. Blockchain's potential beyond cryptocurrency has seen mixed results. While some industries have successfully implemented blockchain solutions, many initiatives have fallen short of expectations. For example, IBM and Maersk's Trade Lens platform, a blockchain-based global trade solution, shut down in 2022 after failing to achieve commercial viability. According to Gartner, by 2021, 90% of enterprise blockchain projects launched between 2018 and 2019 would meet a premature end

within 18 to 24 months [30]. However, success stories exist, such as the Food Trust blockchain network, which has over 200 participating organizations and has processed millions of food items [31]. These contrasting outcomes highlight the challenges and potential of blockchain technology beyond cryptocurrency.

3. AI butterfly theory

Artificial Intelligence (AI) can be compared to the lifecycle of a butterfly, encompassing four distinct stages that mirror its evolution and functionality (Figure 1). The first stage, represented by the egg, symbolizes the birth of AI concepts. This is the phase where foundational ideas and theories are conceived, including machine learning, neural networks, and data-driven decision-making. Much like the egg holds the potential for life, this stage is crucial for laying the groundwork for innovation and future possibilities. The next phase, akin to the caterpillar stage, illustrates the building and growth of AI systems. Just as a caterpillar voraciously consumes resources to prepare for transportation, this stage sees AI systems consuming vast amounts of data to train algorithms, develop models, and establish robust infrastructures. It is a period of significant development focused on strengthening the core capabilities required for the system's advancement. As AI systems mature, they enter a transformative phase represented by the chrysalis or pupa. In this stage, the true potential of AI emerges as it evolves into a tool capable of delivering tangible benefits. Whether optimizing processes, enhancing decision-making, or solving complex problems, AI's utility becomes apparent and impactful. This phase is comparable to the chrysalis producing silk, a functional and transformative output of immense value. Finally, the butterfly stage captures the allure of generative AI, exemplified by tools like ChatGPT and DALL-E, which captivate public attention with their visually appealing and creative outputs. This phase emphasizes innovation that is both fascinating and accessible, though it often focuses on surface-level advancements. While generative AI dazzles with its capabilities, it is essential to remember the foundational work from earlier stages that enabled its existence.

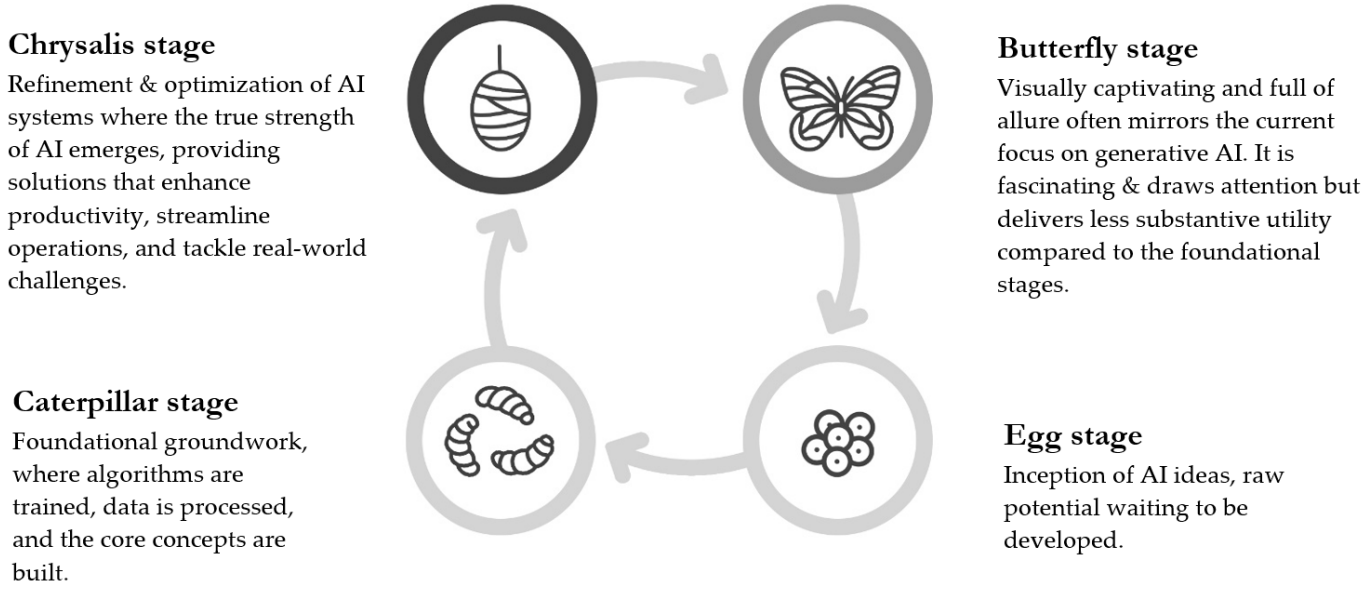

Figure 1. AI butterfly theory

This analogy underscores the importance of focusing on the chrysalis stage, where the core advancements of AI offer the most value. While the butterfly stage of generative AI dazzles with its appeal, it is critical not to lose sight of the transformative utility and foundational capabilities developed in earlier stages. This balanced perspective ensures that AI continues to evolve in ways that prioritize long-term benefits over fleeting excitement. Table 1 presents where stakeholders should focus according to the AI Butterfly Theory. Governments should emphasize the Egg and Chrysalis stages to foster innovation and ensure AI addresses societal challenges. Researchers and higher institutions play a vital role throughout the lifecycle. Businesses, both large and small, can leverage AI's trans-formative capabilities during the Caterpillar and Chrysalis stages while ensuring generative AI tools in the Butterfly stage are ethically and responsibly used. This approach balances innovation with long-term societal benefits.

Table 1. Where should stakeholders focus?

Lifecycle Stage	Stakeholders	Primary Focus
Egg Stage	Researchers, Governments	Basic research, funding innovation, developing theoretical foundations.
Caterpillar Stage	Large Businesses, Government	Building infrastructure, training AI systems, ensuring scalability.
Chrysalis Stage	Small Businesses, Government, Higher Institutions, AI Ethics Groups	Applying AI for real-world impact, ensuring ethical practices, addressing climate and societal challenges.
Butterfly Stage	Large Businesses, Small Businesses, Higher Institutions, AI Ethics Groups	Showcasing generative AI, addressing public concerns (e.g., bias, misinformation).

4. Discussion

The current wave of artificial intelligence excitement bears many similarities to these historical technology bubbles. AI, specifically in the form of machine learning and generative AI, has generated massive interest and investment, with proponents arguing it will reshape sectors such as healthcare, finance, education, and beyond. Companies have heavily invested in AI capabilities, with projected market values reaching hundreds of billions of dollars [32]. However, as with previous technologies, several warning signs suggest that AI may be on the path toward a bubble. Just as the Internet and virtual worlds were initially believed to be all-encompassing, AI is often portrayed as a technology that can revolutionize nearly every domain. Yet, some argue that AI's current capabilities may be limited, and the hype has led to unrealistic expectations. Many AI models require massive amounts of data and computing power, leading to practical and ethical issues, as well as limitations in scalability [33]. Like blockchain and dot-com ventures, the AI industry has seen significant investment from both startups and established companies, with many organizations building or acquiring AI-driven tools. However, just as many dot-com companies had unsustainable business models, there are concerns that some AI-driven companies may lack the robustness to deliver lasting value. Early adopters have already begun to recognize that not every AI model will bring the promised returns, especially in areas where automation is limited by real-world unpredictability [34]. As with Google Glass, AI's widespread adoption faces resistance due to ethical concerns. Privacy, data security, and bias in AI algorithms have raised alarm among policymakers, consumers, and researchers. Notably, studies have highlighted risks such as algorithmic bias that may disproportionately affect marginalized groups, creating legal and reputational risks for companies deploying these technologies [35]. The backlash against these ethical challenges could impede the mainstream adoption of AI if regulatory or consumer pushbacks grow. To avoid the potential pitfalls of past technology bubbles, companies and policymakers should take a balanced, evidence-based approach to AI investments. Firms should focus on scalable AI applications that solve well-defined problems and provide clear returns on investment rather than attempting to apply AI indiscriminately across all sectors. Policymakers, in turn, should establish robust regulations that promote ethical AI use, transparency, and privacy, addressing public concerns and fostering trust. Additionally, developing talent and infrastructure to support AI sustainably is crucial for long-term value, as a shortage of skilled professionals and inadequate systems often hinder AI implementations. Beyond AI, several emerging technologies hold promises and may represent the next wave of transformative advancements. Brain-computer interfaces (BCIs) are gaining attention for their potential to directly connect human brains with computers, enabling new forms of communication and control over devices. Companies like Neuralink and Kernel are exploring BCI applications, particularly in medical fields, to help those with paralysis or neurological disorders regain control over technology and physical movement. Quantum computing is another field that promises exponential computational power, which could revolutionize fields like cryptography, pharmaceuticals, and complex system simulations, addressing problems currently beyond the reach of classical computers. Lastly, advances in biotechnology, particularly synthetic biology, could enable us to engineer organisms for applications in medicine, agriculture, and environmental sustainability, creating new opportunities for bio-manufacturing and personalized treatments. These emerging technologies each carry their own set of challenges, but careful investment, ethical consideration, and measured enthusiasm can help ensure they avoid the same hype-driven pitfalls that have historically plagued transformative innovations. As these fields develop, they could reshape industries in meaningful ways, complementing or even succeeding in AI in areas where its limitations are most apparent.

5. Conclusion

While technological trends may rise and fall, certain foundational fields remain consistently relevant, regardless of shifts in popular innovations. Cybersecurity, for instance, continues to be a critical domain as digital transformation expands, with organizations constantly defending against increasingly sophisticated cyber threats. Privacy and ethical concerns also persist as core issues, especially with technologies like AI and BCIs that collect and process vast amounts of sensitive data. Ethical considerations are essential to ensure that advancements do not infringe on individual rights or create unintended societal consequences. Similarly, risk management and information security are integral to sustaining any digital innovation; these fields work to identify, mitigate, and manage the risks inherent to digital operations and data use. Regulatory compliance, legal frameworks, and industry standards evolve to support these fields, ensuring they adapt to new technologies while providing a stable foundation that mitigates risks and

protects both businesses and consumers. Thus, while new technologies like AI and brain-computer interfaces may surge in popularity, these enduring fields will continue to underpin the safe, ethical, and resilient adoption of innovation. Technologies such as the internet, virtual worlds, Segways, 3D televisions, QR codes, Google Glass, and blockchain reveal a common pattern in technology hype cycles. While each of these technologies achieved significant advances, they also faced limitations that tempered initial excitement. AI is currently at a similar juncture, with sky-high expectations, vast investment, and significant social and technical challenges. History suggests that AI, too, may experience a bubble burst if limitations are not addressed and expectations are not recalibrated. As AI continues to develop, stakeholders must remain cautious, balancing innovation with realism to prevent AI from joining the ranks of technologies that failed to live up to their initial promise.

Ethical issue

The author is aware of and complies with best practices in publication ethics, specifically concerning authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The author adheres to publication requirements that the submitted work is original and has not been published elsewhere in any language.

Data availability statement

The manuscript contains all the data. However, more data will be available upon request from the corresponding author.

Conflict of interest

The author declares no potential conflict of interest.

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