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The Hidden partner : Artificial Intelligence and Video Games.

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"Games have always been a benchmark for AI. If you can't solve games, you can't expect to solve anything else." Greg Brockman, OpenAI [3]

Abstract:

Artificial intelligence (AI) has become a central driver of economic transformation, reshaping organisational structures, value chains, and production models across industries. Among cultural industries, the video game sector occupies a distinctive position due to its intrinsic technological and industrial foundations. Unlike other creative industries that progressively integrated digital technologies, the video game industry emerged directly from the convergence of computing, electronics, software engineering, and entertainment. The paper argues that video games constitute a privileged experimental field for the development, testing, and dissemination of AI technologies.

The article proposes a conceptual framework centred on technological and organisational complementarities between AI and video games. First, it highlights a bidirectional technological relationship in which games not only benefit from AI advances but also contribute directly to the development of AI infrastructures, notably through the demand for GPUs, simulation environments, and large-scale behavioural datasets. Second, the article analyses the organisational transformations induced by AI, including changing firm boundaries, the emergence of hybrid competencies, and the increasing role of players as co-creators within platform ecosystems. Third, the paper shows how these dynamics contribute to a broader systemic convergence between entertainment, simulation, cloud computing, and AI industries.

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[3] Quoted by "The Future of Artificial Intelligence in Video Games", https://ai.engineering.columbia.edu/ai-applications/ai-video-games/

The article adopts an exploratory and qualitative approach based on historical analysis, secondary literature, specialised press sources, consultancy reports, and industry documentation. It traces the long-standing co-evolution between AI and video games, from early laboratory experiments in the 1950s to contemporary generative AI systems. . Throughout four major historical phases , video games have simultaneously served as technological demonstrators, testing grounds for computational innovation, and commercial environments requiring increasingly sophisticated forms of interaction between humans and machines.

The paper reveals how AI in video games extends far beyond gameplay mechanics. AI technologies intervene across the entire value chain, including procedural content generation, adaptive non-player character behaviour, world-building, automated testing, player analytics, matchmaking, monetisation, anti-cheat systems, and personalised user experiences. It shows that the integration of generative AI tools is further transforming production processes by reducing development costs, accelerating prototyping, as well as enabling new forms of user-generated content and collaborative creation. These developments contribute to a reconfiguration of industrial structures and professional roles, particularly through the emergence of specialised middleware providers and AI-native firms.

The study concludes that the relationship between AI and video games should not be understood as a simple producer–consumer interaction but rather as a co-evolutionary system characterised by mutual reinforcement. Far from being a marginal application domain, the industry has historically acted both as a technological catalyst and as an organisational laboratory for AI.

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Key Words: Artificial Intelligence, Creative Industries, , Digital Platforms, Entertainment, Generative AI, Human-machine interaction, Technological Complementarity Video Game Industry.

Introduction : : AI, culture and the videogame industry.

Creative industries drive the recent development of the digital economy and the Internet, foreshadowing transformations across various sectors[4]. Technological advancements in the digital age (e.g., connected devices, virtual reality, mobile devices, cloud platforms) and the emergence of generative AI illustrate this trend, being today at the center of economic, political and managerial discourses. It is presented as an engine for organizational transformation and an unprecedented lever for productivity, capable of redefining value chains and business models. It is therefore often stated that AI revolutionizes every sector and every organisation. In culture, probably more than elsewhere, AI triggers both attraction and fear due to its potential uses and technological implications[5] as generative AI evokes creativity, central to art and culture. However, AI is not just about revolutionizing culture, it is redefining modes of production and coordination. Cultural sectors thus anticipate broader societal issues: automation of intellectual work, elimination of low-skilled tasks, redefinition of income and value sharing, role of technology suppliers, protection of intellectual property rights and specific legislation to be adopted.

As such, video games stand out as an emblematic model of the future of cultural industries[6] This characteristic is due to its native technical-industrial dimension. Unlike other cultural sectors, it has not only evolved with the progressive industrialization of media for the reproduction of creative content (printing, phonograms, cinema, media), but is the result of scientific and computer developments carried out in public laboratories as well as in companies such as Atari, Sega or Tencent. The video game industry, which emerged from consumer electronics and personal computing, was thus born as a singular model where downstream (consoles or now distribution platforms) dominate creation and production[7]. The central position of technology is expressed both in gaming platforms (consoles or smartphones), and by the nature of the associated production ecosystems, which have been able to diversify from a native techno-industrial character. It puts the video game industry in a very special situation. Driven primarily by electronics and IT manufacturers, games as such have long been primarily a form of call product to promote the sale of equipment. The structuring of industry has been built historically by the reversal of the traditional organisation of cultural industries. In games, the centre of gravity was immediately at the level of technology players. Through licensing agreements and mastery of game engines or middleware, they controlled the creation carried out in studios and publishers.

In this context, it is interesting to consider how video games have faced a digital wave. The latter has indeed resulted in movements of a different nature, but all of which have contributed to rethinking the historical forms of industry structuring: dematerialisation of the supply, emergence of new categories of games, disintermediation of distribution, new entrants, emergence of regulation, etc. More generally, we can observe that the centre of gravity in the

[4] Benghozi, 2024.
[5] Cf. "2001 a Space Odyssey.", mentioned in Benghozi and Chevalier, (2019).
[6] Le Diberder and Le Diberder (1998), Benghozi and Chantepie (2018).
[7] Davidovici-Nora, 2016.

cultural sector is shifting both upstream or downstream regarding the structuring of the value chain and the relationships among content producers, platforms and technology suppliers. It becomes a crucial issue for culture because most investments are increasingly directed towards technology and distribution platforms, rather than creative content production. This shift affects how value is shared among contributors, leading to conflicts and negotiations between players, such as news press platforms or music platforms and AI developers.

These factors have led the sector to radically change economic models but unlike the deep crises observed in other cultural sectors such as photography or music, the actors in place have reacted quickly[8]. They have been able to create alternatives based on technology structuring, which is at the very heart of their business from the outset.

The aim of this paper is to account for these relationships, showing how the VG industry serves as a field trial for the development of AI on a larger scale. More precisely it addresses a couple of important questions: what types of organizational and technological complementarities are emerging between AI and VG? And how does the VG industry constitute a privileged ground for the development and dissemination of AI technologies?

Beyond a descriptive presentation of these interactions, it stresses the unique impact of the video games industry as a field trial for the development of AI. The growth of this industry mirrors the progress of technology as well as other socio-economic dimensions. The first part presents a brief history of these relationships. The following section delves into the actual use of AI in games. The last section introduces the stakeholders and the leading companies in the field. The paper concludes stressing the unique impact of video games across many different disciplines and sectors.

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This article is exploratory. It takes a descriptive, historical, and qualitative approach. The analysis draws on a substantial body of secondary data covering the technical history of video games. It has made it possible to trace the subtle evolution of relationships between the various players in the games industry and those in the technology sector, as well as the corresponding evolution of game types and market dynamics. This historical material formed the empirical basis for the analysis and discussion. As academic literature on AI in video games is still rare outside of pure computing and mathematics[9], we rely on extensive desk research, specialized press analysis and reports from consulting firms (Konvoy, Big Cloud, IDG Intelligence).

1. AI development : a conceptual framework

AI is now central to economic, political and managerial discourses. It is presented as an engine for transforming organisations and an unprecedented lever for productivity, capable of

[8] Simon (2022).

[9] According to Sousaa & al (2022), based on a bibliometric analysis of a total of 2604 publications from 1971 to 2022.

redefining value chains and business models[10]. However, far from being reduced to a universal technology, AI is carried out according to differentiated sectoral, institutional and territorial logics[11]. The forms of AI integration vary according to the availability of data, the structure of markets and the ability of actors to build organizational complementarities. Since the spectacular diffusion of so-called ‘generative’ models – whether they produce text, images, sound or code – AI seems to have become a digital Swiss knife, capable of doing everything. Nevertheless, this apparent versatility masks a much more fragmented strategic and economic reality. On top of the large generalist models (OpenAI, Anthropic, Google, Meta), aiming to respond to any type of need, there is an increasingly segmented AI economy as sector players are developing specialized, contextual models integrated into specific value chains.

The digital transformation thus driven by AI is not limited to the adoption of a technology: it redefines the modes of production, coordination and decision-making. In this context, it is less a disruption than a systemic acceleration of trends already at work – automation, datafication, platformization and hybridization of value chains[12.] In most use cases, AI is seen as a lever for incremental productivity rather than a mere disruption, acting on internal efficiency and value creation.

This means rethinking AI as a new resource providing organisational and productivity support, not just from a disruption perspective. These are the changes AI brings to work for all companies: both in its functionalities and in its relation to the economy of abundance and hyper-supply.

While AI has been on top of policymakers’ agendas (Simon, 2024), public discourse on AI often focuses on disrupting and replacing creativity and human work, its most tangible effect in organisations is incremental productivity improvements. In practice, AI thus acts as a lever for streamlining processes, speeding up decision-making, streamlining coordination and enhancing innovation capacities. These transformations do not necessarily change the structure of the company, but profoundly reconfigure its internal efficiency and value creation. As noted by Benghozi (2001), technologies are organised and intertwined in a "system" without it being possible to isolate them from each other in their implementation and use. As such, the integration of AI profoundly changes organisational balances: the implementation of AI depends on market structures and organizational capabilities and the center of gravity moves upstream (techno suppliers) and downstream (distribution platforms), altering the sharing of value.

They can be found in the variety of existing use cases that echoes the rise of vertical and sectoral AI. Through these various use cases, there are contrasting logics of organisational configurations mobilized around these technologies, but also of adoption and economic valorisation. Value creation, distribution and capture depend on institutional, technological and geographical factors. However, the literature rarely mentions the video games industry. This paper assumes that this industry can allow us to shed lights on these logics and to reveal how the “system” is intertwined[13].

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[10] Brynjolfsson & McAfee, 2014; Teece, 2018.
[11] Gawer, 2021.
[12] Benghozi, 2020; Porter & Heppelmann, 2015.
[13] We followed the same approach in our analysis of the sub-segment of esports, Benghozi & Simon (2025).

2. AI and Videogames industry: A long and enduring companionship.

Whilst AI has attracted unprecedented interest in recent years, it is important to note that the term remains highly ambiguous. As Benghozi et al. (2019) reveal[14], the term itself is very old and encompasses a wide variety of technical solutions. People were talking about AI as early as the 1950s, and behind the applications described as such today, many essentially involve the improvement of very conventional algorithms. It is therefore not surprising that the relationship between video games and AI has always been so close: video games have, by their very nature, incorporated the computational and technical dimension from the outset[15]. Conversely, the development of video games has always been a key driver of digital technology, whether in the form of chips designed by Nvidia, virtual reality and the Metaverse, or algorithmic developments. The history of artificial intelligence and video games is one of perfect symbiosis: games have served as a safe 'sandbox' for testing complex algorithms, whilst AI has made it possible to transform clusters of pixels into living worlds.

From a more anecdotal viewpoint, Sir Demis Hassabis, who was jointly awarded the 2024 chemistry Nobel Prize, was as a co-designer of 1994's hit game "Theme Park"[16]. He worked as lead AI programmer for the studio Lionhead and founded its own game company, in 1998, Elixir Studios. He, later (2010), co-founded the artificial intelligence startup DeepMind (acquired by Google in 2014), a company that focused on training learning algorithms to master games, one of its most notable achievements being the creation of AlphaGo, a program that defeated the world champion Lee Sedol at the complex game of Go.

However, among the many applications of AI, which are readily highlighted in the press and public discourse, the video games industry seems indeed to stay under the radar as a major use case. The sector is not explicitly mentioned as some kind of pacesetter or even as a relevant testbed. One reason for this may well be that AI in video games (often referred to as 'Game AI') differs from academic AI. In games, the aim is not to be 'optimal' or to 'win' at all costs, but to provide an entertaining, interactive and immersive experience, with a challenge that can be adapted to the player.

However, it overlooks the history of the relationships between AI and the videogames industry, as game playing has been an area of research in AI from its inception. This development can be summarised by dividing it into four main periods :

- The era of the laboratory and deterministic logic (1950-1970): use of games (chess, Nim) as technological demonstrators
- The arcade and market era: the golden age of heuristics and pathfinding (1970-1995): AI becomes a tool for improving the player experience (e.g. Pac-Man).
- The era of game engines (1995-2010): emergence of middleware (Unity, Unreal) automating key tasks.

[14] Benghozi et al. 2019.
[15] Benghozi et Chantepie, 2018.
[16] Published by Electronic Arts in 1995. See, "Theme Park". *Computer and Video Games*. No. 151. Peterborough: EMAP. June 1994. pp. 28–31. ISSN 0261-3697.

- The age of learning and generation (2011-present): moving from combat AI to creative AI (Deep Learning, PCG).

2.1. The era of laboratory and deterministic Logic (1950–late 1970s)

At that time, AI was not 'intelligent' in the modern sense, but purely mathematical. It was based on simple decision trees and fixed rules. The algorithms calculate the best possible move on a very basic finite-state machines (FSMs). In particular, we can mention a few iconic games. Nim (1951) or OXO (Tic-Tac-Toe) were the first human-machine matches. Pong (1972) consisted in a paddle that simply follows the vertical position of the ball. Space Invaders (1978) offered predictable movement patterns that accelerate.

2.1.1. Playing in the lab: field trials, and demonstrations.

In the 1950ies, computer scientists began experimenting with simple game-playing programs. C. Shannon, who later co-founded the field of AI during the 1956 Dartmouth Summer Research Project on Artificial Intelligence Conference[17], developed the main aspects of computational routine applied to chess in his 1950 article (Shannon, 1988)[18].

The development of games like "Tic-Tac-Toe" and "Chess" on computers paved the way for AI in gaming, demonstrating that machines could be programmed to take on human opponents in strategy games. Initially, the computer games of the 1950s were used for training and instructional programs, and research programs in artificial intelligence. However, soon demonstration programs were designed to impress or entertain the public.

The earliest known publicly demonstrated electronic game[19] was the computerized game "Bertie the Brain", an arcade game of tic-tac-toe, built by J. Kates for the 1950 Canadian National Exhibition. Nim, a game of logic and strategy, was introduced in 1951, using Nimrod[20], built in the United Kingdom by Ferranti for the 1951 Festival of Britain and published in 1952. For the first time, attendees could play a game of Nim against an artificial intelligence. The following year, in 1952, A.S Douglas, created the OXO game which simulated a game of noughts and crosses (Tic-Tac-Toe) on an Electronic Delay Storage Automatic Calculator (EDSAC) computer. Around the same period, non-visual games were being developed at various research computer laboratories. For example, C. Strachey developed a simulation of the game draughts. Strachey's program showcased early signs of AI in gaming. In the latter cases, the games were designed for a general-purpose computer and not for a machine specifically created for an event such as "Bertie".

These games and machines nevertheless were meant as technology demonstration not as entertainment. However, in 1958, "Tennis for Two"[21] was probably the first game created solely

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[17] The conference, organised by John McCarthy, Nathaniel Rochester, Claude Shannon, and Marvin Lee Minsky, is considered to be the birthplace of the field of artificial intelligence.
[18] On chess-games and computers, see Smith (2014a).
[19] This section follows Smith (2014b).
[20] A twelve-by-nine-by-five-foot (3.7-by-2.7-by-1.5-meter) computer, designed by John Makepeace Bennett and built by engineer Raymond Stuart-Williams.
[21] The game is most often hailed as the first videogames, but this may vary with the definition of games. According to Wolf, a first patent anticipating video games was registered in the US as of January 1947 (Wolf, 2012: p. 1).

for entertainment. The program simulated a game of tennis. It was designed by W. Higinbotham as “a public relations vehicle” (Smith, 2014d).

Beyond chess and “tic—tac-toe”, videogames emerged, which were also based on man-machine interaction. Playing in research labs began in the 1960s with games like "Spacewar!" developed in 1962 at MIT on a recently acquired PDP-1 mini-computer. The MIT Computer Science and Artificial Intelligence Laboratory I,ab was set up by J. Mc Carthy and K. Minsky in 1959. Two of the creators[22] of the game, S. Russell and D. Edwards were working with J. McCarthy on a new programming language called LISP, specifically tailored for AI research (Smith, 2014d). As opposed to previous games and machines being dismantled after an initial presentation, the game spread to other university computer labs. The game was copied to several of the early minicomputer installations in American academic institutions. Even if the audience was somewhat restricted to these institutions, it nonetheless became the first video game to be available outside a single research institute. The hackers even “*briefly toyed with the idea of making money on the game*” (Smith, 2004d), however, due to limitations and cost of the then available technologies and infrastructures they did not follow suit.

Technology progressed through the 1960s and 1970s, allowing AI researchers to delve deeper into creating game-playing algorithms. However, the limited processing power and memory of early computers constrained the complexity of these AI systems. But the seeds had been sawn. It would require nearly another decade of innovation in computer technology and solid-state components before a commercial video game could finally become a reality.

2.1.2. Leaving the lab and going to the market: arcade games.

In the 1970ies, when most public R&D funding for AI dwindled away for almost a decade, videogames emerged based on man-machine interaction. Indeed, during the first so-called winter of AI, the videogames sector was one of the few sector where AI was still thriving. However, its focus shifted from a test field toward improvements of the player experience for commercial applications.

In 1970, N. Bushnell, an engineering graduate, came across “Spacewar!” at the Stanford Artificial Intelligence Laboratory. He saw an opportunity to turn it into a commercial product. After two first attempts with two games, “Computer Space”[23], “Galaxy Game”, he launched “Pong”, in 1972, through the newly founded firm Atari[24]. “Pong” is considered one of the earliest arcade video games that introduced artificial intelligence. “Pong” was a basic table tennis game: the AI was simply moving the paddle back and forth to try to hit the ball based on the arranged patterns.

In the 1970ies, the first single-player games with enemy agents[25] were created. “Space Invaders”, released in 1978 by the Japanese company Taito, introduced a more advanced version of AI. In the game, each enemy pursued the player using distinct strategies, marking a

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[22] The game was the output of the collaboration of a group of hackers at the university.

[23] A scaled down version of “Spacewar!” manufactured by Nutting Associates.

[24] Co-founded with T. Dabney.

[25] *“In the context of gaming, enemies were considered as actors, Unreal Engine defines an Actor as: “…an object that can be placed into a level […] and supports transformations such as translation, rotation […]*”. Quoted by Martinez (2023).

departure from uniform behavior among adversaries. The game featured a row of aliens that would move side to side and slowly descend onto the player. These developments marked an early but impactful stride in gaming AI, introducing elements of adaptive and reactive behavior in enemy entities.

Arcade games used early AI in the form of stored patterns (Big Cloud, 2025)[26]. These patterns simulate random movements of aliens that were pre-programmed into the game. The introduction of arcade games like "Pong" and "Space Invaders" brought AI-controlled opponents to the mainstream audience.

The 1970ies also saw the appearance of a different kind of games: text-based adventure games. The first text-based game was "Colossal Cave Adventure"[27], released in 1976 by developer W. Crowther (a MIT graduate) for a PDP-10 mainframe computer. It introduced a rudimentary form of a Natural Language Processing (NLP) engine to interpret player commands. It triggered the creation of numerous other similar games such as "Zork" [28](developed between 1977 and 1979 at the MIT) and paved the way for more sophisticated interactions between players and virtual worlds. At the same time, it should be stressed that it accompanied the transition from mainframe to micro-computers and enable the creation of new genres: strategy, simulation, adventures and role-playing games.

In 1980, Namco launched "Pac-Man", a simple arcade game that introduced different AI heuristics, innovating with the AI through the intersection grids and behavioural patterns. It supported already two of the main approaches to train videogame bots: genetic algorithms and reinforcement learning (see Box 1).

2.2. - The arcade and market era : the golden age of heuristics and pathfinding (1980 - 1995)

The challenge had changed: it was no longer simply a matter of reacting, but of moving around and simulating a personality. This marked the emergence of differentiated behaviours among the users. Technologies were A-star algorithm for pathfinding, and more complex finite-state machines (FSMs) enabling "Patrol / Hunt / Flee" cycles. During this period, the aim was to introduce non-player characters, enhancing the gameplay, releasing new genres.

After leaving the labs and growing as an arcade entertainment, the video games market changed with the appearance first of home consoles and later the deployment of PCs in the late 70ies, early 80ies[29]. New players entered the market, console manufacturers or new publishers focusing on PC games. In that context, the integration of microprocessors (CPU) was a technological leap that enabled greater computational capabilities and facilitated the inclusion of random elements within movement patterns. Martinez (2023) quotes the game, "Interceptor" (a 1976 combat flight simulator from Taito), as an example of how CPUs allowed for more sophisticated and dynamic enemy movements, thereby enhancing the gameplay experience.

[26] For a more technical and comprehensive approach, see Martinez (2023).
[27] Also known as "Adventure" or "ADVENT". See Lessard (2013).
[28] See Woyke (2017).
[29] It also went through two crashes (1977 and 1982), a lot of players exited the market and numerous arcade games closed down (Wolf, 2012).

Later, graphics processing units (GPUs) played a similar role. Indeed, in the 1990ies, the introduction of 3D gaming and the growing popularity of role-playing games (RPGs) brought further improvements of the AI. 3D gaming demanded more sophisticated AI to manage complex environments and narratives. AI enabled to navigate 3D spaces and exhibit behaviours that mimicked human tactics in games such as "Doom" (1993) or "Half-Life" (1998). RPGs lead to the introduction of computer-controlled non-player characters (NPCs) governed by rule-based systems. AI provided the engine that determined an NPC's behavior in the game world. Early attempts to create virtual characters with basic decision-making capabilities were displayed with games such as "Ultima" (1981) or "Baldur's Gate" (1998). "First Queen" (1988), a tactical action RPG, featured characters that can be controlled by the computer's AI using new AI following patterns (Martinez, 2023).

2.3. The era of game engines and the emergence of decision architectures (1996–2010)

During, the late 1980ies and 1990ies, the first game engines appeared with new suppliers of middleware, such as Unity or Unreal Engine. These first game engines were designed to automat key tasks like graphics rendering, physics, and control. Since then, such tools became widespread. Game engines became ubiquitous, along with an array of other diverse production tools; engines turned out being the backbone of game development. One of the outputs was that game engines significantly lowered the barrier to entry. The move to 3D requires more realistic AI. The aim was to break away from determinism so that the player feels they are facing a thinking being. Main technologies turned to be behaviour Trees, GOAP (Goal-Oriented Action Planning), Fuzzy Logic to refine decision-making.

At the turn of the century, an increase computational power increased made it possible to introduce adaptive AI with neural networks. NPCs could then learn from player behavior, adapting their strategies over time. The First Person Shooter (FPS) genre was a major field trial. Later, procedural content generation[30] was introduced: "Spore" (2008) used algorithms to create dynamic and diverse game worlds. It has been applied to game elements such as textures, terrain, vegetation, buildings, level architecture, storyboards, items, characters, quest structures, puzzles, and sound (Hendrikx et al. 2013).

2.4. The age of learning and generation (2011 - present)

AI is no longer used solely for combat, but also for creation. We are witnessing a shift towards systems capable of generating content or learning independently. The technologies are now PCG (Procedural Content Generation), Monte Carlo Tree Search (MCTS), and the first deep learning and neural networks.

Major developments followed with machine learning, deep learning and dynamic AI. The former became widespread for games. Game developers started incorporating algorithms capable of learning and evolving based on player interactions: NPCs could adapt in real-time to player strategies[31]. With deep learning in AI systems, NPCs could replicate human-like

[30] AI procedural generation, also known as procedural storytelling, in game design refers to game data being produced algorithmically rather than every element being built specifically by a developer. For a presentation of the types of game content that can be procedurally generated see (Hendrikx, M., et al.: p.4).
[31] See the example of the FIFA games in the last section.

behaviours as illustrated by games such as “Red Dead Redemption 2” (2018) or “The Last of Us Part II” (2020) with “realistic” AI interactions.

Notable games are based on procedural generation of a virtually infinite universe (fauna, flora, planets) (No Man’s Sky (2016)). On its side, “Alien Isolation” (2014) proposes a ‘dual AI’ system (one AI that knows where the player is and an ‘Alien’ AI that receives clues to track them down organically).

Over the past few years, gaming has gone through two major hype cycles, from the metaverse to AI enabled games. As of 2024, Google launched, GameNGen a neural model-driven approach to game development that opened up new possibilities for zero-code game generation. With this tool, developers can quickly create entirely new game experiences with simple instructions or sample images. We are now entering an era where AI is becoming a real-time creative collaborator, capable of breaking away from pre-written scripts. LLM technologies can be used for dialogue, generating textures and animations, creating autonomous agents. It opens to new concepts in games with dynamic NPCs and AI modding tools generating quests and worlds via simple text commands.

3. AI in games: an overview.

The use of AI in video games is not limited to the gaming aspect alone. It affects the industry as a whole. Thus, AI operates at several levels. Firstly, regarding agents and NPCs, it supports the creation of adaptive and immersive behaviours. As regards production, it enables procedural content generation (PCG) for textures, decors and sounds. Lastly, it also addresses marketing and monetization, providing analysis of player data to personalize offers and in-game purchases.

3.1. A new era in gaming

Nowadays, AI in gaming refers to responsive and adaptive video game experiences (see Box 1 for the most common types). As noted, these AI-powered interactive experiences are usually generated via NPCs that act intelligently or creatively, as if controlled by a human game-player. If standard AI is commonly used to generate such behavior in non-playable characters (NPCs), now Generative AI adds more new use cases for game mechanics in the earlier phases of game development. Generative AI is the use of machine learning techniques to create original content, such as images, text, and music, as the user or developer continues to feed it vast amounts of data to expand its knowledge (Ta, 2023). Generative AI allows game developers to continuously generate content. Tools like Story Machines[32] analyse player behaviour and choices to generate storylines and narrative elements dynamically. As illustrated by the two examples we mentioned, AI is used to enhance and upgrade the capabilities of game agents without the direct assistance of the actual human player.

Box 1. The most common types of AI in gaming techniques.

[32] A No-Code General Purpose 2D Game Engine described by the company as AI-infused: https://www.trystorymachine.com/index.html

1. *Rule-based AI*

Rule-based AI operates on a set of predetermined rules and conditions that dictate the behavior of non-player characters (NPCs) within the game. These rules are usually programmed by developers and define how NPCs should react in various situations. For example, in a stealth game, if the player is spotted by an NPC, the rule-based AI might instruct the NPC to alert nearby guards.

2. *Finite State Machines*

Finite State Machines (FSMs) model NPC behaviors by breaking them down into distinct states and transitions between those states. Each state represents a specific behavior or action. Transitions occur in response to certain triggers or conditions. For instance, in a combat scenario, an NPC might transition from a "patrolling" state to an "alert" state when it detects the player.

3. *Pathfinding AI*

Pathfinding AI focuses on determining the most optimal path for NPCs to navigate through the game environment. Algorithms like A* (A star) are commonly used to calculate the shortest path while avoiding obstacles. This technique ensures that NPCs move intelligently and realistically through complex environments.

4. *Machine Learning AI*

Machine Learning AI introduces a level of adaptability and learning into the behavior of NPCs. It involves training AI models using past experiences, data, and exposure to make decisions. NPCs can learn from player interactions and adapt their behavior accordingly. For instance, an AI opponent in a racing game might learn to take tighter turns and choose better racing lines over time.

5. *Behavior trees*

Behavior trees offer a more flexible approach to AI behavior. They consist of a hierarchical structure of nodes representing specific actions, conditions, or states. These nodes are interconnected to form a tree that outlines the possible behaviors of an NPC. Behavior trees allow for complex decision-making, enabling NPCs to adapt to changing conditions dynamically.

6. *Reinforcement learning*

Reinforcement Learning involves NPCs receiving feedback in the form of rewards or penalties based on their interactions with the game environment or the player's actions. NPCs learn to adjust their behavior to maximize rewards and minimize penalties. For instance, an NPC in a strategy game might learn to prioritize resource gathering to increase its chances of winning.

Source: Dsouza (2025)[33].

In summary, the role of AI in video games can be characterised along several lines. In terms of creativity, we see first of all, as in other segments of the creative industries, that these contributions lead, on the one hand, to a form of standardisation and commoditisation of games. On the other hand, we observe that AI tools can also contribute to innovation and creativity in games, whether in terms of gameplay, storylines, game environments, image enhancement, playing assistance or characters.

3.2. Games and gamers.

According to Inworld Team (2023), an AI game is a game that’s either created entirely or driven significantly by advanced AI systems. AI video games can be broken down into one of four distinct types: AI text games/AI text adventure games/AI story games, AI generated games, games with advanced AI technology, and generative AI games.

[33] For another view of areas of applied AI see Bonn (2023: p.7).

More and more games are integrating AI, one way or another, to enhance gameplay. Table one gives a sample of some of the most popular ones. The FIFA series, published by EA Sports (US), provide a good illustration of how the use of machine learning algorithms that analyze player behavior and adapt to their choices in real time, adaptive gameplay can mirror the unpredictability of real-world football matches (Dsouza, 2025). In FIFA's "Dynamic Difficulty Adjustment" system, AI algorithms observe how players perform in matches and adjust the game's difficulty accordingly. This adaptive approach ensures that players are consistently challenged without feeling overwhelmed. Its "Player Personality System" allocate to each virtual player a distinct identity so that virtual players could exhibit unique behaviours: e.g. making tactical decisions based on their playing style, reacting emotionally to in-game events, and adapting their strategies as the match progresses. Beyond gameplay enhancements, with "FIFA Manager" and "Career Mode," AI-driven scouting mechanisms simulate the real-world process of identifying and nurturing talent. These systems use algorithms to generate virtual players with varying attributes, potential, and play styles. As players progress in their careers, AI assists in determining their development trajectories.

Table 1. The most popular AI Games[34].

Game	Genre	Initial launch	Publisher
1. The last of us	Action-adventures	2013	Sony (Japan)
2. F.E.A.R	Horror	2005	Sierra Entertainment (US)
3. Red dead redemption	Action-adventures	2010	Rockstar Games (US)
4. AI Dungeon	Text-adventures	2019	Latitude (US)
5. Grand Theft Auto 5	Action-adventures	2013	Rockstar Games (US)
6. Minecraft	Survival	2011	Mojang Studios (Sweden)[35]
7. Rocket League	Sports	2015	Psyonix –Epic Games (US)
8.Tom Clancy's Splinter Celt Blacklist	Stealth Action	2013	Ubisoft (France)
9. XCOM2 Enemy Unknown	Role-play	2012	2K interactive (US)
10. Valorant	First person shooter	2020	Riot Games (US)

Source: adapted by authors from AI Games (2025)[36].

Improving the performance of gamers is one thing, but it is not necessarily sufficient for AI games to be attractive. Opinions of players on its impact on game development are far from unanimous, according to a survey of the consultancy Midia (Elliot, 2025)[37]: 20% of the players see it positively and 19% negatively. For the consultancy: "*The jury is still out on generative AI in games*".

3.3. AI: driving economic performance

[34] This sample, as the one in table 2, is just providing some examples. However, rankings change with rankers. For instance, another ranking for the same year gives "AI Dungeon" as number 1 and includes the "FIFA series": see Dsouza (2025).
[35] Acquired by Microsoft in 2014.
[36] https://maticz.com/best-ai-games
[37] Based on a representative sample of 6 300 gamers.

However, creativity is not the only area in which AI tools operate. Their integration takes place not only in the creative and production processes but also, , in marketing, monetization, and player or communities monitoring. The aim, in these cases, is to optimise game distribution methods whilst also facilitating player engagement and revenue generation based on player behaviour. AI has been instrumental in personalizing gaming experiences for a diverse audience. AI algorithms analyse player data to tailor game difficulty, suggest in-game purchases, and even create personalized content, so as to keep the game attractive (Sarkar, 2024).

One should add that, on top of balancing gameplay and NPC dialogue, AI is employed for other tasks such as matchmaking, debugging, and anti-cheat mechanisms. For instance, by analyzing player data, ranging from IP addresses to login times, machine learning algorithms can help detect and prevent cheating and fraud.

The stakes here are all the more significant because the video game market has experienced a slight contraction in 2022 and 2023 (Konvoy, 2025)[38], which cannot be explained solely by the post-Covid years. Over the last decades, the videogame industry went through some deep transformations of its market structure across various dimensions: diversified games platforms (consoles, PCs, online and mobile games), various kind of games, diversity of players (size and demographics of the audience), respective roles of hardware and software, evolution of the main global companies and last the geographic distribution of markets (Simon, 2022).

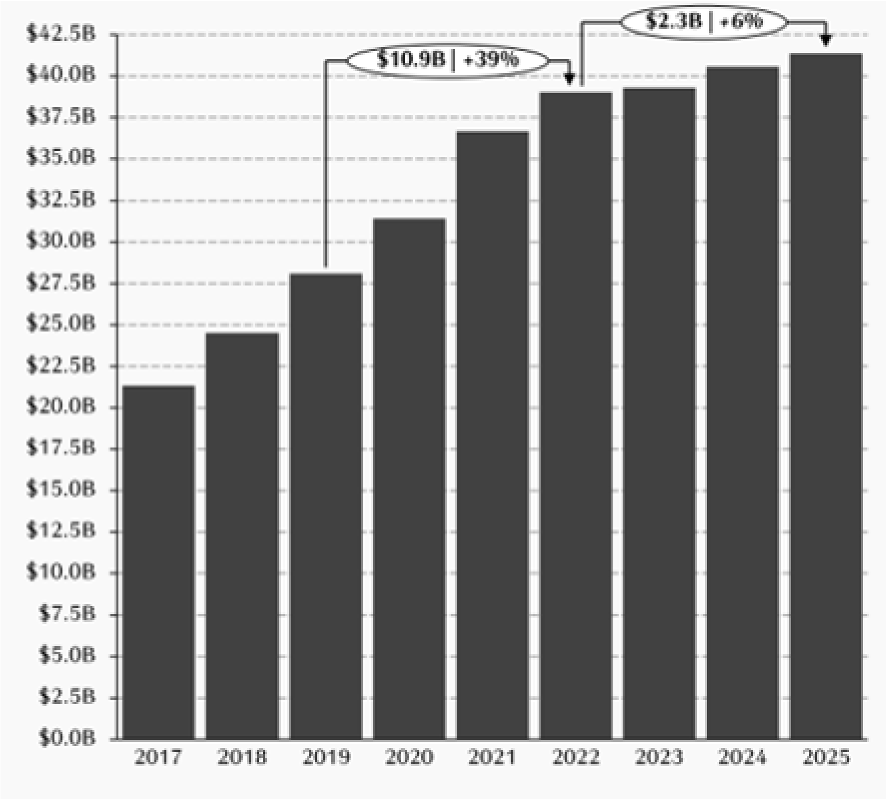
On the one hand, this has triggered a drop in revenue and several major studios (e.g. Ubisoft) faced significant difficulties[39], but it has undoubtedly also been accompanied by a decline in the creativity and appeal of games, as suggested by the marked increase in the number of launch failures[40]. In this context, AI has emerged to industry players as both an opportunity for a comeback and a source of creativity. Besides, the use of AI has not been limited to games on consoles or PCs, with the rise of mobile gaming now the biggest segment of the market. Across the industry as a whole there is a main trend , aiming at harnessing AI to improve performance by reducing production costs. An understandable urge as industry-wide content development spends surged 90% between 2017 and 2024 (Figure 1), Box 2 underlines the various gain than can expected from the use of AI.

Figure 1. Total Video Game Content Development Spend (Worldwide; PC + Console+ Mobile)

[38] It resumed growth as of 2024 and is still predicted to grow according to Konvoy (2025), also see European Commission (2025: p.76).

[39] Konvoy (2025) deems that lay-offs have affected an above average proportion relative to broader tech.

[40] This may be a feature of a crowded market.



Source: Ball (2026).

Box 2. Economic gains expected from AI.

- Save time : 62% of the studios surveyed used AI in their workflows, mainly to prototype quickly and for concepting, asset creation, and worldbuilding
- Improve delivery: 71% of studios using AI say that it has improved their delivery and operations
- Content creation improvement and animation: 37% of surveyed developers use AI to accelerate writing code, while 36% are generating artwork and game levels, testing gameplay loops, and automating narrative elements
- Worldbuilding and creation of NPCs AR/VR and online multiplayer games: 56% of AI adopters use it for worldbuilding, 64% of those creators favour it for developing NPCs to populate these worlds

Source: European Commission, (2025: p.105).

So, whilst AI helps to improve the quality of games and the games themselves (variety of worlds, richness of visuals and immersion, narrative AI, assistant AI, NPCs, etc.), the benefits of AI also lie in the production and distribution side. So, AI makes the exploration phase easier in production. Rather than starting with existing games or environments that need to be mastered, it allows to test and experiment with alternative worlds or solutions quickly and easily, with a view to incorporating them into a finished game.

Given the sheer volume of experiments, processes and workflows involved in game development, ensuring consistency across tools has become absolutely crucial, and here too, AI applications play a key role in this integration and tooling consolidation.

3.4. A rethinking of the players' role

AI in video games is a distinct subfield and differs from academic AI. It serves to improve the game-player experience rather than machine learning or decision making. AI games increasingly shift the control of the game experience toward the player, whose behavior helps produce the game experience.

As a matter of fact, user-generated content (UGC) has been a key element for the development of games. AI tools help players improve creation efficiency, easily transforming creativity and gameplay ideas into personalized game levels. For instance, "sandbox games"[41], rather than focusing on linear gameplay and the requirement to complete levels, allow players to freely explore and build environments. Players enjoy a large amount of freedom in choosing how to play the game. "Minecraft" and "Roblox" are the leading sandbox games where players can create their own path through the games (Simon, 2023). Roblox rolled out generative AI tools (a code completion tool and materials generator) trained on assets expressly released for re-use by the Roblox community[42]. New middleware companies, such as Bitmagic (see table 1), enable players to create and modify games using text prompts.

As virtual reality (VR) and augmented reality (AR) demand more immersive and responsive AI systems, AI algorithms are now being utilized to create realistic avatars, dynamic environments, and personalized gaming experiences in the VR and AR realms. Like with 5G (Simon, 2019b) videogames appear to be enablers even if, so far, the development of VR and AR did not meet most of the expectations in spite of investments from video games and tech companies.

In the subsegment of the esports industry, AI-driven analytics tools also help teams and individual players improve their strategies by analyzing gameplay data, identifying strengths and weaknesses. For instance, platforms like SenpAI.GG use AI to provide coaching and performance analysis for popular games such as "League of Legends" or "Valorant".

4. Economic impact and ecosystem.

The terms 'AI' or 'VG', do not refer to homogeneous ecosystems. On the contrary, it is, therefore, particularly important to deconstruct such a view by identifying the various components of the associated value chains. Each segment is in fact characterised ed by particular types of actors, with specific strategic challenges and resources. In this regard, taking a closer look at the industrial economic structure of AI is essential to better understand the strategic development dynamics at play and the way in which general visions of AI are linked to applications more specifically tailored to particular sectors, namely videogames (Benghozi

[41] Using voxel graphics-based 3D worlds.

[42] 65.5 million Daily users as of 2023, (Sturman, 2023). Roblox is an online game maker of immersive games launched in 2006, and a leading sandbox games provider

(2026), As a consequence, a clear distinction among the players in the value chain seems particularly useful: generic digital platforms that are diversifying, other AI players and, of course, VG main players.

The two core players of the video game industry are developers and publishers[43]. Publishers are often presented as the central economic actors in the video games value chain, ruling the overall organization of the video game market. A publisher releases video games that it either develops internally (within its own studios) or has ordered from a video games developer. In, the latter case publishers supply developers with the required resources and funding. This involves the provision of some AI options. Taking into account the diversity of stakeholders makes it possible to better identify two distinct types of problem. The first concerns the fact that adoption and impacts vary depending on the size of the companies. The second relates to the main technical issues raised (AI development, Cloud, Application portability, latency…) and who is investing in this area.

4.1. The evolving challenges regarding the business size and new entrants.

Large companies, such as Tencent (China)[44] or Ubisoft (Canada-France), have been pioneers of AI (see Table 2). Ubisoft has been using a large--language-model-based AI tool called "Ghostwriter". Established in April, 2016, Tencent AI Lab developed, among others, game AI Engines. As of 2024, Tencent released the GiiNEX Game AI Engine. GiiNEX uses generative AI tools for UGC related to level design, thereby reducing the time required for creating content and enabling engaging experiences for both professional developers and game players. Additionally, GiiNEX uses decision-making AI for game development testing, simulated gameplay and other scenarios to accelerate game innovation. Early 2025, the company released the Hunyuan3D 2.0[45], an update of its open-source Hunyuan AI model, designed to make it easier and faster for developers to create 3D models and characters in video games.

Table 2. AI and publishers[46].

Company	AI Lab/ engine/ tool	Game
Microsoft (US, 1975) acquired: Activision Blizzard (US, 2008), Halo Studios (US, 2007), Mojang (Sweden, 2009)	Investment in OpenAI.	Call of Duty : Modern Warfare 2 (2009) Halo 2 (2004) Minecraft (2011)
MiHoYo (China, 2012),	Glossa	Genshin Impact (2020) Honkai: Star Rail (2023)
NetEase (China,1997)	NetEase Fuxi Lab	Justice (2015)

43 For a presentation of the video games value chain, see De Prato & al (2010: p.33).
44 The world number 1 videogames company. For its strategy of developing into all kind of digital content, see Simon (2021).
45 The Hunyuan 3D 2.0 includes two foundation components: a large-scale shape generation model, the Hunyuan3D-DiT, and a large-scale texture synthesis model called Hunyuan 3D-paint.
46 This sample is introduced so as to provide some examples.

		Cygnus Enterprises (2022)
Roblox (US, 2006)	"Assistant": 3D workspace editing, "Animation Capture": face and body motion, "Code Assist": script editing and creation, "Material Generator": tiling material appearance, "Texture Generator": asset-specific texture mapping.	
Sony Entertainement (Japan, 1993)	Sony AI	Gran Turismo Sophy (2021)
Tencent (China, 1999) Major shareholder of : Riot Games (US, 2006), Supercell (Finland, 2010), Epic Games (US, 1991)	Tencent AI Lab GiiNEX Game AI Engine Hunyuan AI Unreal Engine	 Valorant (2020) Clash Royale (2016) Fortnite Battle Royale (2017)
Ubisoft (France, 1986)	Ghostwriter Anvil.	Assassin's Creed (2007)
Valve (US, 1998)	Source, 3D game engine	Half-Life 2 (2004)

Source: compiled by authors.

Early 2025 as well, the DeepSeek[47]-R1 was launched. For the games industry, DeepSeek-R1's combination of affordability, performance, and open-source accessibility confirms the role of this industry to spearheading developments. By lowering barriers to entry, DeepSeek-R1 enables more developers to experiment with AI-driven game design, leading to richer, more immersive gaming experiences. For example, AI can be used to create dynamic, player-responsive worlds, generate unique in-game assets, or design adaptive difficulty systems.

MiHoYo (China, 2012), a studio and publisher, developed an AI tool to harness the power of large language models to generate scripts for gaming characters (Wang, 2024). Some smaller game studios, are keen on integrating AI technology into their workflows: Unity reported, in March of 2024, that 62% of game studios they surveyed leveraged generative AI (Konvoy, 2024). Mulligan (2024) quotes a recent poll that indicates that 87% of studios are using generative AI tools like Midjourney[48] to create in-game environments. With such tools, innovations are no longer limited to large studios, and they are opening up opportunities for developers of all sizes. Developers can explore elements such as natural language processing, player modelling and machine learning to develop imaginative, reactive AI characters. Unity, has recently announced it aims to open a GenAI marketplace for game developers, primarily using the AI solution to offer personalized scenarios based on player input.

4.2. New middleware companies and intermediaries.

Just like with the new suppliers of middleware of the late 90ies; emerging AI middleware companies (see Box 3), such as Kythera, are providing AI solutions to game developers

[47] A company founded in China in 2023.
[48] A generative artificial intelligence program and service released in 2022.

including navigation, behavior, and tactical markup. Some entities, such as Skybox or Scenario, focus on the provision of services to developers of mobile games. Most of these companies are claiming being "revolutionary game development platforms" that are eliminating traditional barriers to entry and make game development accessible and enjoyable.

Box 3. AI middleware companies: a sample.

3DFY. AI (Israel, 2023) enables game developers to rapidly create 3D fully textured and rigged 3D models.
Astrocade AI (US, 2022) translates natural language descriptions into interactive worlds, automating the generation of art, animation and visual effects, music and sound.
Bitmagic (Finland, 2022) creates multiplayer 3D games with simple prompts, without coding. Players can create and modify games using text prompts.
Kythera AI (UK, 2010), develops advanced tools for designing AI in 3D game engines.
Hidden Door (UK, 2020), a proprietary generative AI platform that can adapt any existing work of fiction into an online social roleplaying game, multiplayer text adventures.
Ludo.ai (US, 2021) data-driven game design decision to create games.
Rho Engine (US, 2024) multi-modal game development platform that automates many of the processes of game development.
Runwayml.com (US, 2018) general-purpose multimodal simulators that creates character animations, textures or design interactive.
Scenario.com (US, 2021) platform for building custom-trained AI models that generate high-quality and diverse game assets, including characters, objects, and environments.
Skybox (US, 2023) an AI tool specifically designed for creating visual effects and realistic environments in mobile games.
Sonantic (UK, 2018) (acquired by Spotify) creation of hyper-realistic AI-generated voices from text.
Spirit AI (UK, 2015) (acquired by Twitch), intelligent authoring of digital beings (from videogame characters to chatbots).
Stability.ai / Dream Studio (UK, 2019), a community driven developer platform providing open AI models for Image, Language, Audio, Video, 3D.

Source: compiled by authors[49].

AI has also a role on the consumer side and paves the way for new forms of intermediation. Actually, like all cultural industries, the video games sector operates within an economy of abundance, where the number of games released each year is growing ever larger (and this will be even more the case with AI). This same AI also offers discovery tools and a solution to help identify and recommend games out of s array. On the distribution side, for streaming platforms, the companies that offer, manage and develop platforms for online media, AI is bringing some more technical improvements for the management of games: enhancing streaming quality (assessing the stream conditions in real-time…), improving the streamer-viewer interactions, better understanding their audience and optimizing monetization. At the same time, it empowers gamers and content creators to analyze gameplay and streaming content. For instance, service

[49] For a comprehensive list of game development start-ups of companies founded since 2020 see https://www.ventureradar.com/startup/video%20game%20development

providers such as Powder AI (France, 2020)[50] offer AI-assisted editing toolkit designed to enhance the moment capturing aspect of the streaming experience.

AppLovin[51] is an ad monetization platform for mobile games and apps that started Lion Studios, in 2018, an internal mobile gaming developer and publisher (Vaughan, 2025). The company provides an AI-powered advertising platform (based on its AI AXON engine). The company focuses on the gaming sector with tailored offerings for game developers. This is another example of a new player ushered in by testing AI in videogames.

5. Discussion: Unpacking the AI-Games Complementarity.

The integration of AI into video games is not merely a matter of shifting the industry's centre of gravity toward technology providers and platforms. More broadly, it opens up the door to various reflections on the very nature of the transformations taking place as a result of technology. A major challenge consists in the technical issues and arbitration, i.e. the tensions between the use of integrated tools and all-in-one platforms (Unreal) and the adoption of standalone tools and modular solutions for specific functions (NPC behavior). If Unity and Unreal dominate 80% of the market, the emergence of autonomous AI tools could decouple creative functions previously embedded in game engines. A second set of issues relates to industrial reconfiguration and skills. Competences turn to be more complex since they shift from pure programming to managing real-time "creative collaborators" while AI tools allow players to create complex worlds through simple text commands. These changes also mean that actors need to reconcile productivity and creativity, to address the risk of standardization and commoditization in the face of the potential for radical innovation in gameplay. Finally, the last challenge relates to the regulatory and competitive frameworks. Technological concentration increases reliance on GPU providers (Nvidia) and Big Tech (Cloud, LLM). It also creates uneven access asymmetries to the computing capabilities and big data needed for cutting-edge AI. Lastly, additional important risks are more and more associated to unauthorized use of data to train algorithms, on how to protect artists' rights and to shield gamers.

As a consequence, the entanglement of AI and the video game industry should not be mischaracterized as a simple, linear relationship of producer and consumer, where the latter merely adopts the innovations of the former. Our observation reveals a far more complex and productive reality: a deeply co-evolutionary dynamic made of synergies and generating distinct types of technological and organizational complementarities. These emerging complementarities can be potted into three interconnected pillars, moving from the material-technological base (data and platforms), through the organizational response (talent and firm boundaries), to the systemic redefinition of industry architecture. In doing so, it provides the

[50] https://powder.gg/

[51] It is worth noting that the company, founded in 2012, has had a meteoric rise as of 2024. Their stock rose from $38.78 on January 1st 2024, to $323.83 on December 31st (+735%). AppLovin was up 2,904% over 2023-2024, and had a market cap of $118bn as of January 2025.

conceptual foundation for analyzing the AI-games nexus not as a market transaction, but as an emergent system of mutualistic development.

5.1. Technological complementarities as a dual carriageway

The most foundational complementarity is technological, yet it is a unidirectional view that has long dominated the literature: the framing of games as a testbed for AI. Early milestones like Deep Blue's chess victory and AlphaGo's mastery of Go are canonical, but it is the shift to complex video game environments that marks the true deepening of this relationship. In the Arcade environment Bellemare et al. (2013) already highlighted that video game ROMs can turn into standardized scientific instruments, creating a direct, unidirectional complementarity where the game artifact becomes an essential input for algorithmic progress. More recently, the game's demands for real-time planning under imperfect information and over massive action spaces directly pushed the frontiers of reinforcement learning[52].

We therefore find ourselves in a situation pointing to a bidirectional and fundamentally generative complementarity. This reveals a generative complementarity, where the game engine becomes the fuel factory for the broader AI economy, intertwining their technological trajectories. The consumer-driven demand for real-time, high-fidelity 3D rendering in video games bankrolled the development of the Nvidia Graphics Processing Unit (GPU). These massively parallel processors later proved to be the indispensable physical substrate for the deep learning revolution. Just as these chips were originally developed for video games before becoming a key component of AI, game engines like Unity and Unreal Engine are no longer just tools for creating entertainment; they are becoming critical infrastructure for AI development. Game technology can thereby produces the training data that serves non-game AI systems. Dosovitskiy et al. (2017) quote the case of a simulator for autonomous driving built on Unreal Engine. As noted by the consultancy Konvoy heavy industry is leveraging simulation technology, which was perfected in gaming (Konvoy, (2026a), and robotics, as well, is built on gaming (Konvoy, 2026b).

It is therefore not simply a matter of "synergies" between AI and VG, but rather a genuine fundamental infrastructural complementarity. The economic logic of the entertainment market inadvertently subsidized the creation of the core hardware of modern AI, forging a material bond that precedes and enables all subsequent synergies.

5.2. The Organizational reconfiguration: boundaries, talent, and user co-creation

This section moves from the purely technical to the socio-economic, examining how firms are restructuring their boundaries and internal processes to capture value from this intersection. The complementarity here is in resources, talent, and organizational forms.

The technological complementarities actually reshape the boundaries and internal structures of firms, generating new organizational forms. Our analysis is in-line with the literature on game

[52] Cf. Vinyals et al.'s (2019) work on StarCraft II

industry that traditionally contrasts the vertical integration of console manufacturers (cf. console makers like Nintendo) with the platformization of distribution (e.g. Steam, app stores) and an emerging AI-driven platform model. AI tools are considered to be integrated into these platforms as a new layer of value capture (e.g., generative AI asset stores, AI-moderation services).

However, the AI-games nexus accelerates a new pattern: vertical disintegration driven by specialized complementors. AI-native firms like Inworld AI or Promethean AI do not produce games; they function as highly specialized middleware providers, inserting an AI layer into the existing development stack. This represents a complementarity in specialization, where the generative capacity of AI creates a distinct new niche within the value chain, blurring the line between game studio and tech vendor.

Such complementarity is not frictionless. As a matter of fact, there is a productive tension between the research-driven culture of AI labs and the project-cycle-driven, often secretive culture of game studios[53]. it creates a managerial diseconomy of scope. Bridging these epistemic cultures requires novel organizational structures and combinatorial knowledge[54], such as embedded research pods and the creation of hybrid roles. It calls for some kind of human-capital complementarity. The ability to articulate two disparate knowledge domains with the probabilistic logic of machine learning models and the deterministic rigour of gameplay could become the most valuable and scarcest asset.

As noted earlier on, with the new role of players (user-generated content, communities, individual adoption of AI), this dynamic extends beyond the boundaries of the company alone and reaches right out to the end user. Generative AI tools, as seen in platforms like Roblox, fundamentally alter this dynamic by collapsing the skill gradient between consumption and production. The player community is transformed from an external source of content into an internal, co-creative production layer of the platform itself. The firm's core organizational role evolves from sole creator to platform curator and toolmaker, and the community emerges as a complementary organizational asset, as vital to the firm's productive capacity as its internal R&D division.

5.3. The emergent systemic convergence.

These micro-level technological and organizational complementarities aggregate to a macro-level systemic reconfiguration, merging previously distinct industries and redefining the logic of value capture. The literature on industry convergence (Bröring et al., 2007) provides a lens to analyze the strategic fluidity of giants like Epic Games. With Unreal Engine, Epic is not merely a game company but a foundational infrastructure provider for film production, architectural visualization, and industrial digital twins. The AI-games relationship accelerates this, dissolving the boundary between "game" and "simulation" and creating new competitive

[53] A similar situation can be observed across all cultural industries in the way they approach R&D (Salvador et al., 2019).

[54] Cf. Tödtling et al., 2015.

arenas. The relevant strategic categories become "user-oriented experience platforms" and "producer-oriented simulation infrastructure providers", within which traditional game studios, AI research labs like DeepMind, and cloud computing providers like Microsoft (through its Azure-PlayStation synergy) all overlap and compete.

As a result, AI's capacity to automate a widening swathe of asset generation commoditizes a large range of tasks. The direct, law-like corollary is a sharp increase in the value of the human-centric assets that cannot be automated. The key strategic bottleneck bounces up from execution to ideation: editorial capacity, distinctive art direction, systemic game design, and creative taste. So, what may seem paradoxical given the way AI is generally presented is that AI's productive efficiency generates a new premium on precisely the irreducible, curatorial human judgment it cannot replicate. This dynamic has the potential to fundamentally reshape studio power structures, concentrating value in the hands of creative directors and systems designers.

Conclusion.

AI moves all the way across the value chain, from hardware (mainframe computers), to the production (developers, middleware providers), publishers and distribution toward the end user.

The evolution of AI in games, is a journey that mirrors the progress of technology over the decades. It shows that from simple games played in the labs, arcade games, and then rule-based NPCs to deep learning-powered intelligent characters, AI is becoming a cornerstone of modern gaming. During the growth of the industry the value chain has evolved both upstream (production) and downstream (distribution). It allowed new players like middleware providers or platforms to enter and reshape the value chain.

This journey reveals that much of the progress made in developing AIs could never have been made had it not been for video games spurring developers on. Games spearheaded the development. It does illustrate that video games are unique in terms of their impact across many different disciplines and sectors including mobile, PCs, sound cards, graphic cards, semiconductors, displays, CPUs, headphones and even specialized furniture as well as haptics. Gaming is arguably a very strategically significant segment of the information technology sector. Its consumers are usually early adopters of the latest technologies. They are demanding customers with "*high standards that makes it possible to advance and refine them before deployment to the highly lucrative enterprise verticals*" (Sable, 2024).

Therefore, video games offer a testing ground to develop new AI, as the field of games can use more varied AI which can in turn lead to different kinds of games. At the same time, other businesses can take advantage of the work which video game developers and other stakeholders have done to enhance their own AIs. For instance, NetEase Fuxi Lab emphasizes:" *the mass data and virtual environment provided by our game platform also enable us to boost the development of AI frontier research*"[55]. By the same token, the Unity Machine Learning

[55] https://neteasefuxirl.github.io/

software is used to develop robots and self-driving cars. As Brockman stated: it works both ways.

In synthesis, the paper suggests an emergent, tri-level system of co-evolution between AI and video games. The material complementarities of shared hardware and generative data fuel a dynamic that compels new organizational forms and dual-depth human capital. This, in turn, drives a systemic convergence that dissolves industry boundaries and inverts the value chain, placing a premium on creative curation over technical execution. The relationship is not a single connection to be cataloged but a generative tension to be managed, marking the frontier of productive activity where these two industries, inextricably, are becoming one.

As our analysis indicates, the videogame industry offers a valuable case to learn from, especially since there is still a discrepancy between breakthroughs in AI in the academic research community and commercial applications and use cases (Simon, 2019a). Indeed, the Cisco 2024 AI Readiness Index highlights that: "*organizations globally have seen a decline across multiple areas of AI Readiness*". Some sectors are faring better than others (Technology Services, Financial Services, Retail, and Business Services), being leaders ("Pacesetters"). This is not surprising, as beyond the disparities between type of businesses, beyond the usual suspects such as tech giants and telecom companies: "*The transformative impact of general-purpose technologies, like AI, however, becomes visible only gradually, when societies and economies reinvent themselves as users of new technologies*" (Tuomi, 2018).

Even if the main companies and studios were able to develop and implement AI tools, a few major issues will still remain linked to the current limitations of AI, which, incidentally, are not always the ones most frequently cited in public debates.

The first limitation relates to skills development and the increasing complexity of production/ organisation methods. Most AI tools are not yet off-the-shelf solutions specifically tailored to the video game industry. Their use therefore requires a sound understanding and mastery of these tools, necessitating a redesign of development processes to accommodate these additional challenges. The increasing complexity of the processes associated with integrating new technical systems does indeed lead to an increase in the volume of technical resources, changes to interfaces and collaboration methods, as well as difficulties in managing tool versioning. Paradoxically, AI therefore also contributes to the increasing complexity of technical layers, requiring the definition of new skills and new roles within the organisation and the value chain, capable of performing integration and centralisation functions.

Monitoring the use of these tools and controlling the quality of outputs produced is also challenging. Using AI, developers may turn to be unable to understand, master and explain the massive code they contribute to develop for their game. As in all sectors, it is becoming essential to ensure that such quality control measures are in place. In the video game industry, this is not simply a matter of avoiding fake news or misinformation, but also of managing the use of intellectual property rights, ensuring the continuity of immersive environments, and avoiding any biased or potentially offensive content.

However, the limitations of using AI in video games are not confined solely to production and distribution; there are also technical challenges that still lie ahead. The main difficulty—one that the IT industry has faced since its very inception—stems from successive waves of technological change and the necessary (and costly) upgrading of equipment. In this regard, because video games rely on the quality and fluidity of human-machine interactions, issues of latency and inference costs become particularly critical: how these are resolved will be decisive in determining the balance between the development of console-based games and cloud-based online games. Another major issue, which is also rarely discussed, concerns the size and quality of memory. Just as the development of smartphones has relied on exponential increases in memory capacity, the development of AI in video games will face the same challenges: the ability to provide and utilize memory capable of supporting gameplay in increasingly complex and rich virtual worlds.

Faced with these challenges, AI in video games – or video games in the face of AI – ultimately find themselves faced with a choice we have previously highlighted for all forms of AI: specialisation or a jack-of-all-trades tool. More specifically, does the future lie in a suite of building blocks allowing the decoupling of a game's functions, or in greater integration with an all-in-one tool such as Unity?

In the former case, the market will appear more open from a competitive standpoint. By basing their performance on the specialized tools available on the market rather than on generic game engines, developers and studios equip themselves to research and choose between the most effective options. In this situation, studios are no longer locked into technical constraints or trapped by solutions built into the core of the game engine. Furthermore, the costs of switching from one solution to another are lower, as they relate only to very specific functions.

It is worth noting that this AI-specific alternative directly echoes very similar challenges within the field of AI: bundling or unbundling, the only two ways to make money, as once said Jim Barksdale, the former CEO of Netscape. And it has always been the same story in videogame, from integrated arcade to indie on-line game. Today, AI tools provide the opportunity to completely rethink the development process by empowering the creation of content, gameplay, animation and storytelling. While at the same time, we are also seeing a commoditisation of development infrastructure and game engines, whether open-source or proprietary: using a single platform support development and reduce costs through to integration of every aspect of the game, including deployment and monetization. As Konvoy notes (2025), for the past two decades, much of game development has been defined by a single architectural choice (Unity or Unreal). These two engines account for roughly 80% of all games released on Steam today. But the situation is changing because, the AI applications most commonly used in development today (for example, to design and control NPC behaviour) are not integrated into these platforms but are offered as standalone tools, thereby contributing to the decoupling of creative functions that were previously integrated.

Ethical considerations add a layer of complexity to the integration of AI in the video game industry: safeguarding artists' rights and preventing unauthorized use of data and artworks in AI algorithms on the one hand, and the potential for manipulative practices and data privacy concerns, on the other hand. Such considerations may, or may not hinder further developments.

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