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Nvidia Corporation: PC Gaming Industry Strategic Audit

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Abstract

Nvidia is a semiconductor company focusing on high-performance computer graphics technology. The company designs graphics processing units (GPUs), which are used in a variety of fields such as data centers, artificial intelligence (AI), and gaming. This paper seeks to examine Nvidia's position within the PC gaming industry. First, PESTEL and Porter's Five Forces analyses are used to detail the overall PC gaming industry. The next section examines how Nvidia competes through its strategy, resources, and competitive advantages. Finally, future challenges and recommendations to position the company are explored.

Keywords: Nvidia, PC gaming, cloud gaming, gaming, graphics processing unit, GPU, artificial intelligence, AI, GeForce, RTX, Porter's 5 Forces, PESTEL, strategy, strategic audit

Background/History

Founded in 1993 by Jensen Huang, Chris Malachowsky, and Curtis Priem, Nvidia Corporation is a US-based semiconductor company with a focus on computer graphics technology and its applications. In 1999, the company went public and created the first graphics processing unit (GPU), an integrated processor capable of efficiently performing many calculations in parallel. In 2006, it developed the CUDA architecture, which opened GPUs for more general use, particularly in scientific computing areas such as deep learning with artificial intelligence (AI).

Today, Nvidia is a major player in the gaming industry, with products such as the RTX line of GPUs used widely for PC gaming. The company is also heavily involved in the development of AI, with models such as OpenAI's popular ChatGPT utilizing upwards of 10,000 Nvidia GPUs during training (Hamblen, 2023). Other fields that Nvidia is involved with include data science, autonomous vehicles (AVs), and virtual reality. It groups most of these fields into four main markets (Nvidia, 2023):

- Data Center: AI, data analytics, scientific computing
- Gaming: game console chips, cloud gaming services, RTX GPUs for PC gaming
- Professional Visualization: software for digital design applications, virtual reality
- Automotive: AVs, AI-assisted driving, software platforms for electric vehicles

In fiscal year 2023, Nvidia generated \$26.9 billion in revenue, placing the company at 134th on the Fortune 500 list (Fortune, 2023). It also employed 26,196 employees in 35 countries worldwide (Nvidia, 2023).

This analysis aims to examine Nvidia's position within the PC gaming industry.

Industry Overview/Business Model

Within the PC gaming industry, Nvidia offers both software and hardware products. One of its most notable software products is the GeForce NOW cloud gaming service. By using this service, gamers with otherwise underpowered devices can enter a queue to stream and play supported games from cloud servers. Nvidia offers a free tier and a paid subscription that provides higher graphics quality and faster queue times. Among cloud gaming services, GeForce NOW has 20 million registered users (Kan, 2022a) and an estimated global market share of 10-20%, based on average monthly users (Bradshaw, 2023). Nvidia's most significant competitors in this space are console cloud gaming services such as Microsoft's Xbox Cloud Gaming (60-70% market share) and Sony's PlayStation Cloud Gaming (10-20% market share).

For GPU hardware, Nvidia follows a fabless manufacturing strategy, similar to many other semiconductor companies (Nvidia, 2023). This means that Nvidia designs its own chips but does not manufacture them, saving the costs of operating its own foundries. Instead, the company contracts with various suppliers to provide the raw components, manufacture, and then package/assemble/test its products. The most important part of this process is the manufacturing of the semiconductor wafer that makes up the main core of the GPU, which is done by suppliers such as Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung Electronics.

For its main line of RTX desktop gaming GPUs, Nvidia sells some directly to consumers through its website as well as through retailers including Best Buy, which are labeled the "Founders Edition." It also sells to add-in card/board (AIC/AIB) companies such as ASUSTek and Gigabyte Technology, as well as original equipment manufacturers (OEMs) such as Dell and HP, who may add slight modifications before selling to consumers. The process is similar for laptop GPUs, except Nvidia does not sell directly to consumers. Among discrete gaming GPUs,

Nvidia's main competitors include Advanced Micro Devices (AMD) and Intel. Nvidia is the market leader, with about 86% market share as of late 2022 (Shilov, 2022b). Recently however, Nvidia's revenues from this segment could be threatened, as demand for discrete gaming GPUs fell to a 20-year low in late 2022 (Shilov, 2022b) after being driven up by the growth in gaming during the COVID-19 pandemic.

PESTEL Analysis: Macroenvironment

A PESTEL analysis is a framework used to examine the macroenvironmental factors that may impact a company or industry. It categorizes factors into six categories that make up the acronym: Political, Economic, Social, Technological, Environmental, and Legal (Washington State University, 2022). The following section utilizes this framework to examine external factors that may impact Nvidia in the PC gaming industry.

Political

Political factors have a primary effect on the hardware side of the PC gaming industry. One major factor to consider is the political tension between China and Taiwan. Relations between the two nations have historically been very tense. There are rumors of possible military conflict, with some reports suggesting that China has considered an invasion of the island by 2027 (Yen, 2023). Currently, TSMC is a major supplier for many companies that make the computer chips used inside of PCs. This includes those that make discrete GPUs. Nvidia's older product lines relied on Samsung's foundries; however, the cores of Nvidia's latest RTX 40-series GPUs are manufactured solely by TSMC (Burnes, 2022). As such, any disruption caused by China to TSMC's operations, the bulk of which are in Taiwan, would substantially affect the

supply of components in the PC gaming industry, including Nvidia's ability to obtain supply for its newest products.

Another political factor to consider is the foreign trade policy between the United States and China, such as tariffs placed on imports/exports between the two countries. Many of the other electronic components that go into GPUs aside from the main core, such as printed circuit boards, are manufactured or sourced in China. Under the Trump administration, the US and China were involved in several trade disputes, leading to tariffs on a variety of items, including GPUs. Starting in early 2021, any GPUs imported into the US were subject to a 25% tariff, forcing prices higher (Kan, 2022b). Afterwards, the Biden administration temporarily lifted the tariffs in March 2022, then extended this exemption until September 2023. Due to various other factors such as a global chip shortage and the growth of cryptocurrencies during the time the tariffs were in effect, there was not a substantial negative effect on consumer demand for GPUs in the PC gaming industry. However, if similar tariffs are reinstated in the future, it may cause demand to shrink as prices are forced upwards, which could threaten Nvidia's business.

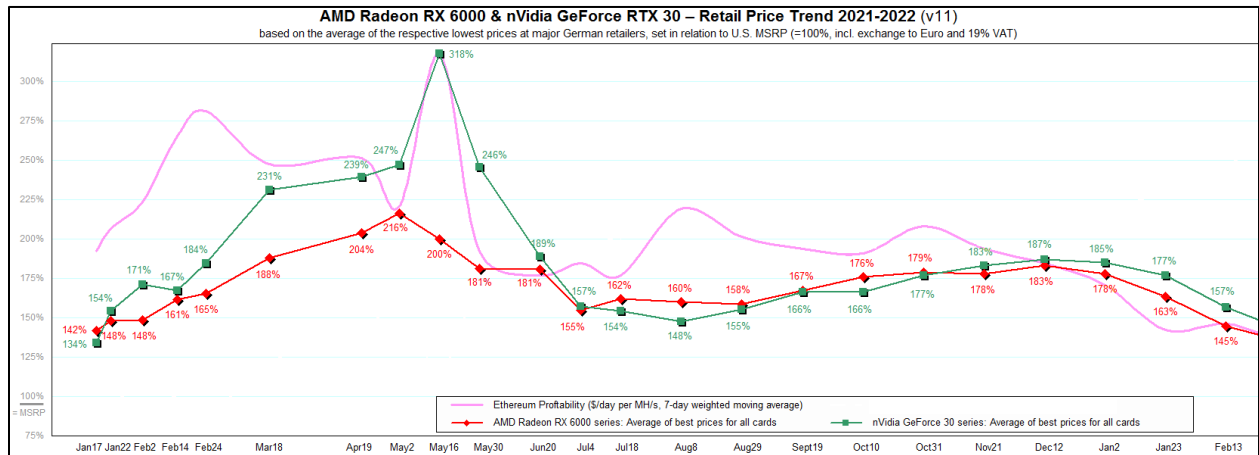
Economic

An economic factor impacting the PC gaming industry is the fluctuating value of various proof-of-work cryptocurrencies. Cryptocurrency mining often utilizes gaming PC components, especially GPUs. This is because the calculations used for graphics processing are similar to those used in the process of cryptocurrency mining, which is how proof-of-work cryptocurrency is earned. Although there are separate products specially designed for mining, which Nvidia does produce separately (Nvidia, 2022a), gaming GPUs are often a cheaper and more popular option. Between late 2020 and early 2022, one of the largest proof-of-work cryptocurrencies suitable for

GPU mining was Ethereum. Ethereum experienced a boom in value and therefore profitability to mine during this period, leading to a surge in the demand for GPUs.

Figure 1

Ethereum Profitability and Nvidia/AMD GPU Price Trends at German Retailers from Early 2021 to Early 2022



Note. Ethereum profitability is shown in pink, Nvidia GPU price trends are shown in green, and AMD GPU price trends are shown in red. Prices are expressed as percentages of retail MSRP. Adapted from *Der grafikkarten-markt im cryptomining-hype 2020-2022* [The graphics card market in the cryptomining hype 2020-2022], by Leonidas, 2022, 3DCenter.org (<https://www.3dcenter.org/artikel/der-grafikkarten-markt-im-cryptomining-hype-2020-2022>).

During this period, there were also several other factors that combined to create a spike in the price of gaming GPUs, such as a global chip shortage leading to reduced supply, growth in demand due to increased interest in PC gaming during the COVID-19 pandemic, and the aforementioned trade tariffs (Roach, 2021). Therefore, it is difficult to pinpoint exactly how large of an effect Ethereum mining had, but historical GPU price trends appear to be highly correlated with Ethereum profitability. Figure 1 shows a plot of Ethereum profitability in pink, along with

GPU price trends for Nvidia and AMD products (the two major GPU producers at the time) in green and red, respectively. The data was collected from German retailers, which experienced trends similar to the rest of the globe. Overall, GPU prices tended to follow Ethereum profitability, peaking around the most profitable period in May 2021. Some studies estimate that \$15 billion worth of GPUs were purchased for mining purposes over this timeframe (Shilov, 2022a), making up 25% of all gaming GPU shipments at some points (Peddie, 2021). A similar cryptocurrency-driven spike in demand contributing to a GPU supply shortage also occurred in 2018 (Lee, 2018), providing further evidence of the impact of cryptocurrency on the PC gaming industry. During both booms, GPU makers such as Nvidia and AMD reported increased revenues and profits from their gaming segments (Nvidia, 2022a; Lee, 2018). Ethereum has since switched to a proof-of-stake model, making GPU mining obsolete, but if another proof-of-work cryptocurrency becomes mainstream in the future, a similar spike in GPU demand could occur in the industry. Additionally, as cloud gaming becomes more prevalent, a future shortage of physical GPU supply may contribute towards increased usage of cloud-based gaming services instead, such as Nvidia's GeForce NOW.

Another economic factor to consider is the amount of disposable income held by consumers in the economy. Gaming in general provides entertainment but is not a necessity. Therefore, when disposable income levels are high, there may be more gamers and more demand in the gaming industry. One study by Fullscreen Media found that avid gamers tended to have twice the discretionary income of non-gamers (Fullscreen Media, 2018). However, if disposable income is low, people may choose cheaper entertainment options instead. Furthermore, within the gaming space, the costs of getting into PC gaming specifically are generally higher compared to other devices such as game consoles, since PC gaming usually requires more expensive

hardware. This can further exacerbate the effect of disposable income levels. Figure 2 shows the trend of disposable personal income in the United States between mid-2019 and early 2023. The elevated levels of disposable income throughout late 2020-2021 roughly coincide with periods of increased spending on PC gaming hardware, which increased an estimated 62% year-over-year in 2020, and a further 25% in 2021 (NPD Group, 2022). When disposable income levels decreased in 2022, however, spending on PC gaming also decreased, with GPU sales even hitting a 20-year low (Shilov, 2022b). In the future during these periods of lower disposable income, it is also possible that cloud gaming services can again offer a lower-cost option as they continue to develop and support a wider variety of games.

Figure 2

Real Disposable Personal Income in the US from Mid-2019 to Early 2023



Note. Real disposable income from Mid-2019 to Early 2023, expressed in billions of chained 2012 dollars. From *Real disposable personal income*, by Federal Reserve Bank of St. Louis, 2023, FRED (<https://fred.stlouisfed.org/series/DSPIC96#>).

Social

The rising popularity of PC gaming and gaming in general is a major social trend affecting the industry. The interest in gaming was especially heightened by the COVID-19 pandemic, as many people turned to gaming for entertainment during quarantine and lockdown measures. A survey by G2A, a marketplace for gaming products, estimated that 86% of people spent more time playing games in the US during lockdown measures (G2A, 2020). This period of time also helped to change perceptions of gaming from being an isolating and solitary activity to a more positive and social activity, with surveys indicating that many players felt gaming was positive to their mental health, especially with online and multiplayer games (Read, 2022). Finally, while younger demographics are still the largest group of gamers, older groups also are becoming more interested in gaming, with a 200% increase in gaming-related searches during the pandemic made by people over age 60 (G2A, 2020). Earlier studies had also indicated that parents made up 42% of PC and console gamers already (Fullscreen Media, 2018). The lasting effects of the surge in popularity of gaming from the pandemic may help the industry continue to experience growth, from an estimated \$196.9 billion in 2020 to \$321.1 billion in 2026 (PricewaterhouseCoopers, 2022). As part of the overall gaming industry, PC gaming is likely to benefit from this growth as well.

Technological

One main technological trend affecting the PC gaming industry is the continual performance advancement due to improvements in the hardware of core PC components (i.e., the CPU and GPU) as well as gaming software features. Higher performance means that game developers can create more complex, realistic, and innovative games, which ultimately affects consumer interest and demand. For CPUs, the observation known as Moore's Law states that

there is a doubling in the computing power of microchips roughly every 1-2 years (Mack, 2015). Moore's Law has been driven over the last 50 years mainly by advancements in chip manufacturing technology to shrink the transistors used on chips (Rotman, 2020). However, it is becoming increasingly difficult and expensive to continue doing this, which could lead to the end of Moore's Law in the future if other improvements are not developed. For GPUs, there is a similar observation known as Huang's Law (named after Nvidia CEO Jensen Huang) which predicts GPU computing power to improve at a faster rate than Moore's Law due to a combination of several other factors, such as the different hardware architecture as well as software and algorithmic improvements (Perry, 2018). As an example, Nvidia's 30-series RTX GPUs delivered double the performance of the previous 20-series (Nvidia, 2020), and the newest 40-series RTX GPUs now deliver up to four times the performance of the 30-series two years later (Nvidia, 2022b), due in large part to advancements in integrating AI with game image rendering. If this rate of technological advancement in the industry changes in the future, it could affect the availability and quality of games, and subsequently consumer demand.

Another technological trend is the development of cloud gaming. Cloud gaming allows consumers to stream games that are running on a remote server instead of their own local machines, eliminating the need to purchase expensive hardware and making gaming a more portable experience. It also has the potential to simplify game development since games will only need to be created for a central platform. Currently, several companies such as Sony, Microsoft, Nintendo, Facebook/Meta, Amazon, Google, Nvidia, and Electronic Arts have all launched or tested cloud gaming services with varying degrees of success. The technological infrastructure is still developing and not all games are supported on these services, but there is

large growth potential, with an estimated average annual growth rate of 47.9% in the size of the cloud gaming market starting in 2020 to reach \$7.24 billion by 2027 (Bajpai, 2021).

Environmental

Environmental factors currently do not have as large of an impact on the PC gaming industry, but there are still a few points to note. As societal environmental interests become more prevalent, many large companies in the industry such as Nvidia and AMD have put in place a corporate social responsibility program. Initiatives range from designing products with improved power efficiency to partnering with suppliers to use renewable energy in their facilities. Recently, there have also been some concerns with the power consumption of gaming devices. One study found that gaming in the US contributed the equivalent annual carbon emission level of 5 million cars (Mills et al., 2019). PCs were found to be the least power efficient compared to other gaming devices such as consoles. While still uncommon, some environmental legislation has also been enacted. Laws regulating the power consumption of devices including high-end gaming PCs took effect in 2021 in six states (California, Colorado, Washington, Oregon, Hawaii, and Vermont), prohibiting sales of certain models in these states (Ung, 2021).

Climate change may also have an impact on different parts of the value chain. In particular, the chip manufacturing process consumes large volumes of water. During mid-2021, another contributing factor to the global chip shortage was a period of drought in Taiwan. TSMC was forced to cut back on its water consumption, and extra water had to be brought in by truck (Yang, 2021). If this pattern becomes more prevalent in key supplier areas like this, it could lead to supply constraints for the industry in the future.

Legal

One legal factor to consider is the merger and acquisition activity in the overall gaming industry, including any antitrust laws that could apply. The most significant recent activity has been the attempted acquisition of Activision Blizzard by Microsoft (which owns the Xbox console gaming platform) for \$68.7 billion (Welsh, 2023). This would grant Microsoft ownership of many popular game franchises such as *Call of Duty*, so the merger is currently being examined by various government regulators in the US, UK, and EU for antitrust concerns. Although Microsoft has pledged to make such game titles available on other platforms like GeForce NOW and Nintendo Switch for a certain time period, it may have industry impacts if these games eventually do become Xbox exclusives. Depending on the precedent set by the antitrust investigation, it could also spur a wave of further acquisitions of game developers/publishers by gaming platform owners to try and get exclusive titles. This would potentially affect consumer demand and buying habits if certain games were only available on PC, Xbox, PlayStation, etc.

Another legal factor to consider involves legislative restrictions around gaming in China, currently one of the world's largest gaming markets. Foreign games must be approved to enter the Chinese market, and foreign companies often must partner with local companies to operate there. For example, Nvidia partnered with Tencent Games in 2019 to offer a cloud gaming service called START powered by Nvidia GPUs (Nvidia, 2019). Furthermore, starting in September 2021, the government put policies in place banning people under age 18 from playing games for more than three hours a week. Afterwards, there was a decrease in playing time by the under-18 age group by as much as 92% (Ye, 2023). If these policies eventually lead to a decrease

in consumer demand for gaming products in China, companies may want to reconsider their operations in the country.

Porter's 5 Forces: Industry Environment

Porter's Five Forces, originally published by Michael Porter in 1979, is a framework used to analyze the competitive forces within an industry environment (Porter, 2008). The five forces include: the threat of new entrants; the threat of substitution, existing industry rivalry, the bargaining power of suppliers, and the bargaining power of buyers. The following section uses this framework to analyze the segments of the PC gaming industry where Nvidia operates.

Threat of New Entrants

The threat of new entrants into the discrete GPU segments where Nvidia competes in the PC gaming industry is low due to high barriers to entry. GPU technology requires years of research and development by a skilled workforce in order to create chip designs, and many features of existing technology are proprietary and protected by intellectual property rights. Furthermore, access to distribution channels is difficult to build up. Chip manufacturing foundries are extremely capital-intensive to operate in-house and partnering with established suppliers such as TSMC or Samsung requires large orders and economies of scale. Relationships with AIB partners who distribute the final products can also take time to develop effectively.

The main threat that exists is from another large hardware manufacturer that makes related products entering the discrete GPU space. This happened when Intel, which traditionally only focused on integrated GPUs, started producing discrete gaming GPUs in early 2022 (Intel, 2022). There are also several companies producing discrete GPUs but operating only in China –

one such company is Moore Threads, which is headed by the former manager of Nvidia's Chinese operations (Liu, 2023). These products currently lag significantly behind in computing performance. However, if technological development speeds up in the future and these companies expand outside of China, they may pose a threat of new entry into the global discrete GPU market.

On the software side involving cloud gaming operations, the threat of new entrants is higher but overall moderate. Cloud gaming offers large growth potential, which may attract new entrants. However, it requires heavy investment into technological infrastructure such as data centers and networks, which is a barrier to entry. The main threat again comes from established technology companies who may create their own platforms. An example of this is Amazon launching its Luna gaming service in late 2020 (Bajpai, 2021).

Threat of Substitutes

The threat of substitutes to PC gaming is high. Since the purpose of PC gaming is to provide entertainment, substitute products include a variety of other entertainment options – watching movies/TV, sports, live shows, etc. These substitutes can all provide a cheaper alternative for entertainment without needing to buy an expensive PC. Even within the overall gaming space, consoles offer a cheaper option to play games without needing to purchase expensive hardware components like a discrete GPU.

Existing Industry Rivalry

Rivalry among the existing firms in the discrete GPU segment of the PC gaming industry is moderate. Even with the entry of Intel in 2022, there are only three producers of discrete GPUs on a global scale: Nvidia, AMD, and Intel. Based on data from late 2022 (Shilov, 2022b), Nvidia

is the market leader in terms of market share (86%), followed by AMD (10%), then Intel (4%). Despite Nvidia's current dominance, there is still some rivalry with AMD, which usually competes in price, offering products with slightly lower but still similar performance to its AIB partners and end consumers but at a lower MSRP. Having just entered the market, Intel's products are generally not competitive yet but may improve in the future, which could heighten the rivalry in the industry.

In terms of cloud gaming software, rivalry is more intense due to the higher number of competitors. As mentioned in the PESTEL analysis, Sony, Microsoft, Nintendo, Facebook/Meta, Amazon, Google, Nvidia, and Electronic Arts all have launched a cloud gaming service at some point. Even though Microsoft's Xbox cloud gaming currently has the largest market share of 60-70% (Bradshaw, 2023), cloud gaming software is still in its early stages and has high growth potential. If companies can attract users to their platform through tactics such as better advertising or game selection/exclusivity, then they can easily increase their market share. As such, rivalry is high.

Bargaining Power of Suppliers

The bargaining power of suppliers in the GPU industry is high. There are multiple supplier options for the general electronic components, but the manufacturing for the main core is only available through either TSMC or Samsung. Since there are so few options for producing the most important component of the GPU, chip foundries have high bargaining power as a supplier. Additionally, since these foundries produce nearly all the world's most advanced computer chips, they do not rely solely on manufacturing GPUs for their business, further increasing their bargaining power.

For cloud gaming, the most important suppliers are the game developers/publishers that provide their games for use on the platform. Supplier power here is lower but still moderate. There are more suppliers that exist, from large game companies to smaller independent studios, which lowers supplier power. However, companies with the rights to popular franchises, combined with the fact that cloud gaming is still a relatively small market at the moment, serves to increase supplier power. As cloud gaming becomes more prevalent, supplier power will start to weaken more as these platforms capture a larger audience for game developers.

Bargaining Power of Buyers

Buyer power for GPU hardware is fairly low. Since there are only three major discrete GPU producers, AIB partners and retail consumers do not have much choice in switching to other options. Also, since GPUs are essential for modern PC gaming, buyers also must make the purchase. As a result, companies like Nvidia can exert a lot of power over their buyers. For example, Nvidia has pressured their AIB partners in the past into purchasing excess inventory of old products in order to ensure shipments of future new-generation GPUs (Taylor, 2018).

In the cloud gaming segment, buyer power is higher due to the wider variety of options available. If buyers are not seeking a particular game, switching costs are still fairly low since all services currently offer a library of different games, and most are based on a monthly subscription model (Honorof, 2023). However, some services do offer exclusive titles in their game library, which decreases buyer choice and increases switching costs. Overall, buyer power is moderate.

Strategy and Objectives

As a whole, Nvidia describes its strategy as “a platform strategy, bringing together hardware, systems, software, algorithms, libraries, and services to create unique value for the markets [it] serve[s]” (Nvidia, 2023). Overall, this aligns with a general differentiation strategy to set its products apart. The company heavily invests in research and development to create technologies such as the CUDA programming model that allow its GPUs to be applied in a multitude of different fields.

Across its business units, Nvidia has several main strategic objectives (Nvidia, 2023). First, it aims to continue developing technologies such as CUDA to advance the computing platform it has created. This is important because it allows the same underlying GPU architecture to be utilized across all segments where Nvidia operates (Data Centers, Gaming, Professional Visualization, Automotive). Secondly, Nvidia has committed towards establishing their lead in the field of AI, working to make their GPU platform the best choice for developing machine learning models. Third, the company aims to leverage this AI leadership to create and support its autonomous vehicle software. Lastly, Nvidia continues to focus on extending their lead in computer graphics, which involves developing new technologies and introducing AI into fields such as gaming and professional design.

Resources

One of Nvidia’s most valuable resources is its reputation and brand name. As the company that first created and popularized GPU technology (Nvidia, n.d.-a), Nvidia and its products’ brand names (GeForce, GTX, RTX, etc.) have an established history of quality and

continual innovation with consumers. The Nvidia brand name has become closely related with high-performance graphics technology. This strong brand image provides the company with more widespread awareness of its products, helping to build customer loyalty.

Another important resource that Nvidia possesses is its technical and scientific expertise in GPU design. Over its history, Nvidia has built up a process of continual innovation – it is regularly able to design and release GPUs with improved architectures every 1-2 years, roughly in line with Huang’s Law. This innovation process resulting from the technical expertise of the engineering teams in Nvidia’s research and development activities allows the company to always be releasing improved products. In turn, this further supports Nvidia’s brand image and allows the gaming industry to develop better games, driving up consumer demand.

One last major resource that Nvidia has is its intellectual property, in particular its proprietary technology. Among the most valuable of these is the CUDA interface which allows GPU technology to be applied towards a multitude of general tasks in different fields (Nvidia, n.d.-b). Other examples include Deep Learning Super Sampling, or DLSS (an AI-based system for upscaling images to higher resolutions in games), and Nvidia Broadcast (an AI-based system for streaming video and audio). Many other applications such as games, video editing software, etc. are built on top of these features, meaning that consumers who want to use those applications may be more driven to buy an Nvidia GPU for a better experience.

Competitive Advantages

A major competitive advantage for Nvidia in the gaming industry is the wide variety of product features that its GPUs offer resulting from the company’s technical expertise. One

important feature is ray tracing capability, which is an advanced method of rendering graphics by simulating rays of light (Nvidia, n.d.-c). This is more computationally intensive, but creates much higher quality, more advanced effects in games. Nvidia's GPUs contain specialized RT cores that result in much higher ray tracing performance when compared to similar products from competitors like AMD (Walton, 2023). Another important feature is the aforementioned DLSS, which uses AI to upscale compatible games to higher resolutions as well as generate entirely new frames to improve performance (Nvidia, n.d.-c). This is made possible due to AI-specialized Tensor cores in Nvidia GPUs. AMD also offers image upscaling technology, but it does not incorporate AI and generally offers a smaller improvement than DLSS (Roach, 2022). As such, Nvidia products are better able to provide the most advanced gaming features at the highest levels of performance, giving the company a competitive advantage.

Another competitive advantage that Nvidia possesses is increased compatibility with non-gaming software. Consumers in the PC gaming industry often use PCs for related functions other than purely gaming. For example, video creation/livestreaming on sites like Twitch and YouTube are popular ways to share gaming experiences. Due to the CUDA platform Nvidia has developed, applications used for creative purposes such as video processing and 3D modeling generally perform better with Nvidia GPUs than those from competitors like AMD (Bach, 2023). As a result, Nvidia products have a competitive advantage in appealing to consumers who are interested in using their PCs for other functions besides gaming.

In the cloud gaming space, Nvidia also has a competitive advantage regarding the gaming experience it provides. While other large cloud gaming services such as Microsoft's Xbox Cloud Gaming and Sony's PlayStation Cloud Gaming are based on game consoles, Nvidia's GeForce NOW is somewhat unique in that it provides a remote PC gaming experience. Currently, the

service offers a tier based on the RTX 4080 desktop GPU, which is significantly more powerful than game consoles. This means that GeForce NOW is able to provide a remote experience of playing the latest PC games on the highest graphics settings that other services cannot match (Wilson, 2023), giving Nvidia a competitive advantage.

All these technical advantages serve to support Nvidia's overall brand image of providing the highest-quality, most cutting-edge products when it comes to gaming. This is yet another competitive advantage due to the increased prestige and brand recognition in consumer perceptions.

Future Challenges and Positioning

There are many challenges in the PC gaming industry that Nvidia will need to consider in the future. The following section explores some of these challenges and provides options and recommendations in order for the company to maintain a sustainable competitive advantage.

Post-Pandemic Demand

During the COVID-19 pandemic, GPU demand far outpaced supply due to factors previously discussed such as supply chain issues from the global chip shortage, the boom in cryptocurrency mining, and an increased general interest in gaming. This also drove GPU prices much higher. However, with gaming in general now experiencing a decline in demand post-pandemic, a major challenge that Nvidia faces in the short-term is adapting to this new situation. Nvidia's GPU prices have so far remained elevated even as prices of other PC hardware are decreasing (Laird, 2023). The company should consider adjusting this strategy of pricing its products at a high premium, which worked well for taking advantage of the strong demand

during the pandemic but now could lead to negative consequences in both public perception and sales.

Given the current demand conditions, continuing to price its products at high premiums is likely to lead to slow sales and more negative public reception as consumers may feel the products are not worth the price. For example, the recent launch of the RTX 4070 at a price of \$599 experienced slow sales despite good levels of traffic and interest on online product pages (Laird, 2023). This led to Nvidia having to cut supply and retailers offering discounts shortly after launch. To address the new demand conditions, Nvidia should consider further scaling back its production and lowering the premium charged on GPUs. Changes in production are important but do not have immediate effects due to the lead times involved in managing inventory (Nvidia, 2023). Combining this with changes in pricing can help the company adapt quicker overall. However, Nvidia should also be careful not to cut prices so low as to harm its image of offering high-quality, premium products.

AI and Technological Advancement

Nvidia should continue to invest in research and development activities to maintain its current competitive technological advantage. On the hardware side, Nvidia should try to continue to create GPU designs that offer similar improvements in power efficiency and performance as the leaps in previous generations. However, it is possible that improvements in this area may slow down as the process of shrinking transistors approaches a physical size limitation.

To account for this, Nvidia should also continue to invest in software technologies. In particular, the rapid development in the field of AI means that AI-based features like DLSS have the potential to greatly improve future GPU performance in accordance with Huang's Law,

despite potential limitations in physical hardware improvements. Continual investment into AI will allow Nvidia to maintain its lead in this field. Besides improving the technology, Nvidia should also focus on expanding DLSS support to a greater variety of games in order to appeal to a wider audience. This would help to attract more consumers since DLSS currently offers a level of performance that other competitors cannot match. The CUDA platform is another software product that is important to maintain and continue developing because the CUDA platform provides a way of adapting GPU processing power for other tasks besides gaming that competitors cannot match in effectiveness. Overall, these actions should allow Nvidia to maintain or extend its technological competitive advantages.

Emergence of Cloud Gaming

One last future challenge to consider is the emergence of cloud gaming. While Nvidia is a player in the cloud gaming space, it holds a much smaller market share compared to its presence in the physical GPU market. As cloud gaming becomes more prevalent, gamers may be less inclined to purchase physical hardware, which would overall negatively impact Nvidia. To position itself, Nvidia should continue support for its GeForce NOW service, with a focus on expanding the library of games that it supports. Since Nvidia's service is based on a PC rather than a console environment, it is already able to offer a higher-performance experience, but it needs to do so with an equally sized game library to turn that into an effective competitive advantage. Another option that Nvidia could consider is to lower pricing on existing GPU models or develop more budget-oriented, lower-tier models to better appeal to price-sensitive consumers who may be drawn towards the cheaper cloud gaming option.

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