



Article

What Does CGI Digital Technology Bring to the Sustainable Development of Animated Films?

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Abstract: This study examines the impact of the use of CGI digital technology on the sustainability of animated films. The study shows that because of the powerful virtual capabilities of CGI digital technology, CGI animated films that use CGI digital technology have a huge box office advantage over non-CGI animated films that do not use CGI digital technology, greatly increasing the profitability of animated films and expanding the scope for their sustainability. This study found that CGI digital technology enables animated films to achieve the same visual realism as live-action films, breaking down the barriers to viewing traditional animation and greatly enhancing the competitiveness of animated films. These results show that CGI digital technology has had a profound positive impact on the sustainable development of animation.

Keywords: CGI; digitalization; sustainability; animation



Citation: Sun, Z. What Does CGI Digital Technology Bring to the Sustainable Development of Animated Films? *Sustainability* **2023**, *15*, 10895. <https://doi.org/10.3390/su151410895>

Academic Editors:
Michail Kalogiannakis and Jing Gao

Received: 15 May 2023

Revised: 9 July 2023

Accepted: 10 July 2023

Published: 11 July 2023



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1. Introduction

The digitization of the cultural industry is a concentrated expression of the deep integration of culture and technology [1]. The application of digital technology has many positive effects on the sustainable development of the cultural industry. The accelerated application and iteration of digital technology has a profound impact on the innovation of the cultural industry and the supply of quality cultural products and has become the key to stimulating the vitality of cultural construction [2]. Changes in the cultural industries are always linked to technological advances. Printing technology led to the rise of newspapers, books, and advertising, while telecommunications technology led to the rise of radio, film, and television [3]. Today, digital technology is bringing about another major change in the cultural industries: the digitalization of the cultural industries.

The incorporation of digital technology into the animation industry began in the 1960s. By that time, computer science had developed to the point where it began to use related technologies to create animation. The development of multimedia technology also contributed to the development of digital animation. With the help of this technology, technicians were able to use digital techniques to simulate real physical movement and create stunning animated images [4]. CGI, short for computer-generated imagery, is a computer graphics technology widely used in animation [5]. In 1995, the first CGI animated film, *Toy Story*, was produced, marking a new stage in the development of animated films.

The concept of sustainability has three main objectives, including environmental protection (e.g., carbon emissions and waste management), social development (e.g., human rights, diversity, and equity), and economic development (e.g., profitability) [6]. In this study, the author focuses on the ‘economic development’ dimension of the concept of sustainability by explaining the impact of the use of digital CGI technology on the profitability of animated films. In order to explain the impact of CGI digital technology on the sustainability of animated films, the study has two main objectives: firstly, to verify statistically whether CGI digital technology has been effective in increasing the profitability of animated films at the box office and secondly, to explain the reasons for the effectiveness of CGI digital technology.

2. Literature Review

2.1. CGI Digital Technology

CGI as a digital technology was developed on the basis of three-dimensional computer graphics. Much like the CAD (computer aided design) systems that came with computer graphics, computer animation technology had a “design assist” flavor in its early stages. As early as 1963, Kenneth Knowlton and others at Bell Labs were experimenting with computer animation [7]. Subsequently, a number of universities, research institutes, and related companies continued the technical exploration, but most of these technical explorations were limited to two-dimensional assistive animation systems, mainly developing the use of computers to achieve intermediate animation and coloring technical aspects. Since the 1970s, computer-based 3D animation systems have been developed. With the continuous development of advanced modelling techniques such as realistic rendering technology, NURBS and polygons, and high-end 3D graphics technology such as particle effects, CGI digital technology has entered a rapid development channel, making CGI digital technology more mature and perfect [8].

The development of CGI digital technology has been accompanied by the widespread use of CGI digital technology in various fields. Since the 1980s, CGI digital technology has been used in a wide range of fields. Today, CGI digital technology is used in a wide range of fields such as architecture and interior design, scientific computing and industrial design, virtual reality and education, computer games, advertising, and film and television production. It is particularly well suited to the production of virtual characters and special effects for films and to the production of animated films [9].

Creating virtual characters and special effects for filming. CGI digital technology is replacing traditional artificial models or other means as the absolute protagonist in the production of special effects for film and television. Since the 1980s, 3D virtual characters and virtual spaces created using CGI digital technology have appeared in all kinds of film and television productions. In 1982, Disney released the first computer-animated film: *Tron*, which pioneered computer animation. Spielberg’s *Young Sherlock Holmes* in 1985 was the first film to use computer-generated characters, and subsequently, computer-generated characters appeared in a number of works including *The Abyss*, *Terminator 2*, *Jurassic Park*, *Spider-Man*, and *The Lord of the Rings*. The use of digital CGI technology for film and television effects is equally impressive, such as the shipwreck sequence in *Titanic*.

Animated film production. Since the huge success of *Toy Story* in 1995, a large number of CGI animated films have been produced and released around the world. *Monsters, Inc.*, *Finding Nemo*, *Shrek*, *Ice Age*, and a host of other CGI animated films are all huge hits. CGI animation has quickly overtaken traditional animation as the most popular genre of animation.

2.2. The Digital Transformation of CGI for Animation

In 1994, the runaway success of Disney’s animated feature film *The Lion King* marked an insurmountable high point for traditional animation. With its brilliant success, *The Lion King* was the perfect end to the golden age of traditional animation. Since then, traditional animation has fallen out of favor and has been on a steep decline.

In the decade after *The Lion King*, Disney released eleven traditional animated films, including *Pocahontas*, *The Hunchback of Notre Dame*, *Hercules*, *Mulan*, *Fantasia 2000*, *The Emperor’s New Groove*, *Atlantis: The Lost Empire*, *Treasure Planet*, *Lilo & Stitch*, *Brother Bear*, and *Home on the Range*. Of these eleven animated films, with the exception of *Mulan* and *Lilo & Stitch*, several others have failed, such as *Atlantis: The Lost Empire*, *Treasure Planet*, *Brother Bear*, and *Home on the Range*, all of which failed to recoup their costs, and all of which lost serious money considering the financial investment in promotion.

At the turn of the century, in contrast to the decline of traditional animation, CGI animation rose to prominence, with the birth of *Toy Story* in 1995. *Toy Story* became the highest grossing film of 1995. It was also the first animated film to be nominated for an Academy Award for Best Original Screenplay. Since the release of *Toy Story* in 1995, CGI

animation has continued to set new expectations with dazzling visuals and box office returns and has continued to redefine the box office standards that define the success of an animated film. In 1998, *A Bug's Life* was released, grossing USD 162 million in the US and USD 363 million worldwide, making it the highest-grossing animated film of the year. The following year, *Toy Story 2* was released and set another box office record for an animated film, grossing USD 245 million in the US and USD 497 million worldwide. 2001 saw the release of *Monsters, Inc.*, which broke the USD 100 million mark in its first 10 days of release, reaching a new high of USD 290 million domestically and USD 579 million worldwide. In 2003, *Finding Nemo* finally surpassed the live-action *Pirates of the Caribbean* as the top-grossing film of the year in North America and went on to gross an incredible USD 941 million worldwide, a new milestone in animation history.

At the time, other film production companies besides Disney/Pixar were releasing their own CGI animated films. DreamWorks, Twentieth Century Fox, Warner, and Sony/Columbia all followed Disney/Pixar in releasing CGI animated films. Outside the United States, CGI animated films have gained popularity around the world, and other countries are also releasing locally produced CGI animated films. As a result, the mainstream form of animation has shifted from traditional animation to CGI animation.

In a symbolic move, the Disney Company closed its Legacy Animation Studios in Orlando, Florida, USA, on 12 January 2004. This followed the closure of Disney's traditional animation studios in France, Canada, and Japan. The following year it was announced that DisneyToon Studios in Australia would be closed. Disney announced a complete shift to CGI animation [10].

2.3. The Technical and Aesthetic Characteristics of CGI Animation

CGI digital technology was created as computer graphics matured and combined with animation motion technology. It is based on computer graphics and combines various disciplines such as computer science, psychology, mathematics, and physics into one, making the transition from traditional image technology to real-time image technology. Because of its powerful graphic image and motion processing capabilities, CGI digital technology has been widely used in a variety of fields [11]. Although the application of CGI digital technology is not limited to the field of animation, it must be said that the performance in the field of animation is one of the most brilliant "performance" spaces for CGI digital technology; the application of relevant CGI technologies is being fully explored [12–21], which is also widely known due to the great success of a number of CGI animated films.

The technical characteristics of CGI digital technology can be summarized as virtualization, which is reflected in virtual characters, virtual movement, virtual scenes, virtual shots, and virtual lighting. The reason why virtualization can be achieved in all aspects lies in the digital nature of CGI digital technology. Compared to traditional animation technology, CGI digital technology is very different in terms of material carriers. It does not require paper or pencils or any other material; it exists as an infinite sequence of numbers in the combination of 0s and 1s. The digital approach has given CGI digital technology unprecedented power. If there were many technical limitations to the creation of animation before, the advent of digital technology has completely freed the imagination of the creator.

Every technology carries with it a certain value load. This value load is reflected in the fact that technology itself, by virtue of its own built-in characteristics, induces, encourages, and dissipates certain value choices. That is to say, technology has a latent underpinning, a great power within itself to inspire, entice, encourage and promote some value choices, while at the same time denying and rejecting others. It seeks a value system that is compatible with it and can gradually dismantle those that are not [22,23].

Seduced by the properties of digital virtual technology, CGI animation reinforces the human visual unconscious on an aesthetic level. The "visual unconscious" is a concept used by Benjamin to describe the unique significance of cinematic art. According to Benjamin, one of the unique meanings of cinematic art in comparison to other arts is its ability to

reveal the human visual unconscious and, furthermore, to reveal things that we do not perceive in our everyday vision, thus enriching our visual world. This is something that no other art can achieve. Specifically, the cinema camera is able to capture movement that is invisible to the naked eye through a series of devices such as lifting and lowering, splitting and isolating, stretching and contracting, and zooming in and out. Benjamin's use of the concept of the 'visual unconscious' further revolutionized the art of cinema, in that the visual unconscious presented in cinema is not only an unseen world but also an unknown world and that the 'visual unconscious' presented in cinema allows a whole new world to emerge ahead of its time [24]. On this level, CGI animation reaches a new level in the expansion of the visual unconscious, because it not only shows it in greater detail but also gives life to each world of the visual unconscious, i.e., it not only shows the visual unconscious but also 'resurrects' it. Specifically, CGI animation "resurrects" three unconscious worlds. (1) The resurrection of the microcosm. For example, CGI animations such as *A Bug's Life* have perfectly reproduced the microcosm of the ant kingdom, bringing a wonderful and vibrant ant world to life on the screen. (2) Resurrection of the macrocosm. Like the microcosm, the macrocosm is difficult to show with traditional technology, but CGI animation can reproduce it flexibly with the help of digital technology, such as the "resurrection" of the space world in CGI animation such as *WALL-E* and *Final Fantasy*. (3) The revival of "surreal" worlds. This can be divided into several categories: one is that the real world exists but it is difficult to observe the non-micro/macro world, such as *Finding Nemo*, *Shark Tale*, and other CGI animations with the resurrection of the underwater world; another category is the imaginary resurrection of the world that may exist in history, such as *Dinosaur*, *Ice Age*, and other CGI animations with the resurrection of the dinosaur world and the glacial period world, respectively. There is also the 'resurrection' of fantasy worlds that do not exist in the real world, such as *The Incredibles* and *The Polar Express*, which are perfect representations of surreal worlds. All in all, no matter which of the above 'resurrections' are made, they have greatly expanded and 'resurrected' the world of the human visual unconscious.

2.4. The Spectacle Turn in Visual Culture

The concept of 'visual culture' has been around for a long time, since 1913, when the Hungarian film theorist Balázs explicitly proposed the concept of 'visual culture'. He argued that the role of the visual in everyday life had diminished since the invention of printing and that much meaning was conveyed through printed symbols rather than through facial expressions. Since then, visible thought has become intelligible thought, and the culture of the visual has become the culture of the conceptual. However, the birth of cinematic art not only created new works of art, but also gave humanity a new capacity to feel and understand this new art. In this way, vision returned to human culture and visual culture was "resurrected" [25]. But the study of visual culture in the strictest sense began in the 1960s with the publication of *The Landscape Society* by Guy Debord, the leader of the French "Situation International" movement. For Debord, life itself in modern society is represented as a vast accumulation of landscapes. In its own terms, landscape is an affirmation of representation and an identification of all social life as purely representational. In essence, however, landscape does not refer to the mere accumulation of images, but to images as mediators of social relations between people [26]. The reassertion of the visual as the main cause of culture is due, on the one hand, to the development of visual technologies such as cameras and other machines, and, on the other, to the logic of a consumer society in which the 'symbolic value' of commodities can only be constructed most effectively by resorting to the manifestation of visuality. This is due to two factors: firstly, the construction of the 'symbolic value' of a commodity must be based on the perception of the recipient, and of all perceptual experiences, the visual dominates; secondly, the construction of the 'symbolic value' of a commodity must be promoted through the mass media. Secondly, the construction of the 'symbolic value' of a commodity must be promoted through the

mass media, and in the current media context, there is no doubt that the audiovisual media occupy the dominant form, with the written media taking a back seat.

The turn to the spectacle of visual culture is reflected in the shift from the ‘landscape’ of visual culture to the ‘spectacle’. The spectacle of visual culture, most notably proposed by Kellner in his book *Media Spectacle*, means that in a highly media-saturated society, real-life ‘landscapes’ and ‘spectacles’ are often to be entertained and dramatized by the media as ‘hype’. In Kellner’s definition, spectacle emphasizes the dramatic and entertaining aspects of the landscape. He says: “I propose media spectacles as those media cultural phenomena that embody the fundamental values of contemporary society, guide individuals in adapting to modern lifestyles, and dramatize conflict and resolution in contemporary society; it includes media-produced spectacles of luxury, sporting events, political events.” The phenomenon of the spectacle has become even more seductive under the influence of multimedia culture, which has led us, the subjects of media and consumer society, into a new symbolic world of entertainment, information, and consumption [27]. In contrast to Debord’s concept, Kellner’s concept of spectacle reveals the accentuation and intensification of the connotation of ‘spectacle’ in the new social context of ‘landscape’. If Debord’s landscape emphasizes the proliferation of images and their domination of modern society as mediators of new social relations, making society completely visual, Kellner’s spectacle emphasizes the dramatization and entertainment of landscape by the media, i.e., the total aestheticization and virtualization of landscape. In short, the society of landscape is a society of images, while the society of spectacle is a society of anthropomorphism. At a time when society as a whole is moving towards the spectacle and the “strange” is the immediate aesthetic interest, the audience’s pursuit of and preference for the visual spectacle is both inevitable and inescapable, and the strong rise of spectacle film and CGI animation is strong evidence of the aesthetic interest of the spectacle society.

2.5. The Box Office and the Sustainability of the Film Industry

The box office, the revenue generated from a film’s screenings or theatrical run, is one of the most important indicators of a film’s success and can be calculated in terms of admissions or ticket sales and is generally used as a direct measure of a film’s economic competitiveness. A film’s box office performance, measured in terms of box office receipts, is a direct reflection of a film’s profitability. Film production is a collective creation that costs a lot of money and has obvious commodity characteristics [28]. The film industry chain can be defined as “development–production–screening–consumption” and needs to recover costs and make a profit through the box office or other means in order to achieve sustainable development.

Box office receipts are therefore crucial to the sustainability of animated films. A high box office for an animated film is evidence that the film is economically competitive and profitable. This also applies to the genre of animation. If the box office of a certain genre is high, it proves that the genre is popular with audiences and has strong economic competitiveness and profitability, and there is naturally a lot of room for its sustainable development. In a sense, the box office revenue of an animated film directly reflects its profitability and will directly affect the scale of sustainable development of animated film.

Based on the literature review, we hypothesize that, due to the powerful virtual nature of CGI digital technology, CGI animated films can realistically represent the unconscious world of human beings and embody a certain aesthetic of spectacle, and this aesthetic characteristic is in line with the spectral turn of visual culture. As such, it has greatly enhanced the box office profitability of CGI animated films, positively influenced the sustainable development of animated films, and directly affected the change of the mainstream form of animated films. Therefore, we propose the following hypotheses:

Hypothesis 1. *The powerful virtual capabilities of CGI digital technology give CGI animated films a box office advantage over non-CGI animated films.*

Hypothesis 2. CGI digital technology enhances the box office profitability of animated films, improves the competitiveness of animated films with live-action films, and expands the sustainable development of animated films.

Based on the literature review, this paper will compile box office data from Box Office Mojo's film box office database to provide an in-depth analysis of the impact of CGI digital technology on the sustainable development of animated films and the reasons for the impact, so as to provide a scientific reference on the role of digital technology in the sustainable development of the cultural industry.

3. Data Collection and Research Methodology

3.1. Data Collection

The data for this study were obtained from the Box Office Mojo database. Box Office Mojo is an American website that tracks box office receipts in a systematic, algorithmic manner. It categorizes the box office performance of films and counts the total revenue of films, providing tracking and statistics to understand how films are performing. The site was founded by Brandon Gray in 1998 and acquired by IMDb, which is owned by Amazon, in 2008. It is the leading online box office reporting and analysis service, tracking domestic and international box office. Box Office Mojo is a resource for entertainment industry professionals, journalists, researchers, financiers, and film fans worldwide. It provides comprehensive box office data for over 60 countries and territories. Box Office Mojo includes daily, weekly, weekend, monthly, yearly, seasonal, and holiday domestic box office grosses, as well as international box office grosses. In addition, Box Office Mojo includes a selection of all-time rankings and a release calendar for upcoming films [29]. Today, Box Office Mojo is the most influential website in the field of international box office data. This study defines the period of Box Office Mojo's movie box office data from 1937 to 2022 for two main reasons: first, Box Office Mojo's animated movie box office data date back to 1937 with *Snow White and the Seven Dwarfs*, known as the world's first animated feature film; second, the movie box office data for 2022 have been generated and will not change.

3.2. Research Methodology

This study focuses on analyzing the impact of CGI digital technology on the sustainability of animated films, focusing on the box office performance of CGI animated films to verify the usefulness of the intervention of CGI digital technology for the sustainability of animated films. CGI animated films that use CGI digital technology in their production will be able to demonstrate that CGI digital technology has increased the profitability of animated films and improved their sustainability if their box office figures are increased. Conversely, if the data show that the box office of a CGI animated film is lower than that of a non-CGI animated film, this proves that the impact of CGI digital technology on the sustainability of animated films is negative.

This study retrieves box office data from Box Office Mojo, selects the data needed for this study, and then creates a Microsoft Excel spreadsheet to draw relevant conclusions by analyzing the Microsoft Excel spreadsheet.

This study used manual data collection for data statistics. As Arkady Maydanchik et al. point out, manual collection is the most primitive and basic method of data collection. This method requires manual data entry, which is a tedious process but can better ensure the accuracy and completeness of the data [30–32]. From 1 April to 1 May 2023, according to the research plan, this study retrieved and counted the box office receipts of animated films in the Box Office Mojo database. First, the Box Office Mojo database was searched through for box office receipts for animated and CGI animated films. In the “Genres” section of the “Indices” section of the Box Office Mojo website, there is a list of “Animation” and “CGI Animation”. The Box Office Mojo database contains box office data for 720 animated films and 194 CGI animated films from 1937 to 2022, according to the latest search results on 1 May 2023. In other words, when divided by whether or not CGI digital technology was

used, the 720 animated films include 194 CGI animated films and 526 non-CGI animated films. Based on box office data provided by Box Office Mojo, this study calculated the total box office, individual box office, and share of box office for animated, CGI animated, and non-CGI animated films. The study then counted the number of animated films in the top 10 worldwide box office films of each year, based on box office data provided by Box Office Mojo. Specifically, Box Office Mojo provided the top 200 worldwide grossing films for each year since 1977, and this study checked only the top 10 list for each year individually to verify whether they were animated films and, further to the needs of the study, whether they were CGI animated films. Based on the results, the study identified which CGI animated and non-CGI animated films were in the top 10, in which years, and how many times. Finally, a Microsoft Excel spreadsheet was created to further analyze and interpret the results and draw conclusions based on the above statistics.

This study focuses on the box office performance of CGI animated and non-CGI animated films over the period 1995–2022 and the change in the number of CGI animated films in the annual top 10 of the global box office charts since 1995, in order to test hypotheses 1 and 2 proposed in this paper.

CGI animation vs. non-CGI animation. Using the criterion of whether CGI digital technology was used in the production, this study divides animated films into two categories: CGI animation and non-CGI animation. As the name suggests, CGI animation refers to animated films produced using CGI digital technology. Non-CGI animation, on the other hand, is animation that does not use CGI digital technology and includes a variety of traditional animation genres such as hand-drawn animation, puppet animation, physical animation, and sand animation. 1994 saw the huge success of *The Lion King*, often regarded as the last glory of traditional animation. The following year, the first CGI animated film, *Toy Story*, was released, raising the curtain on CGI animated films. In the following decade, traditional animation and CGI animation developed in parallel, completing the transition from traditional animation to CGI animation as the main form of animation. Hypothesis 1 proposed in this paper suggests that the powerful virtual capabilities of CGI digital technology give CGI animated films a box office advantage over non-CGI animated films. This hypothesis is tested using box office data for non-CGI animated films and CGI animated films.

The annual top 10 global box office chart. This is one of the most commonly used statistics in the film industry to show which films have been the most successful in a given year. It is both an indicator of popularity and reception, and an economic indicator, as box office is economic revenue and a direct reflection of profitability. A film that makes it into the top 10 indicates that it has been a huge box office success and is one of the ten highest grossing films in the world. If a film genre is able to appear frequently and repeatedly in the top 10, it is an indication that the genre is highly competitive at the box office, has great profit potential, and has great scope for sustainable development. It is important to note that the annual top 10 global box office ranking is a ranking of all film genres, not just animation. The reason for choosing the top 10 in this paper, rather than expanding the scope further to include the top 20, the top 30, or even the top 50 or top 100, is that the competition in the top 10 is more intense and can also visually show the market competitiveness and profitability of different film genres. Widening the scope will also dilute its explanatory power. Hypothesis 2, proposed in this paper, suggests that CGI digital technology increases the box office profitability of animated films, improves the genre competitiveness of animated films, and expands the sustainable development of animated films. This hypothesis is tested by comparing the box office receipts of CGI animated films and non-CGI animated films, as well as by comparing the number of both in the annual top 10 global box office charts.

4. Results

This study conducted an exhaustive search of the Box Office Mojo database of box office data for all animated films (both CGI animated and non-CGI animated) from 1937

to 2022. The data for all animated films included in the Box Office Mojo database were included in the analysis of this study.

Based on the search and analysis, the results are as follows.

4.1. The Statistics of Animated, CGI-Animated, and Non-CGI-Animated Films

Based on the Box Office Mojo database, the statistics for animated films produced between 1937 and 2022 are as follows:

Box Office Mojo data show that 720 animated films were produced between 1937 and 2022, of which 194 (26.94%) were CGI animated films and 526 (73.06%) were non-CGI animated films; the total box office for animated films was USD 32,974,949,401, of which CGI animated films grossed USD 24,500,741,472, or 74.3%, and non-CGI animated films USD 847,420,729, or 25.70%; the average box office per film for animated films was USD 45,798,541, of which USD 126,292,482 was for CGI animated films and USD 16,110,661 was for non-CGI animated films. The single-frame box office average for CGI animated films was 275.76% of the single-frame box office average for animated films and 783.91% of the single-frame box office average for non-CGI animated films.

Hypothesis 1 states that “the powerful virtual capabilities of CGI digital technology give CGI animated films a box office advantage over non-CGI animated films”. As shown in Table 1, box office statistics for CGI animated and non-CGI animated films between 1937 and 2022 support this hypothesis.

Table 1. Statistics of animated, CGI animated, and non-CGI animated films (1937–2022).

Genre	Total	Number of Movies	Average
CGI Animation	USD 24,500,741,472	194	USD 126,292,482
Non-CGI Animation	USD 8,474,207,929	526	USD 16,110,661
Animation	USD 32,974,949,401	720	USD 45,798,541
CGI Animation/Animation	74.30%	26.94%	275.76%
Non-CGI Animation/Animation	25.70%	73.06%	35.18%
CGI/Non-CGI	289.12%	36.88%	783.91%

4.2. Annual Top 10 Box Office Statistics

The box office is a direct reflection of a film's profitability. The annual top 10 is a list of the 10 most profitable films in the world for that year, and the top 10 is a ranking of all film genres, with animated films competing with other genres to win a place in the top 10.

Box Office Mojo has produced annual rankings of the world's box office since 1977. The statistics for animated films that have made the annual top 10 at the global box office since 1977 are as shown in Table 2.

Table 2. Statistics for animated films that have made the annual top 10 at the global box office (1977–2022).

Annual Rank	Animation Film	Worldwide	Year	CGI Animation OR NOT
5	<i>Minions: The Rise of Gru</i>	USD 939,628,210	2022	CGI Animation
10	<i>Puss in Boots: The Last Wish</i>	USD 480,533,490	2022	CGI Animation
10	<i>Sing 2</i>	USD 408,396,446	2021	CGI Animation
2	<i>Demon Slayer the Movie: Mugen Train</i>	USD 453,210,959	2020	NOT
6	<i>Sonic the Hedgehog</i>	USD 319,715,683	2020	CGI Animation

Table 2. Cont.

Annual Rank	Animation Film	Worldwide	Year	CGI Animation OR NOT
8	<i>Legend of Deification</i>	USD 240,646,355	2020	NOT
10	<i>The Croods: A New Age</i>	USD 215,905,815	2020	CGI Animation
2	<i>The Lion King (CGI)</i>	USD 1,656,943,394	2019	CGI Animation
3	<i>Frozen II</i>	USD 1,450,026,933	2019	CGI Animation
8	<i>Toy Story 4</i>	USD 1,073,394,593	2019	CGI Animation
4	<i>Incredibles 2</i>	USD 1,242,805,359	2018	CGI Animation
4	<i>Despicable Me 3</i>	USD 1,034,799,409	2017	CGI Animation
3	<i>Finding Dory</i>	USD 1,028,570,889	2016	CGI Animation
4	<i>Zootopia</i>	USD 1,023,784,195	2016	CGI Animation
6	<i>The Secret Life of Pets</i>	USD 875,457,937	2016	CGI Animation
5	<i>Minions</i>	USD 1,159,398,397	2015	CGI Animation
7	<i>Inside Out</i>	USD 857,611,174	2015	CGI Animation
1	<i>Frozen</i>	USD 1,280,802,282	2013	CGI Animation
3	<i>Despicable Me 2</i>	USD 970,766,005	2013	CGI Animation
7	<i>Monsters University</i>	USD 743,559,607	2013	CGI Animation
5	<i>Ice Age: Continental Drift</i>	USD 877,244,782	2012	CGI Animation
8	<i>Madagascar 3: Europe's Most Wanted</i>	USD 746,921,274	2012	CGI Animation
6	<i>Kung Fu Panda 2</i>	USD 665,692,281	2011	CGI Animation
10	<i>Cars 2</i>	USD 559,852,396	2011	CGI Animation
1	<i>Toy Story 3</i>	USD 1,066,969,703	2010	CGI Animation
5	<i>Shrek Forever After</i>	USD 752,600,867	2010	CGI Animation
8	<i>Tangled</i>	USD 592,461,732	2010	CGI Animation
9	<i>Despicable Me</i>	USD 543,113,985	2010	CGI Animation
10	<i>How to Train Your Dragon</i>	USD 494,878,759	2010	CGI Animation
3	<i>Ice Age: Dawn of the Dinosaurs</i>	USD 886,686,817	2009	CGI Animation
6	<i>Up</i>	USD 735,099,082	2009	CGI Animation
3	<i>Kung Fu Panda</i>	USD 631,744,560	2008	CGI Animation
6	<i>Madagascar: Escape 2 Africa</i>	USD 603,900,354	2008	CGI Animation
9	<i>WALL·E</i>	USD 521,311,860	2008	CGI Animation
4	<i>Shrek the Third</i>	USD 813,367,380	2007	CGI Animation
6	<i>Ratatouille</i>	USD 623,726,085	2007	CGI Animation
8	<i>The Simpsons Movie</i>	USD 536,414,270	2007	NOT
3	<i>Ice Age: The Meltdown</i>	USD 660,998,756	2006	CGI Animation
6	<i>Cars</i>	USD 461,983,149	2006	CGI Animation
10	<i>Happy Feet</i>	USD 384,335,608	2006	CGI Animation
6	<i>Madagascar</i>	USD 542,063,846	2005	CGI Animation
1	<i>Shrek 2</i>	USD 928,760,770	2004	CGI Animation
4	<i>The Incredibles</i>	USD 631,442,092	2004	CGI Animation
9	<i>Shark Tale</i>	USD 374,583,879	2004	CGI Animation
2	<i>Finding Nemo</i>	USD 871,014,978	2003	CGI Animation
8	<i>Ice Age</i>	USD 383,257,136	2002	CGI Animation
3	<i>Monsters, Inc.</i>	USD 528,773,250	2001	CGI Animation
4	<i>Shrek</i>	USD 484,409,218	2001	CGI Animation
5	<i>Dinosaur</i>	USD 349,822,765	2000	CGI Animation

Table 2. Cont.

Annual Rank	Animation Film	Worldwide	Year	CGI Animation OR NOT
3	<i>Toy Story 2</i>	USD 487,059,677	1999	CGI Animation
5	<i>Tarzan</i>	USD 448,191,819	1999	NOT
5	<i>A Bug's Life</i>	USD 363,258,859	1998	CGI Animation
6	<i>Mulan</i>	USD 304,320,254	1998	NOT
1	<i>Toy Story</i>	USD 244,651,588	1995	CGI Animation
1	<i>The Lion King (2D)</i>	USD 763,455,561	1994	NOT
1	<i>Aladdin</i>	USD 346,476,295	1992	NOT
1	<i>Beauty and the Beast</i>	USD 248,802,521	1991	NOT
1	<i>Who Framed Roger Rabbit</i>	USD 238,092,038	1988	NOT

Based on this table and further statistics, the following results can be obtained, as shown in Table 3:

Table 3. Summary for animated films that have made the annual top 10 at the global box office (1977–2022).

Total	CGI Animation	Non-CGI Animation
58	49	9

The first CGI animated feature film, *Toy Story*, was produced in 1995. Taking this as a starting point, the table of CGI animated and non-CGI animated films in the top 10 of the annual box office WAS further analyzed and the statistics are as shown in Table 4:

Table 4. Summary for animated films that have made the annual top 10 at the global box office (1995–2022).

Total	CGI Animation	Non-CGI Animation
54	49	5

Their annual distribution is as shown in Table 5:

Table 5. Annual distribution for animated films that have made the annual top 10 at the global box office (1995–2022).

Year	CGI Animation	Non-CGI Animation
1995	1	0
1996	0	0
1997	0	0
1998	1	1
1999	1	1
2000	1	0
2001	2	0
2002	1	0
2003	1	0
2004	3	0

Table 5. Cont.

Year	CGI Animation	Non-CGI Animation
2005	1	0
2006	3	0
2007	3	1
2008	3	0
2009	2	0
2010	5	0
2011	2	0
2012	2	0
2013	3	0
2014	0	0
2015	2	0
2016	3	0
2017	1	0
2018	1	0
2019	3	0
2020	2	2
2021	1	0
2022	2	0

The annual averages of CGI animated and non-CGI animated films in the top 10 since 1995 are as shown in Table 6:

Table 6. Annual averages of CGI animated and non-CGI animated films in the top 10 (1995–2022).

CGI Animation	Non-CGI Animation	CGI/Non-CGI
Per Year	1.75	0.18

As can be seen from the tables above:

1. Before the birth of CGI animated films in 1995, the competitiveness of animated films in the annual top 10 global box office was generally weak, and few animated films could squeeze into the top 10. In the 18 years between 1977 and 1995, only four animated films entered the top 10. Whereas after the birth of CGI animated films, 49 CGI animated films entered the top 10 in the following 28 years. The competitiveness of CGI animated films on the market is evident.
2. The non-CGI animated films that entered the top 10 of the annual global box office were mainly concentrated in the 1990s, i.e., before and at the beginning of the birth of CGI animation. Since the beginning of the 21st century, non-CGI animated films have hardly entered the top 10, only *The Simpsons Movie* in 2007 and *Legend of Deification, Demon Slayer the Movie: Mugen Train* in 2020 entered the top 10, and as we all know, 2020 was the first year of the COVID-19 outbreak. The world went into a wide range of closure and control, the film market was severely affected, and the box office data were seriously distorted; thus, it is difficult to truly reflect the global distribution power of film works.
3. After a two-year hiatus, CGI animated films have become an “evergreen tree” in the top 10 worldwide box office since 1998, missing only 1994 and remaining in the top 10 in all other years. In many years, they have been able to maintain their presence with more than two films, and in some years, they have even been able to occupy half

of the top 10. In 2010, for example, five of the top 10 global box office hits were CGI animated films.

Hypothesis 2 argues that “CGI digital technology has enhanced the box office profitability of animated films, improved the genre competitiveness of animated films, and expanded the sustainable development of animated films”. Statistics on the entry of animated films into the annual top 10 of the global box office charts show that, a total of 58 animated films have entered the annual top 10 of the global box office, including 49 CGI animated films and 9 non-CGI animated films. If we take the birth of CGI animation in 1995 as the starting point, a total of 54 animated films have entered the annual top 10 at the global box office, including 49 CGI animated films and 5 non-CGI animated films, with an average of 1.75 CGI animated films entering the annual top 10 at the global box office and an average of 0.18 non-CGI animated films entering each year. The number of CGI animated films is 9.72 times higher than the number of non-CGI animated films. In particular, before the birth of CGI animated films in 1995, only 4 animated films had entered the top 10 in the 18 years between 1977 and 1995, whereas after the birth of CGI animated films, 49 CGI animated films entered the top 10 in the following 28 years. This statistic supports Hypothesis 2.

5. Discussion

This study contributes to a better understanding of the impact of digital technology on the sustainability of cultural industries. Through statistical analysis of box office data from the Box Office Mojo database, this study found that the box office average for CGI animated films is 7.83 times higher than the box office average for non-CGI animated films. Among animated films, CGI animation contributed 74.3% of the box office with a 26.94% share. In the 28 years since the birth of CGI animation, it has only been absent from the top 10 worldwide box office films in 3 years, and CGI animation has been present in all other years, with an average of 1.75 films per year, while non-CGI animation has only been in the top 10 in 4 years, with an average of 0.18 films per year, and CGI animation is 9.72 times more popular than non-CGI animation. The intervention of CGI digital technology has greatly improved the profitability and competitiveness of animated films and has injected unprecedented energy into the sustainable development of animated films.

In the field of animated film history, several major works have paid due attention to CGI animation. Giannalberto Bendazzi's *Animation: A World History* [33], Maureen Furniss's *Animation: The Global History* [34], and Stephen Cavalier's *The World History of Animation* [35] all mention CGI animation and argue that the intervention of digital CGI technology has had a significant impact on animation, creating a new stage in the history of animation. Tom Sito's *Moving Innovation: A History of Computer Animation* provides a detailed overview of CGI animation and argues that computer graphics (or CG) has changed the way we experience the art of moving images [36]. Hyejin Yoon's *The Animation Industry: The Technological Changes, Production Challenge, and Global Shifts* compares and analyzes digital CGI technology in the context of the technological evolution of the art of animation [37]. This study uses box office data to empirically test the idea that CGI animation is taking animation to a new level.

At the same time, although these works on the history of animation focus on the uniqueness of CGI animation, they do not go any further in exploring what exactly makes CGI animation unique, or what makes it so profitable and competitive. This paper will explore this further.

This study argues that CGI animation is a new genre of animation compared to traditional animation, and that CGI animation has a different quality from traditional animation, both in terms of ‘movement’ and ‘image’. Specifically, at the ‘movement’ level, it adds a natural and fluid quality to both expression and movement, which is an imitation of traditional animation. At the “image” level, in addition to the artificial three-dimensional shape of traditional animation, CGI animation also reflects a new change in the background and props, i.e., from the abstract and symbolic style of traditional animation to a realistic

style. Even in character modelling, through the use of motion capture technology, the natural and smooth simulation effect caused by CGI animation in terms of expression and movement is completely different from the traditional animation character image of dull, making the character image realistic and full of life.

The intervention of CGI digital technology has enabled CGI animation to achieve a visual realism that traditional animation does not have because, in terms of modelling, it can provide realistic backgrounds and props with three-dimensional space, and in terms of action, it can provide facial expressions that mimic human emotions and human-like movements that combine the physical properties of objects. Therefore, even though the character image itself is virtual and does not exist in reality, it can also give the audience a sense of visual realism because the state of life it portrays corresponds to the audience's daily life experience. The basis for the audience to judge whether a character image has visual realism can only come from their existing life experience. What it looks like in real life should be what it looks like on screen so that it feels real and believable. For example, in real life, movement is continuous, smooth and natural. In real life, space is three-dimensional, so creating three-dimensional space on screen can ensure visual realism. Although most of the character images in CGI animation works do not exist in real life, such as the furry monsters and big-eyed creatures in *Monsters, Inc.*, the audience cannot compare them with a specific image in real life. However, this does not prevent audiences from judging them on the basis of basic life forms in real life. For example, judging its authenticity as a living organism by its hair, expression, and movement. As Stephen Prince has shown, there is ample evidence that filmgoers compare what they see in films with their visual and social experience of the real world in a variety of ways [38]. Images that convey a sense of authenticity are those that are structured to match the audience's audiovisual experience of three-dimensional space, which is possible because the filmmaker has given these images the characteristics they deserve. This kind of image has a large amount of computer signal storage. This signal storage can include factors such as light, color, structure, movement, and sound and is composed of various factors mentioned above according to the way they are understood in the audience's daily life. Therefore, it can be said that fictional images are fictional in terms of their reference objects, but real in terms of human perception. The reason why CGI animation can provide audiences with a sense of visual realism is that it uses digital CGI technology at the image level to provide audiences with factors such as light, color, structure, movement, and sound that are consistent with their everyday experience.

The most important thing is that by achieving visual realism, CGI animation can break through the viewing barrier of traditional animation and compete with live-action films on the same platform. What is the viewing barrier of traditional animation? It is nothing more than the "fakeness" of vision! Neither traditional two-dimensional nor traditional three-dimensional animation can deliver visual realism to the audience. When watching animation, audiences have to imagine visually 'fake' life states as 'real' through an agreed hypothetical contract. This is often a barrier to viewing for most adult audiences. It may not be as serious for underage audiences because their acceptance psychology is not fully developed, especially young children who are more likely to accept animated images. However, most adults will have a direct psychological resistance to the "fakeness" of the visual. From the "fakeness" of vision to the "realness" of psychology is a rigid and forced process that requires the subjective participation of the active imagination. But for most adult audiences this forced subjective participation often becomes a burden. They prefer to accept a process from the "realness" of vision to the "realness" of psychology. In this process, visual realism can move smoothly and unimpeded into psychological reality. There's no rigid, forced fantasy here; it is a natural and smooth process. This is how live action films are accepted.

If we use the pair of terms "abstraction" and "empathy" proposed by Wilhelm Worringer [39], traditional animation undoubtedly belongs to the category of "abstraction" in the broadest sense, while live-action films correspond to the category of "empathy".

The root cause of such differences lies in the visual authenticity of the image. The visual “fakeness” of animation forms a psychological barrier that hinders empathy and prevents a smooth transition from vision to psychology. Live-action films do not have this problem. Therefore, we see that during the era of traditional animation, if an animated film managed to make it into the top 10 of the annual box office, it was an infinite honor because of this congenital barrier that traditional animation has compared to live-action films, making it very difficult to win in competition with live-action films.

However, once CGI animation overcame this inherent flaw in traditional animation and brought visual realism to the image, the original inherent barrier between animation and live-action films disappeared. Animation and live-action films are now on the same competitive platform. Even CGI animation has a relative competitive advantage because live-action films are bound by a “realistic” contractual relationship with the audience and cannot imagine freely like animated films. A long-term “hypothetical” contractual relationship has been established between animation and the audience, which is not bound by realism. When both are visually equal, the advantages of CGI animation can be highlighted. This is why we can see that in the annual top 10 global box office rankings for the last 20 years or so, CGI animation has been at the top of the list almost every year. Even topping the list is no longer a rarity.

6. Conclusions

In this study, based on statistics and analysis of box office data for animated, CGI animated and non-CGI animated films in the Box Office Mojo database, we conclude that the intervention of CGI digital technology has enabled CGI animated films to achieve unprecedented box office competitiveness relative to non-CGI animated films, with a significant increase in profitability and a profound positive impact on the sustainable development of animated films. The main reason for this is that the virtuality of CGI digital technology adds visual realism to animated films, breaking through the shortcomings and barriers that have long existed in traditional animation at the audience level. Animated films can now compete fairly with live-action films on a level playing field and gain a competitive advantage by virtue of their own hypothetical nature.

Future studies will need to continue to explore this issue. The incorporation and penetration of digital technology into social life is profound and extensive, and it is spread across all fields and industries. Compared to other areas where the relationship between digitalization and sustainable development has been well researched, research in the field of cultural industries has lagged behind and received little attention. Although scholars have begun to explore this [40,41], there are still relatively few relevant studies. Future researchers could use larger samples and better methods to explore how CGI digital technology works to improve the sustainability of animated films, as well as providing more specific case studies. A limitation of this study is that since the US is the strongest and most representative in the field of CGI animated films, this paper only focuses on the transformation process of CGI animated films in the US in the case study, without paying much attention to CGI animation in other countries, and future studies can break away from this limitation to conduct a more comprehensive exploration.

Funding: This research was funded by the Huaqiao University’s Academic Project Supported by the Fundamental Research Funds for the Central Universities [Grant Number: HQHRZX-202207].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available from the corresponding author upon request.

Conflicts of Interest: The author declares no conflict of interest.

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