




Article

The Digitalization of Motion Picture Production and Its Value Chain Implications

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Abstract: Technological change and development have been ongoing in the motion picture industry since its beginnings some 125 years ago. What further advancements of digitalization can be expected over the next decade and what are its implications for the industry's value chain? To answer this question, we conducted an international two-stage Delphi study. The results suggested a more frequent use of smartphones as cameras, the emergence of full digital film sets and digital star avatars, as well as advancements in VR-based and interactive movies. The findings imply challenges for traditional players in the motion picture value chain. Production technology becomes both simpler and more complex, leading to the threat of new entrants.

Keywords: cinema; Delphi study; digitalization; film; movie; motion picture; technological forecasting



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1. Introduction

Motion pictures are of cultural and economic importance and form the central core of the motion picture industry, which generated worldwide sales of more than US \$100 billion in 2019 (Escandon 2020). Before the COVID-19 lockdowns, the number of screens in cinemas worldwide was still growing, along with films being produced (Richeri 2016). Due to this economic relevance and the rapid changes in the industry, it has always been the subject of extensive economic research (Hababou et al. 2016). One focus is on the investigation of factors influencing box office success, such as star power, director power, the production budget, theatrical release, and film reviews (Basuroy et al. 2003; De Vany and Walls 1999; Elberse 2018; Hadida 2009; Moul and Shugan 2005; Ravid 1999; Simonton 2009).

Technological developments and the associated changes in consumer behavior have a significant influence on the motion picture industry and its value chain (Eliashberg et al. 2006; Zhu 2004). Several industries have shown major shifts in value configurations as a consequence of digitalization (Beaulieu and Bentahar 2021; Reuschl et al. 2021; Sommarberg and Mäkinen 2019; Tiberius and Hirth 2019; Verhoef et al. 2021; Weyer et al. 2020).

The three traditional main streams in the motion picture value chain consist of production, distribution, and exhibition, which are then followed by the audience's consumption (Eliashberg et al. 2006; Simon et al. 2015). A chain of connected companies and individuals partake in each step of the value chain. Producing a movie requires various suppliers and contributors, such as screenwriters, financiers, equipment manufacturers, producers, and editors (Zhu 2004). The distribution includes all activities to deliver movies, from film duplication to delivery to cinemas for exhibition. Theatrical exhibition is still the main stream of revenue for movie studios (Eliashberg et al. 2006). Each part of the value chain relies heavily on this network to progress a film project (Fang and Xiong 2020).

Technological leaps, such as those from silent to sound films, from black and white to color films, or from 2D to 3D films, can be seen as radical innovations (Domínguez Escrig et al. 2020; Rhaïem and Amara 2021; Tiberius et al. 2021a) and have attracted moviegoers to the cinemas. Similarly, home cinema technology has also advanced in a fast manner, competing with movie theaters. Faster internet connections allow for streaming high-resolution movies and therefore challenge the traditional cinema distribution (Hadida et al. 2020; Zhu 2004), and also the TV industry (Schauerte et al. 2020). Streaming video services, such as Amazon Prime, Disney Plus, or Netflix, disrupt the motion picture value chain by offering consumers on-demand movies and eradicating the serial periodicity in the premiere of content (Izquierdo-Castillo 2015).

Such technological change has accelerated in recent years with ongoing digitalization. How will digitalization further change the film industry? While foresight studies in general (Iden et al. 2017) and technological forecasting in particular (Mas-Tur et al. 2021; Sarin et al. 2020; Singh et al. 2020) are common in many industries, they are rare in the film industry. One of the few Delphi studies specifically examines the development and future structure of the German film finance network (Kumb 2017). Only sales forecasting is quite common throughout the media industries (Hofmann-Stölting et al. 2017; Huang and Pai 2020; Martin and Rennhoff 2017).

Apart from the production stage, digitalization might also change pre-production. For example, Behrens et al. (2021) showed how the use of big data analysis can help producers to better meet the audience's wants and needs. Analyzing users' forum discussions can, for example, provide valuable insights in what the audience likes and dislikes, especially as they differ from region to region (Ghosh Dastidar and Elliott 2020).

To the authors' knowledge, there is no study predicting how technological advancements might impact the motion picture value chain. Existing research has concentrated on analyzing reactions on the distribution sector (Kehoe and Mateer 2015), technological innovation trends (Protogerou et al. 2016; Benghozi et al. 2015), the internet as a disruptor (Fang and Xiong 2020), and the changing experience of going to the cinema itself (Grundström 2018). None have conducted a Delphi study to support predictions of future changes impacting the industry's value chain.

It is of great significance for practitioners to recognize the ongoing technological changes in their industry that might challenge or disrupt the established value chain. Being aware of such developments and examining possible and especially probable future scenarios can be imperative for a company's future success (Semke and Tiberius 2020; Tiberius 2019; Tiberius et al. 2020b).

With our study, we intend to close the above-mentioned research gap. Our research goal is to identify a plausible technological forecast for the motion picture industry for the next 10 to 15 years and to reflect on its implications for the value chain. To achieve our research goal, we conducted an international, two-stage Delphi study as a forecasting method, which supports a comprehensive literature review identifying potential advancements in technologies and their impact on the value chain. With this research, we contribute to research on the motion picture value chain by examining the implications of digital production technologies on moviemakers, theaters, distributors, and home video channel operators.

In the remainder of this paper, we explore the motion picture industry's current technological trends, which we use to formulate ten plausible technological projections. We then explain the Delphi methodology, how the study was conducted, present the results as descriptive statistics and a narrative scenario, and discuss these findings. Then, we discuss the impact of these technologies on the value chain, their interactions with each other, as well as to what extent they might harm or boost parts of the value chain. We also discuss the limitations of the study and make suggestions for future research.

2. Current Technological Trends and Projections

Technological advancements have always had a strong impact on the movie industry, particularly in recent years (Eliashberg et al. 2006; Hagberg et al. 2016; Motion Picture Association 2019; Weinberg et al. 2020; Zhu 2004). In the following, we address the current technological trends in the field and formulate projections for its possible further development. It has to be stressed that projections do not necessarily need strong scholarly justifications as conclusions for the scenario can be drawn from both the agreement with plausible and the disagreement with implausible projections (Tiberius and Hirth 2019). However, to receive a high response rate and avoid a high dropout rate in the Delphi survey, the majority of projections should be reasonable. Therefore, we based their formulation on a literature review and plausible considerations. A solely literature-based development of projections is impossible due to the lack of foresight studies in the field. Therefore, knowledge from other fields also has to be included. When formulating the projections, particular attention was paid to their short and precise formulation in order to avoid misunderstandings or misinterpretations among the respondents (von der Gracht 2012).

The order of the projections roughly corresponds to the technology's increasing complexity (Figure 1). The first projection addressed the smartphone as an already existing device that also already has been used several times for film making. Compared with traditional movie cameras, shooting a movie with a smartphone represents a clear simplification. In contrast, the last projections address the further advancement of VR technology and interaction with a movie in a way that they approximate specific video game genres.

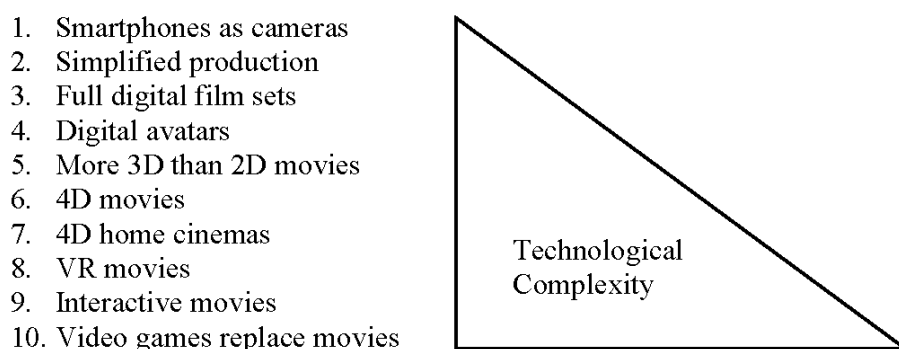


Figure 1. Overview of the projections. Source: own elaboration.

One of the most important innovations of the last few decades was the development of digital film technology and data compression, which enable movies to be digitally filmed, edited, stored, transmitted, and presented (Stump 2014). A further stage in this technological development can be seen in the use of smartphones instead of professional camera equipment for film production. The quality of smartphone cameras has improved significantly over recent years (Barritt et al. 2019; Boissin et al. 2015; Seo 2016). The first known example of a smartphone movie production, “SMS Sugar Man”, was filmed in 2008 by the South African movie maker Aryan Kaganof. Back then, the quality was not yet convincing. In contrast, the 2015 motion picture “Tangerine L. A.” shows higher quality. The American independent movie maker Sean Baker acted as the screenwriter, director, producer, and cinematographer using an iPhone, as well as the editor. Replacing expensive and complex cameras with modern smartphones brings various advantages such as cost savings, easy transportation and handling due to lighter weight, and simplified access to movie production for independent artists (Chen 2021; Churchill 2019). Assuming that the technological improvement of smartphones and their cameras will continue in the future, the number of movies produced with smartphones might increase significantly. P1: Within the next 10 to 15 years, the number of films produced with a smartphone will increase significantly.

The collective term Computer Generated Imagery (CGI) denotes digital two- or three-dimensional effects that are used in movie and video game production. CGI mostly refers to animations, which can be used to create and edit special effects, backgrounds or characters, or combine them with real film recordings (Booker 2020; Eliashberg et al. 2006; Netzley 2000). CGI can be used to reduce costs and increase quality and is therefore an integral part of modern film production (Abbott 2006; Wales 2017; Waterman 2007). Numerous modeling, animation, and rendering technologies developed by large animation companies are now available through over-the-counter software packages. As a result, 2D and 3D rendering and the creation of professional CGI material is no longer reserved for large production companies with so-called render farms and large budgets (Abbott 2006; Diaz 2017; Foundry 2019). Rather, modern CGI technology can now also be used by small production companies or independent filmmakers (Diaz 2017). In order to remain competitive, it is important to make the production of CGI as efficient as possible. Companies specialized in the production of visual effects as well as large film production studios are increasingly relying on scaling effects and building on existing CGI elements for new productions (Diaz 2017; Foundry 2019). It is possible that CGI processes could be simplified through scaling effects and that post-production steps could be automated in the future through the use of artificial intelligence (AI). For example, in 2016, the trailer for the movie “Morgan” was edited by an AI system for the first time (Smith 2016). In the future, entire feature films could be post-processed automatically. P2: Within the next 10 to 15 years, producing professional motion pictures will be as easy as designing websites is today.

In the past, the use of CGI was limited to post-production (Tsapanos et al. 2011). Some tools can now be used while filming. For example, director James Cameron used virtual monitors for the production of the 2009 movie “Avatar”, which enabled him to follow the animated results of the motion recordings in real time (Johnson 2009). In the future, previzualization technologies could be developed to such an extent that actors could act in a digital film set during filming and post-production of the animated film set would be omitted (Foundry 2019). P3: Within the next 10 to 15 years, complex movie sets will be digitally created for actors to perform in them live and without further post-production.

The so-called uncanny valley hypothesis states that robots or animated characters with increasing but not perfect resemblance to humans are not perceived as sympathetic but rather as frightening and scary (Geller 2008; Mori et al. 2012). For robots or animated images to attract as much sympathy from the audience as a real human being, the resemblance must be perfected such that they can no longer be distinguished (Geller 2008; Mori et al. 2012; Seymour et al. 2018). Figure 2 depicts this gap in the audience’s acceptance or familiarity with the animated image.

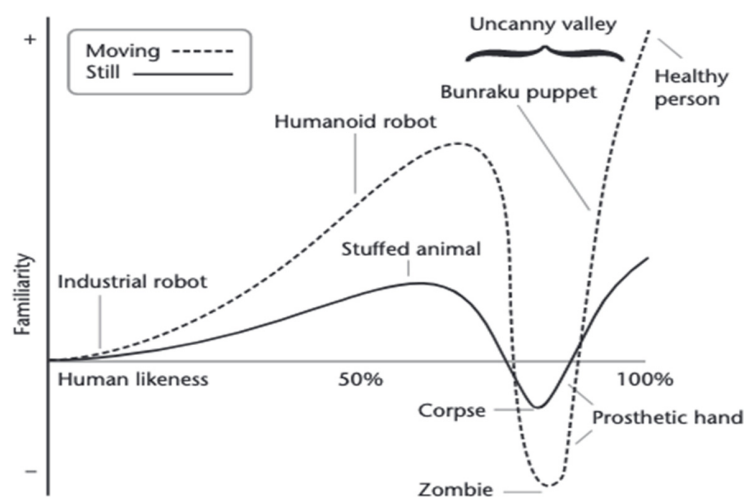


Figure 2. Uncanny Valley. Source: Geller (2008).

Attempts to overcome the uncanny valley in motion pictures have been unsuccessful so far. For example, the close-ups of the animated face of the hero in the movie “The Legend of Beowulf” had a frightening effect according to critics (Gallagher 2007). However, overcoming the uncanny valley is not impossible per se, as the Japanese project “Saya” suggests (Tan 2016). The still image of a computer-animated schoolgirl shows its human features precisely and convincingly (Figure 3). The moving image of Saya, however, still seems quite unnatural (Tan 2016). To perfect synthetic actors, interdisciplinary insights from fields such as AI, artificial life, biology, cognitive sciences, mechanics, physics, robotics, etc. have to advance significantly (Pina et al. 2000). Should it be possible in the future to overcome the uncanny valley for motion pictures, it would be conceivable that animated-avatar actors could replace real actors. Professionally produced avatars could potentially be reused in multiple films. Using a pre-produced avatar may save production costs. The most famous avatars could develop into stars, similar to avatar influencer Lil Miquela, who now has 2.8 million followers on Instagram (<https://www.instagram.com/lilmiquela>, accessed 5 November 2020). P4: Within the next 10 to 15 years, digital avatar actors will become famous celebrities.



Figure 3. CGI Project, “Saya”. Source: Tan (2016).

Stereoscopic 3D films already had a “golden era” in the 1950s (Mendiburu 2012). Since then, the technology has been developed further and experienced a new boom in the early 2000s (Motion Picture Association 2018). In particular, 3D was touted as the future of film production and consumption by “Avatar” director James Cameron. The technology can be seen as an opportunity to offer the viewer a better and more extraordinary experience. However, developments in the last few years illustrate the uncertainty surrounding the future of this technology. Whereas the sales generated by 3D films have declined sharply in recent years, the number of 3D cinema screens worldwide rose steadily between 2006 and 2019 (Motion Picture Association 2019). Several reasons might suggest that 3D movies will not be the new standard. For example, viewers of the 3D version of a movie do not enjoy the motion picture more than viewers of the 2D version (Sobieraj and Krämer 2014) or show a higher emotional arousal or satisfaction (Rooney and Hennessy 2013). A more fundamental problem of 3D movies is that some viewers experience motion sickness (Solimini 2013; Wibirama et al. 2018). Whereas watching in 3D shows no cognitive after-effects (Bombeke et al. 2013), the sensation experienced during the movies strain moviegoers’ information-processing capacity so much that they are less distracted by other stimuli (Rooney and Hennessy 2013). Thus, consumers have problems memorizing placed brands (Breves and Schramm 2019; Terlutter et al. 2016), which is inimical for product placements as an additional funding source for movies (Lubbers and Adams 2004). However, we formulate the projection in a positive way, as it can also be disagreed with. P5: Within the next 10 to 15 years, mainly 3D instead of 2D movies will be produced.

The 3D technology can be further enhanced to 4D with additional special effects such as wind, smells, or moving seats that adapt to the plot of the film (Lee et al. 2015;

Wood 2018). Further advancements even allow for a multimodal interaction with the movie (Casas et al. 2016). The 4D technology is being promoted in particular by the South Korean company CJ 4DPLEX, which now offers its so-called 4DX technology in over 700 cinemas worldwide (CJ4DX 2020). Obviously, 4D movies are even more demanding on human information-processing capacities, with negative effects toward product placement memorization (Terlutter et al. 2016). Therefore, there is much speculation about the further market penetration of this film technology (Mendiburu 2012). P6: Within the next 10 to 15 years, significantly more 4D/4DX movies (incl. scents, wind, temperature changes, and movements) will be produced.

In connection with P6, it was shown that an increase in the production and consumption of 4D films is conceivable. A breakthrough of this technology would possibly occur when affordable 4D home theaters receive market penetration. P7: Within the next 10 to 15 years, affordable 4D home cinemas will be available.

Technological developments in the field of virtual reality (VR) currently influence numerous industries (Alzayat and Lee 2021; Flavián et al. 2019; González-Zamar and Abad-Segura 2020; Nesenbergs et al. 2021; Pinto et al. 2021; Sukotjo et al. 2021). Head-mounted displays with a head-tracking function allow a wide-viewing angle (Sera et al. 2016). In this way, passive viewers become active and can navigate within an artificial environment and their real-time simulations (Flavián et al. 2019; Guttentag 2010; Heim 2000). While, theoretically, a 360-degree view enabling watching both up and down is possible, the plot defines the intended viewing area, which most viewers will follow most of the time (Fearghail et al. 2019). Director Chris Milk sees the future of film in VR technologies (Milk 2015). He expects that VR can be used to tell a story that is individually tailored to the viewer and in which particular likes and dislikes can be taken into account (Churchill 2019). The emotional effect of VR movies on viewers is much stronger than of traditional 2D movies (Ding et al. 2018). P8: Within the next 10 to 15 years, significantly more VR movies will be produced.

Whereas pure VR might be limited to changing the viewer's perspective on the ongoing plot, viewers could actually become decision-makers in interactive films in which they actively participate in the action (Perron 2008). After the international success of the 2018 project Black Mirror Bandersnatch, Netflix already announced that more interactive series will follow (Ramachandran 2019; Television Academy 2019). P9: Within the next 10 to 15 years, significantly more interactive films, in which the viewer can co-determine the plot (e.g., Black Mirror Bandersnatch) will be produced.

However, the agency of the viewer is limited to a few decisions that change the plot development and show different prerecorded sequences (Allison 2020). If the idea of VR-based, interactive movies is extended, films could actually become like video games (Brookey 2010). P10: Within the next 10 to 15 years, movies will be replaced by video games to a great extent.

3. Methodology

To develop a technological forecast for the motion picture industry, we conducted an international Delphi study. The Delphi technique is a popular forecasting method, which is shown by its use in 175 studies published in business and management journals and in 116 studies published in social science and law journals between 1975 and 2017 (Flostrand et al. 2020). The method aims to forecast man-made, i.e., cultural phenomena (Woudenberg 1991). In contrast to natural phenomena, which follow natural laws, cultural future development is based on the social interplay between different individuals' and groups' intentions, behavior, and agency as well as coincidences (Tiberius 2011).

The most likely future scenario is developed based on experts' iterative assessments of the projections discussed in Section 2. After the first assessment of the projections by the experts, the panel is informed about the interim results and is asked to assess the projections again to reduce the variance of the assessments, i.e., to enhance the group consensus about the projections (Bell 1967; Dalkey and Helmer 1963; Ermolina and Tiberius

2021; Gassmann et al. 2021; Prommer et al. 2020; Rowe and Wright 1999, 2001; Skulmoski et al. 2007; Schwark et al. 2020; Studen and Tiberius 2020; Tiberius and Hauptmeijer 2021; Tiberius and Hirth 2019; Tiberius et al. 2021b; Weyer et al. 2020; Woudenberg 1991).

Delphi studies employ not a random but a purposive sampling technique that selects respondents based on their expertise, which is considered to provide more accurate forecasts than the opinions of laypersons (Gordon 1994; Graefe and Armstrong 2011; Hasson et al. 2000; Helmer and Rescher 1959; Hsu and Sandford 2007; Parente and Anderson-Parente 2011; Rowe and Wright 2001; Welty 1972; Winkler and Moser 2016). For the selection of experts for foresight studies, several methods have been regularly used for Delphi studies of which none can be considered completely bias-free (Mauksch et al. 2020). We followed the “external cues” or “professionalism” method, which is the most popular identification approach and is based on objective profession-related criteria, such as job position, years of experience in the field, certifications, publications, etc. (Bolger and Wright 2017; Mauksch et al. 2020). For our study, a heterogeneous group of film experts was selected (Gordon 1994). Potential study participants were identified through various professional networks (especially LinkedIn) based on their professional background, as represented by the following external cues: job group, a minimum of five years of experience in the industry, and memberships in professional associations. The panel was composed of experts who work in a wide variety of areas of the film industry. Employees of production companies (directing, camera or audio technology), distribution companies, film critics, and screenwriters took part in the study. Care was also taken to include experts from different regions—Asia, Europe, and North America—to ensure that the study was internationally representative. The list of potential respondents consisted of a total of 340 experts. Sixteen of them could not be reached. Of the remaining 324 experts, 39 took part in the first round. The response rate was low at 12%, which was what we expected because (1) the film industry is characterized by a high degree of exclusivity, which limits the possibilities for contacting experts, (2) practitioners have little affinity for scientific research, and (3) the outbreak of the COVID-19 pandemic was likely to have a negative impact on the response rate. However, the target value of 15 to 35 experts, as suggested by Gordon (1994), was met due to the large potential sample. Thirty experts took part in the second survey round, which corresponds to a repetition rate of 76.9%, which is regarded as above average. The panel structure is shown in Table 1.

The first survey period was carried out from 2 March to 22 March 2020. As this was an international study, the survey was conducted in English. As typical in Delphi studies, participation was anonymous. Study participants were asked to agree or disagree with the projections. For this purpose, a four-point and thus even-numbered Likert-scale (Likert 1932) was used (“disagree”, “rather disagree”, “tend to agree”, “agree”). This has the advantage that there are no neutral answers and so the tendency towards the middle can be avoided (Boone and Boone 2012). The second survey period lasted from 30 March to 19 April 2020. The results of the first round were displayed to the participants. The survey was ended after the second round due to the already high consensus, which made further rounds obsolete.

Table 1. Panel structure.

Characteristics	1st Round (N = 39)		2nd Round (N = 30)		Differences	
	n	%	n	%	n	%
Gender						
Male	27	69%	23	77%	−4	−15%
Female	12	31%	7	23%	−5	−42%
Other	0	0%	0	0%	0	0%
Age						
Under 30 years	6	15%	3	10%	−3	−50%
30 to 40 years	16	41%	14	47%	−2	−13%
41 to 50 years	5	13%	5	17%	0	0%
51 to 60 years	9	23%	5	17%	−4	−44%
Older than 60 years	3	8%	3	10%	0	0%
Region						
Asian-Pacific	7	18%	6	20%	−1	−14%
Europe	14	36%	12	40%	−2	−14%
North America	18	46%	12	40%	−6	−33%
Group						
Camera, audio, editing, technology	9	23%	7	23%	−2	−22%
Production, direction, animation	15	38%	13	43%	−2	−13%
Screenwriter	1	3%	1	3%	0	0%
Marketing, PR	2	5%	2	7%	0	0%
Distribution	7	18%	6	20%	−1	−14%
Film critic	2	5%	1	3%	−1	−50%
Casting, actor	3	8%	0	0%	−3	−100%

4. Results

The following numerical values were assigned to the four possible answers: “disagree”: 1, “somewhat disagree”: 2, “somewhat agree”: 3, “agree”: 4. The median ($x_{0.5}$) of the aggregated answers is considered as the group opinion. Rather than the mean, it was used because it is more robust against outliers (Helmer and Rescher 1959; Hill and Fowles 1975). The interquartile range ($IQR = x_{0.75} - x_{0.25}$) was used as the scattering measure (Gordon 1994). The first and second round results can be found in Table 2 and the group assessments of the projections is summarized in Table 3.

The respondents (somewhat) agreed to the following projections: 1, 3, 4, 8, and 9. They (somewhat) disagreed with the following projections: 2, 5, 6, 7, and 10. From the first to the second round, a shift of the median towards a stronger agreement occurred for projection 1. For projection 6, the disagreement increased. The IQR reduced from the first to the second round for projections 1, 4, 6, and 7. Therefore, the opinions converged, as strived for. As a consequence, in the second round, no IQR was higher than 1, which showed a high level of consensus.

Table 2. Descriptive statistics.

	Projection	1st Round (N = 39)		2nd Round (N = 30)		Differences	
		$x_{0.5}$	IQR	$x_{0.5}$	IQR	$\Delta x_{0.5}$	ΔIQR
1	Smartphones as cameras	3	2	4	1	1	−1
2	Simplified production	1	1	1	1	0	0
3	Full digital film sets	3	1	3	1	0	0
4	Digital avatars	3	1.5	3	1	0	−0.5
5	More 3D than 2D movies	1	1	1	1	0	0
6	4D movies	2	2	1	1	−1	−1
7	4D home cinemas	2	2	2	1	0	−1
8	VR movies	3	1	3	1	0	0
9	Interactive movies	3	1	3	1	0	0
10	Video games replace movies	1	1	1	1	0	0

Table 3. (Dis)agreement with projections.

Assessment	Projections
Agree ($x_{0.5} = 4$)	1
Somewhat agree ($x_{0.5} = 3$)	3, 4, 8, 9
Somewhat disagree ($x_{0.5} = 2$)	7
Disagree ($x_{0.5} = 1$)	2, 5, 6, 10

Based on the results, we can formulate the following scenario: The experts expect that within the next 10 to 15 years, the number of films produced with a smartphone will increase significantly. Complex movie sets will be digitally created for actors to perform in them live and without further post-production. Avatar actors are expected to become famous celebrities. There will be significantly more VR-movies produced, and the number of interactive films in which the viewer can co-determine the plot (e.g., Black Mirror Bandersnatch) will increase as well.

In contrast, we can also formulate a negative scenario, i.e., what the experts are not expecting to occur within the next 10 to 15 years: Producing professional motion pictures will not become as easy as designing websites. The number of 3D movies compared to 2D movies will not increase. There will not be significantly more 4D/4Dx movies produced. Affordable 4D home cinemas will still not be available. It is unlikely that movies will be replaced by video games to a great extent.

5. Discussion

Whereas in many Delphi studies median shifts from agreement to disagreement or vice versa or increasing scatterings and therefore dissent can be observed, the results from our study were satisfying in regards to consistently clear assessments and a high group consensus. Therefore, there are no discussions necessary regarding such issues.

However, among the rejected projections, not all agreements could clearly be expected. We attribute the disagreement with projections mainly to three reasons. First, rather extreme or excluding statements did not find consent, whereas more conservative formulations of the same ideas might have been agreed to. For example, in Projection 2, we compared the ease of future movie production with today's development of websites, which usually does not require any coding skills anymore, as it did in the past. It is possible that this comparison to websites was too exaggerated. In Projection 5, we did not only ask if we

will see the production of more 3D movies in the future but also whether they would outnumber 2D movies. Whereas experts might have agreed to an increase in the number of 3D movies, which currently only account for a fraction of all movie productions, they did not suggest that 2D movies will more or less vanish. The same is the case for Projection 10, which stated that video games will replace movies.

Second, several projections might have received a dissent due to the desirability bias (Ecken et al. 2011; Winkler and Moser 2016) according to which respondents rate probabilities higher (lower) for future events they find preferable (avoidable). For example, Projection 2 addresses the ease of movie production. As a consequence, much of today's movie staff would not be needed any more, a scenario not favorable for them at all. Projection 10, the replacement of movies by video games, would even render the whole movie industry obsolete.

Third, for some projections, the given time horizon of 10 to 15 years might have been too short for the implied technological progress. This might probably be the case for the emergence of 4D/4Dx movies (Projection 6) and corresponding home cinemas (Projection 7). However, the experts might also not have anticipated a customer demand for this technology. Whereas cinephiles might be curious to have such experiences once or from time to time, the majority of the audience might not establish a persisting demand.

6. Implications for the Value Chain

The motion picture value chain is becoming increasingly complex due to new entrants and more technical intermediaries, leading to greater tensions between the artistic and the technological dimensions of the motion picture sector (Benghozi et al. 2015). As shown in Figure 4, advancements in digital technology have the potential to greatly impact the traditional motion picture value chain.

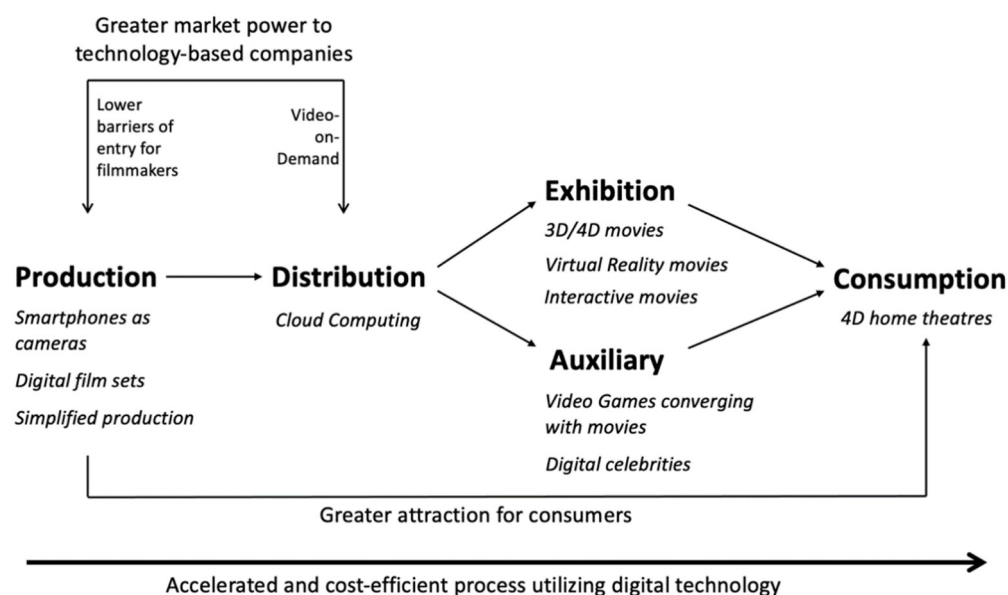


Figure 4. Conceptual framework. Source: own elaboration.

Simplified production processes can have an impact on the production, distribution, and consumption stages of the value chain. Conventional film shooting is being challenged by realistic digital technology (Fang and Xiong 2020). Film production sees some shift from art and handicraft to IT expertise, which may simplify the production process, since large parts of the shooting can take place in studios. However, according to our Delphi study, industry experts did not think producing professional movies will be as easy as building websites is today. In contrast, novel technologies become more complex and require completely new capabilities.

Technological advancements, such as CGI, can create more dramatic effects and therefore draw more viewers. Some producers also try to use such technologies to reduce costs (Ji and Waterman 2010). However, this attempt is doubtful, as the generation of artificial realities requires high expertise and significant manpower. In fact, budgets for visual effects have increased between 10% and 50% (Simon et al. 2015). It is doubtful that these increased costs can be compensated by decreased costs of real set shootings. As a consequence, the predominant purpose of novel production technologies can be seen in enhancing the movie experience rather than cost-cutting.

Virtual effects are evolving, from James Cameron's use of virtual monitors while shooting his movie "Avatar" released in 2009 to Disney's use of LED walls as a set for "The Mandalorian". Virtual Reality technology and its contribution to 100% digital film sets has challenged many aspects of filmmaking. Production design that has traditionally been limited to pre-production and production is now completing the process by adding finishing touches in post-production. The production process can not only benefit from the completely digital film set itself, but also the digitalization of the video camera. Digital cameras make immediate audio and video feedback possible. That way, directors can decide whether an additional or a re-shoot is necessary. This can, to some rather small extent, also save time and therefore costs (Kuchelmeister 2020). Moreover, shooting and editing could happen almost simultaneously with the digital format, making post-production faster and more efficient (Hu 2016). Our study supports these findings and, based on the results, we can predict that complex movie sets will be digitally created for actors to perform in them live and without reduced post-production.

Furthermore, our study observed that smartphones might partly replace traditional movie cameras. This challenges players in the production stage like camera manufacturers since the demand for their products declines. Additionally, technology that is easily accessible and simple to handle lowers the barriers of entry into the market (De Voldere et al. 2017). In particular, independent filmmakers can benefit from technological innovations in smartphones, such as 4K resolution, microphone mini-jacks, adjustable focus, and add-on lenses or filters (Işıkman 2018). Therefore, filmmaking becomes more accessible and can provide new narratives deviating from mainstream storytelling.

Increasingly, digital production processes can lead to easier global distribution of motion pictures. One significant enabler of this is cloud computing, not addressed in the Delphi study. By being able to store, upload, or access files that are no longer constrained by server size, filmmakers do not have to build entire IT infrastructures for a single project. Independent producers especially can use cloud services to decrease costs and easily distribute their finished films (Accenture 2014).

All of the aforementioned production technologies have started to contribute to shifts of the various phases in the motion picture value chain. Greater market power may be allocated to technology-based companies. Lower barriers can allow for smaller, yet still professional productions and a wider variety of filmmakers leading to more competition. Hence, traditional contributors must find a new balance for themselves within the value chain, recognize opportunities that come with recent changes (Cruz-Ros et al. 2021; Filser et al. 2020), and find new ways to innovate themselves in an agile manner (Brand et al. 2021).

Products and services utilizing these technologies have an impact on the value chain as well. Even though our study suggests that there will not be more 3D and 4D movies (than 2D), technology might further advance and cause disruptions. Researchers are currently developing technologies to enjoy 3D movies without requiring special glasses, which would offer consumers a more immersive experience (Efrat et al. 2016). Parts of contemporary audiences want to play a more active role in their media consumption (McSweeney and Joy 2018). Story-telling can be enhanced by including the audience in decisions and thereby eliminating the psychological distance between viewer and screen (Blake 2017). Netflix's "Bandersnatch" is significant as it shows the altered technological

environment that makes traditional cinemas lose their competitive advantage (Roth and Koenitz 2019).

While video games might not completely replace movies in the future, as reported by the industry experts in our study, there could be instances where both mediums collaborate to contribute to a greater consumer experience. VR technology has the potential to merge the two together and involve the audience in a virtual world (Betzler and Leuschen 2020).

There are several contingencies further harming the motion picture value chain. A new level of cyber security is essential for the ever-growing danger of storing all data digitally in a cloud. With such a large amount of people working on a project, it can get progressively more difficult to track everyone's actions. Additionally, the current bandwidth with which data is being compressed for upload is still insufficient for the increasing file sizes that come with higher-resolution films (Motion Picture Laboratories 2019). Therefore, there is an imbalance between the speed of compression innovation and the expanding file sizes uploaded to the cloud that needs to be resolved.

Nevertheless, various impactful opportunities exist, which boost the value chain. A complete digitalization of movies can contribute to a more consistent projection quality, programming flexibility, and possibly some cost-saving benefits (Simon et al. 2015). In the future, the whole film production value chain may shift towards a significantly more digitalized model utilizing cloud computing. Cloud resources can be flexibly scaled so that they only cost money when they are actually used (Accenture 2014). Production processes benefit from faster and more cost-efficient transportation of film material through automated data transferring. In post-production, all of the latest content is readily available for editing, no matter the location (Telekom 2018). Movies can therefore be made more readily available for consumers that continue to expect more content in less time (Telekom 2018). Creators can build closer relationships with consumers through digitalization. In doing so, decision-makers can learn about their customers' preferences and thus tailor their products to specific needs (Acker et al. 2015).

The findings of this study are easily transferable to other industries. One of the first creative industries that was impacted by digitalization was the music business (Benner and Waldfogel 2016; Jain 2020; Moreau 2013; Urbinati et al. 2019). Disruptive distribution initiatives, such as streaming, challenged the traditional value chain and moved the power to new IT players (Benghozi and Salvador 2016). The situation is comparable to traditional car manufacturers, which are currently challenged not only by extant competitors but new entrants, such as Tesla or Google, which have no competences in car making but in software and electronics. Such new entrants might be able to promote major institutional changes in the industry (Tiberius et al. 2020a).

7. Conclusions

This research explores the possible future of the international film industry. Ten technological forecasts were developed for the digitalization of the industry. These were evaluated in two survey rounds by an international group of experts consisting of employees from a wide range of areas in the film industry to support an extensive literature review. The number of films produced with a smartphone are expected to increase significantly. Complex movie sets are forecasted to be digitally created for actors to perform in them live and without further post-production. Avatar actors are expected to become famous celebrities. According to the expert panel, there will be significantly more VR-movies produced, and the number of interactive films in which the viewer can co-determine the plot (e.g., Black Mirror Bandersnatch) will increase. Implications for the industry possibly include greater market power allocated to IT companies and the threat of new entrants due to digital technologies, which make movie production both simpler and more complex. We discussed the major technologies impacting the motion picture value chain in the upcoming 10 to 15 years. The production stage might see major changes. In many sectors, technological advancements, especially digitalization, force traditional skills of industry professionals to adapt to deal with the on-going virtualization of jobs (Azevedo

and Almeida 2021; Betzler and Leuschen 2020; Colombari and Neirotti 2021; García-Pérez et al. 2021; Kornelakis and Petrakaki 2020). This trend towards digitalization challenges traditional players in the production stage, such as camera manufacturers, production designers, and actors as their relevance and survival are under threat.

On the one hand, the expected technological changes simplify the production process. For example, a smartphone is much easier to handle than a complex and heavy movie camera; an exploding building in a digital environment, compared to a real one, does not involve any dust, dirt, or risks, and can be repeated multiple times; a digital actor has no changing moods, cannot get sick, and does not demand a \$20 million USD wage.

On the other hand, the technologies also become more complex and require completely new capabilities. The emergence of digital filmsets has already shown that production design has started to move from art and handicraft to IT expertise. However, an advancement of VR and interactive movies could reshuffle the cards in the entire industry. Similarly, video game producers already have multiple competences future movie making might require. Even though the expert panel disagreed with the replacement of movies by video games, we argue that the further development of VR and interactive movies logically leads to an arrangement that is not far from some video game genres. With VR-based, interactive movies, the audience does not only get more intense sensations and the agency to make several decisions during the plot but also become quasi-actors. As a consequence, the clear separation between the production and consumption stages might be challenged. Truly interactive movies are not only consumed by the audience. Rather, they become prosumers and the value of the movie experience is co-produced.

Producers should take advantage of the current digitalization in their industry to produce higher quality content more efficiently. By using cloud computing, virtual movie sets, and simplifying technologies like smartphone cameras and CGI, production processes can be accelerated and costs potentially lowered. Digitalization offers creators opportunities of removing intermediaries and therefore avoiding market and revenue imbalances between other players in the value chain (De Voldere et al. 2017). Concurrently, cyber security must be advanced to avoid risks of intellectual property theft and piracy.

Additionally, industry professionals should increase their focus on the consumers. Nowadays, audiences are offered an abundance of alternatives, so to stay competitive, their wants and needs should be considered carefully. By using diverse modes of production, like smartphones as cameras, a new way of audience engagement is introduced into storytelling (İşikman 2018). Adapting new technologies and services, for example interactive, VR, or 4D movies, creates more immersive consumption experiences.

Regarding the theatrical distribution and exhibition stages, movie theaters will probably not vanish but it is questionable if they will remain the primary outlet for movies in the future (Weinberg et al. 2020). Cinemas have always updated their technologies to attract movie goers by providing an experience exceeding the one at home (Weinberg et al. 2020). The technological lead, however, depicts only a temporary competitive advantage. In the past, with every technological novelty, such as advanced sound systems or 3D movies, home cinema devices have made them available soon after the introduction of these technologies in movie theaters. The more complex and costly upcoming technologies are, the higher the chance for cinemas to expand their lead. For example, the panel did not expect the arrival of affordable 4D home cinema sets.

Digital technologies should be adapted to distribute movies to consumers. Home distribution and Video-on-Demand are the new industry-standard, which means stakeholders have to change their business models (Bouncken et al. 2021; Filser et al. 2021; Kraus et al. 2020) to avoid being eliminated from the value chain. Distributors need to increase their marketing efforts, invest in applications to track the customer experience, and provide such insights to producers to jointly improve their revenues (Franklin et al. 2013).

Exhibitors will need to create an experience for their customers that starts as soon as they enter the movie theatre. Visualizing alternative content and entertaining consumers potentially gives an advantage over home channel distributors. Moreover, analyzing con-

sumer data and customizing their cinema-visit experience accordingly becomes imperative to be able to compete with streaming services.

Notwithstanding the emergence of technologically advanced movie types, Riepl's (1913) law suggests that new media formats will not completely replace older ones. Just as news on the internet has not replaced newspapers, the radio, or TV, more technologically advanced movies will not replace more traditional ones completely. It must not be forgotten that the rather passive role when watching a traditional movie will still represent exactly the customer needs of a large market segment. The implications for the actors within the motion picture value chain are summarized in Table 4.

Table 4. Summarized Implications for Value Chain Actors. Source: Own elaboration.

Value Chain Actors	Implications
Producers	Take advantage of different production modes Utilize cloud computing for accelerated processes Extend cyber-security systems
Distributors	Invest in Video-on-Demand services Create Joint Ventures with producers
Exhibitors	Analyze consumer data for customized experiences Increase screens with higher resolution capable of 3D/4D Create interactive alternative content for audiences

Future research should focus on what the individual players in the value chain gain or lose from digital film initiatives, and how they are impacted by disruptive technologies. This might assist companies in transitioning to digital and stay competitive with new players. Moreover, further studies on consumers and their psychological mindsets concerning new technologies might be helpful for decision-makers to update their business strategies.

Like every study, this work has various limitations. First, while elaborate guesswork and Delphi studies can promote future discussions of the evolution of the film industry, it cannot guarantee that all of its projections will come true. Second, the methodology of Delphi studies has been extensively criticized in previous literature. For instance, by presenting the first-round results to the respondents, they will not be able to make unbiased second judgements (Goodman 1987; Sackman 1975). However, it targets an increase in group consensus, and therefore might be acceptable. Third, there is a shortage in relevant research papers and studies to sufficiently support our findings, which is common for foresight studies. Fourth, a particular limitation of this study is the outbreak of the COVID-19 pandemic, which caused a high degree of uncertainty for many industries (Kraus et al. 2020). Fifth, the questionnaire unfortunately did not ask for the years of experience in the industry. While we selected the potential respondents based on a minimum industry experience of five years, we could not describe the distribution of the industry experience among the final panel members in greater detail.

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