

Forecasting 3DTV Mass Adoption in the United States: The Role of the *Avatar* Franchise and Economic Criteria

การคาดการณ์การยอมรับทีวีสามมิติในวงกว้างในสหรัฐอเมริกา: บทบาทของแฟรนไชส์อวตาร และเกณฑ์ทางเศรษฐกิจ

Marian Ehret^{1*}

¹Innovative Media Program, Bangkok University International, Bangkok University

*Corresponding author e-mail: marian.e@bu.ac.th

Received: 12/11/2025 Revised: 19/01/2026 Accepted: 02/02/2026

Abstract

No 3DTV mass adoption has begun in the United States in the 2020s, despite recurring forecasts predicting its emergence. This study aims to determine when and how 3DTV mass adoption may occur in the US, with particular emphasis on the role of the *Avatar* franchise and the economic criteria required to enable such adoption. A qualitative research design was employed, integrating a structured expert interview with a systematic review of academic literature, industry reports, and macroeconomic datasets. The analysis from a macroeconomic perspective was guided by an integrated theoretical framework combining Everett Rogers' diffusion of innovation model and Frank Bass' new product adoption forecast model. The findings indicate that *Avatar 5* (2031), the concluding installment of James Cameron's 3D cinema series, holds the greatest potential to trigger 3DTV mass adoption. Drawing on historical diffusion patterns observed in the adoption of HDTV, the study projects that 3DTV could achieve mass adoption among US consumers by 2042. Evidence from historical TV format replacement cycles supports this forecast. The results further suggest that 3DTV is likely to be adopted as a hybrid device, enabling both 2D and 3D content consumption, including applications related to Virtual Reality. Macroeconomic data help explain why earlier television formats—black and white TV, color TV, HDTV—were successfully adopted from the 1940s to the 2000s, while 3DTV failed to gain traction in the 2010s and early 2020s despite the influence of the first three *Avatar* films. Insights from the expert interview were used for methodological triangulation, reinforcing the validity of the study's findings by corroborating model-based forecasts with practitioner perspectives on consumer behavior and marketing dynamics.

Keywords: 3DTV, mass adoption, *Avatar*, Everett Rogers, Frank Bass

บทคัดย่อ

ยังไม่ปรากฏแนวโน้มการเปิดรับโทรทัศน์สามมิติ (3DTV) ในวงกว้างในสหรัฐอเมริกาในช่วงทศวรรษ 2020 แม้ว่าจะมีการคาดการณ์อย่างต่อเนื่องว่าการยอมรับดังกล่าวจะเกิดขึ้น งานวิจัยนี้มีวัตถุประสงค์เพื่อกำหนดว่าเมื่อใดและอย่างไรที่การยอมรับ 3DTV ในวงกว้างอาจเกิดขึ้นในสหรัฐอเมริกา โดยให้ความสำคัญเป็นพิเศษกับบทบาทของแฟรนไชส์ภาพยนตร์ Avatar และเกณฑ์ทางเศรษฐกิจที่จำเป็นต่อการเอื้อให้เกิดการยอมรับดังกล่าว งานวิจัยใช้ระเบียบวิธีวิจัยเชิงคุณภาพ โดยผสมผสานการสัมภาษณ์ผู้เชี่ยวชาญแบบมีโครงสร้าง เข้ากับการทบทวนวรรณกรรมทางวิชาการ รายงานอุตสาหกรรม และข้อมูลเศรษฐกิจมหภาคอย่างเป็นระบบ การวิเคราะห์ดำเนินการจากมุมมองเศรษฐกิจมหภาค ภายใต้กรอบแนวคิดเชิงบูรณาการที่รวมแบบจำลองการแพร่กระจายนวัตกรรมของเอเวอเรตต์ โรเจอร์ส และแบบจำลองการคาดการณ์การยอมรับผลิตภัณฑ์ใหม่ของแฟรงค์ แบลส์ ผลการศึกษาชี้ให้เห็นว่า Avatar 5 (2031) ซึ่งเป็นผลงานปิดท้ายของภาพยนตร์สามมิติชุดของเจมส์ คาเมรอน มีศักยภาพสูงสุดในการกระตุ้นการยอมรับ 3DTV ในวงกว้าง โดยอ้างอิงรูปแบบการแพร่กระจายในอดีตจากการยอมรับโทรทัศน์ความละเอียดสูง (HDTV) งานวิจัยคาดการณ์ว่า 3DTV อาจได้รับการยอมรับในวงกว้างในหมู่ผู้บริโภคชาวอเมริกันภายในปี 2042 ซึ่งได้รับการสนับสนุนจากวัฏจักรการทดแทนรูปแบบโทรทัศน์ในอดีต นอกจากนี้ ผลการวิจัยยังเสนอว่า 3DTV มีแนวโน้มถูกนำมาใช้ในฐานอุปกรณ์ระบบผสมผสาน (Hybrid) ที่รองรับทั้งเนื้อหา 2 มิติและ 3 มิติ รวมถึงการประยุกต์ใช้ที่เกี่ยวข้องกับเทคโนโลยีความเป็นจริงเสมือน ข้อมูลเศรษฐกิจมหภาคช่วยอธิบายทั้งความสำเร็จของรูปแบบโทรทัศน์ก่อนหน้านี้ ตั้งแต่โทรทัศน์ขาวดำจนถึง HDTV และความล้มเหลวของ 3DTV ในช่วงทศวรรษ 2010 ถึงต้นทศวรรษ 2020 แม้จะได้รับแรงหนุนจากภาพยนตร์ Avatar สามภาคแรก ข้อมูลจากการสัมภาษณ์ผู้เชี่ยวชาญถูกนำมาใช้เพื่อยืนยันข้อค้นพบและเสริมความน่าเชื่อถือของผลการวิจัย

คำสำคัญ: โทรทัศน์สามมิติ การยอมรับอย่างแพร่หลาย อวตาร เอเวอเรตต์ โรเจอร์ส แฟรงค์ แบลส์

1. Introduction

1.1 Background and significance of the problem

This qualitative media study explored the future mass adoption of 3DTV in the United States, to be triggered by James Cameron's Avatar media franchise. Such an adoption would be significant for representing the next major step in the evolution of TV formats in the world's largest consumer market. Beyond its relevance to market performance and technological diffusion, understanding 3DTV adoption is also important for media researchers, industry stakeholders, consumers, and policymakers, as it may influence media consumption practices, user experiences, digital inclusion, and regulatory decisions related to emerging audiovisual technologies.

Ehret (2020) and Pan et al. (2021) believed 3DTV would massively conquer American households from 2022 onwards, after the release of Avatar: The Way of Water (2022) (Cameron

et al., 2022), to achieve a market saturation of 50% by 2032. However, this mass adoption has not yet begun. More recently, Feurer et al. (2023) called 3DTV a failure, and Park et al. (2025) confirmed that this product's disappearance had been caused by its slow adoption rate. Optimistically, Kim & Lee (2023) emphasized that 3DTV mass adoption may instead occur with a delay, despite non-alignment with earlier predictions.

Not knowing when and how this adoption would exactly occur created, due to its economic importance in a marketing context, a research gap. At the same time, this uncertainty also affects consumers' expectations toward future media technologies, firms' long-term innovation strategies, and policymakers' ability to anticipate infrastructure and content regulation needs. Frank Bass' forecast model for the adoption of new products, in combination with Everett Rogers' diffusion of innovation theory, was applied to address the research gap. The failed 3DTV mass adoption necessitates a more thorough investigation into its future development and remaining potential significance.

Conceptually, the study links the problem of delayed 3DTV adoption with clearly defined research objectives through an integrated theoretical framework. Rogers' diffusion of innovation theory is used to identify when adoption reaches a societal majority, while Bass' forecast model explains the temporal dynamics of product diffusion. These theories are embedded within a macroeconomic perspective to assess how broader economic conditions interact with media innovation, franchise-driven demand, and consumer adoption behavior. This framework provides a coherent structure connecting the research problem, objectives, hypotheses, and analytical approach.

1.2 Research questions and objectives

The investigation of the above research gap was anchored by two research questions and related research objectives.

RQ 1: When and how will 3DTV mass adoption occur in the United States and in relation to the Avatar franchise?

RO 1: To determine the timeframes by when 3DTV mass adoption in the United States will likely occur, and how the Avatar franchise will impact this process. To specify the nature of how 3DTV will be used by consumers.

RQ 2: Which economic criteria must be met to enable a successful 3DTV mass adoption in the United States?

RO 2: Macroeconomic conditions in the United States must be stable enough to allow a slight majority of American households to purchase the new 3DTV set. To assess the

economic criteria and macroeconomic conditions that must be met to enable a successful 3DTV mass adoption in the United States, given the historical precedent of TV format replacement cycles. The findings are intended to inform academic debates, strategic decision-making in the media and electronics industries, consumer-oriented technology design, and evidence-based policy discussions on emerging media infrastructures.

Both research questions and research objectives served the study's purpose of better understanding the timeframes and conditions of 3DTV mass adoption in the United States.

1.3 Research hypotheses

Two working research hypotheses were developed, which align with the aforementioned research questions and objectives.

RH 1: Since the commercially successful 3D movie *Avatar* (2009) (Cameron et al., 2009) had triggered the unsuccessful 3DTV market introduction of 2010, another work in the 3D franchise, specifically *Avatar 5* (2031), is expected to trigger a successful future 3DTV mass adoption in the US. As *Avatar 5*, the last anticipated work of the franchise, was scheduled for release in December 2031, the mass adoption to reach a majority of American households could not take place earlier than in the 2040s. This hypothesis anticipates an adoption following the roll-out of earlier TV models in the US.

RH 2: Previously successful mass adoptions of dominant TV models in the US, from 1947 until 2008, occurred under economically more stable conditions than during the period from 2020 to 2025. As of 2025, macroeconomic conditions in the US do not facilitate 3DTV mass adoption. However, if these conditions were to become more stable, they will likely support such an adoption process within the specified timeframes.

The two research hypotheses require an examination of the timeframes and macroeconomic conditions in the context of 3DTV mass adoption in the US to answer the research questions.

2. Literature Review

2.1 Related Theoretical Concepts

The theoretical concepts applicable to the study context were Everett Rogers' diffusion of innovation model and Frank Bass' forecast model of new product adoption—which are referenced in **Table 1** at the end of section 2.

Rogers (2003) model was useful to determine when mass adoption had successfully occurred. Within the five groups of adopters—innovators, early adopters, early majority, late majority, and laggards—the transition from early to late majority was significant. It marked the

point when 50% of a society had adopted a new product, turning the process into a majority's mass adoption (Rogers, 2003). Clegg (2022) confirmed that this model's characteristic S-curve pattern of adoption could explain how product demand suddenly increased. Specifically, Kim & Jung (2023) used the model to examine the use of communication channels that informed on the decision-making for plant-based meat substitutes. Ehret (2020) asserted that Rogers' model would describe a potential 3DTV mass adoption in the US from 2022 onward, triggered by the movie *Avatar: The Way of Water* (2022)—given that technological product sophistication, consumer health effects, 3DTV content variety, suitable marketing strategy, and acceptable product price would support this process. However, as of 2025, this predicted 3DTV mass adoption has not begun yet. Since the combined groups of innovators, early adopters, and early majority—which are necessary to reach the critical 50% benchmark—are primarily driven by economic concerns, this research gap requires the examination of Rogers' model within the study context through an integrated macroeconomic perspective. Sharpening the use of this model by relating it to a macroeconomic angle could confirm its aforementioned broad applicability.

Bass (2004) model was perceived as the most sophisticated forecast model, due to accounting for both internal and external factors affecting a prospect's buying behavior. Kim & Jung (2023) cited mass media channels as an example of the Bass model's external influence, motivating consumers to mass adopt plant-based meat alternatives. Parvin & Beruvides (2021) established that this model could be used in studies using smaller or larger sample sizes of consumers, whose adoption behavior would describe an S-curve. Rogers (2003) confirmed that the Bass model was useful to determine the period needed for the roll-out of a product. Ehret (2020) applied Bass' model by comparing the time for Americans mass adopt black and white TV, color TV, and HDTV to a hypothetical 3DTV mass adoption in the US, wrongly concluding that if it began in 2022, it would reach half of American households already by 2032. This assumption was too optimistic, as no 3DTV mass adoption was kicked off following the release of *Avatar: The Way of Water* (2022). Consequently, as Kim & Lee (2023) had asserted, 3DTV roll-out in the United States could still occur starting from a later date. Identifying this future year of the initial mass adoption was necessary to address the research gap. Due to its sophistication, versatility, and usefulness in understanding temporal diffusion patterns, Bass' model, combined with Rogers' model, remains applicable in the study context.

2.2 Related Research

Reviewing literature on related research focused on works considering technological aspects of 3DTV, pessimistic forecasts on 3DTV mass adoption, optimistic predictions in the

same context—for the periods until and after 2022. Significant literature is listed in **Table 1** at the end of section 2. The review revealed a scarcity of literature referring to the Avatar franchise concerning 3DTV.

There was literature examining technical traits of 3DTV, including those that could either inhibit or support adoption. Alvi et al. (2021) explained that the basic stereoscopic depth effect of 3DTV was created by projecting the same scene simultaneously from two slightly divergent camera angles. Raza (2023) identified this stereoscopic effect as an important factor in making sports content more attractive to watch on a 3DTV set. However, Yu et al. (2021) criticized that 3DTV could more easily cause visual fatigue than 2DTV, due to overstimulating the brain. Lin et al. (2023) added that technically unappealing 3D visuals could disappoint prospective buyers, but that this effect could be mitigated by placing the TV set 210 cm away from the viewer. Carvalho et al. (2024) found that the use of Point Clouds (PCs), a collection of data points in a three-dimensional space, could enhance the color and visual quality of the 3D experience. Matloob et al. (2021) believed that de-noising 2D images to suppress the occlusion effect could support the creation of more viewer-acceptable 3D images. To support 3DTV mass adoption in the US, it was decisive to solve all the above inhibiting technical issues preventing it from happening.

Considering 3DTV mass adoption, a minority of the literature was pessimistic. Noam (2021) reported on the 2017 market withdrawal of LG and Sony, the last two significant producers of 3DTV sets. Blake (2023) was even more critical, asserting that the 3DTV failure in the 2010s was foreseeable as early as 2012, making his research relevant to the study context. His position implicitly confirms the assumption that it is already possible by 2025 to comprehend Ehret (2020) forecast error of an American 3DTV mass adoption by 2032. Ezratty (2022) confirmed that as of 2022, the 3DTV market had almost died—due to overestimating its market potential, exposing viewers to physical stress, high costs for content production and 3DTV sets. Worse, Feurer et al. (2023) concluded that this product had failed, and Schell (2025) added that this outcome was due to the low popularity of 3D images. Schell's statement is not accurate, as will be explained. However, it correctly confirms that no 3DTV mass adoption seems to have begun as of 2025. While the above literature confirmed or explained a continued failure of 3DTV rollout in the 2010s and the 2020s, it was juxtaposed with a majority of literature, which emphasized the potential of this innovative product to eventually find a mass audience.

A significant amount of literature expressed belief in the 3DTV market potential already in the unsuccessful period from the 2010s until 2022. Gunaratna (2021) attributed the start of the later failing 3DTV roll-out in the 2010s to Cameron's successful Avatar (2009), and its first-time

use of digital stereoscopic 3D cinema effects. The Korean *chaebol* Samsung believed wrongly in 3DTV mass adoption in the US of the 2010s to such an extent that they used “3D TV” as a label between 2011 and 2015 (Imai, 2021). Zhang et al. (2022) made Samsung’s fixation on this product better understood by citing DisplaySearch’s unrealistic conviction that by 2018, 196 million 3DTV sets would be shipped from China. This number would have represented the majority of all TV sets delivered from China at that time. Since the U.S. was China’s most important export market back then, it is safe to assume that DisplaySearch’s false forecast implied an adoption of 3DTV sets by most American households already by 2018. In a similar vein, Pan et al. (2021) believed, still in the early 2020s, wrongly like Ehret (2020), that 3DTV was transforming into one of the market’s major TV consumer products. Their projection was supported by the prospect of using RGB-D images to achieve an automatic 2D to 3D image conversion (Pan et al., 2021). This way, more 3DTV content could theoretically be created. Similarly, Chang et al. (2021) perceived sports content as a potential facilitator of 3DTV success. Although most of these predictions on the early success of 3DTV were evidently wrong, they proved that media experts realized the sales potential of this media product at an early time.

The trend of an optimistic academic perception of 3DTV mass adoption continued after the cinema release of *Avatar: The Way of Water* (Cameron et al., 2022). Yozgat et al. (2024) emphasized that 3D technology adoption was a continuing trend that had already lasted ten years. While this trend did not represent 3DTV development, it could function in a supportive manner in the future. Kim & Lee (2023) backed up the central study argument by stressing that 3DTV mass adoption could still occur, although later than initially forecasted. Simonetti et al. (2024) provided support for this perception by assessing that 62% of TV viewers expressed a clear preference for wanting to watch all or most of their TV content in 3D instead of 2D. This data justifiably refuted Schell’s (2025) perception of consumer disinterest in 3D content. An essential factor that could facilitate 3DTV adoption would be Internet at the speed level of 4G or faster (Mahajan et al., 2023; Prathigadapa et al., 2024). Tadinada et al. (2022) specified that the roll-out of Virtual Reality (VR) applications could be enabled by using 3DTV as a carrier device. Moreover, Rao et al. (2024) added that next to VR technology, Augmented Reality (AR) systems could also help 3DTV to be adopted on a broader scale. The significance of AR and VR applications for 3DTV mass adoption can hardly be underestimated. Unlike SDTV, 3DTV could, due to its unique spatial depth presentation, function as a facilitator of both systems and their experiences. The AR, and the visually more demanding VR, market segments could allow 3DTV to cater to its niche. More recent academic perceptions of 3DTV mass adoption disproved not

only pessimistic assumptions about the future of 3DTV, but also identified clear solution paths allowing 3DTV to achieve long-term popularity with a mass audience.

Table 1:

Synthesized Overview of Literature on 3DTV Adoption

Author(s) & Year	Focus / Context	Key Concepts & Variables	Main Findings	Relevance to Current Study
Rogers (2003)	Diffusion of innovations	Adopter categories; S-curve; critical mass (50%)	Mass adoption occurs at transition from early to late majority	Used to define when 3DTV reaches mass adoption
Bass (2004)	New product adoption forecasting	Internal/external influences; temporal diffusion	Adoption follows predictable diffusion patterns	Applied to forecast timing of 3DTV adoption
Ehret (2020)	3DTV adoption forecast (US)	Rogers–Bass models; Avatar (2009, 2022)	Predicted 3DTV mass adoption by 2032	Serves as a failed forecast to be reassessed
Pan et al. (2021)	Technological optimism	2D–3D conversion; content availability	Expected 3DTV to become a major TV format	Illustrates overly optimistic projections
Kim & Lee (2023)	Delayed adoption perspective	Timing misalignment; innovation persistence	3DTV adoption may still occur later	Supports core premise of delayed adoption
Feurer et al. (2023)	Market assessment	Adoption rate; market failure	Declared 3DTV a failed product	Represents pessimistic literature strand
Park et al. (2025)	Consumer adoption trends	Slow diffusion; product disappearance	Confirms lack of mass adoption	Validates research gap
Alvi et al. (2021)	Technical foundations	Stereoscopic depth	Explains core 3DTV visual mechanism	Provides technical context
Yu et al. (2021)	User experience	Visual fatigue; cognitive load	3DTV can cause viewer discomfort	Explains adoption barriers
Lin et al. (2023)	Viewing conditions	Distance optimization	Proper setup mitigates discomfort	Indicates solvable technical barriers
Carvalho et al. (2024)	Image quality	Point Clouds; visual enhancement	PCs improve 3D visual quality	Shows technological improvement potential

Author(s) & Year	Focus / Context	Key Concepts & Variables	Main Findings	Relevance to Current Study
Noam (2021)	Industry behavior	Market withdrawal	LG and Sony exited 3DTV market	Evidence of commercial failure
Blake (2023)	Retrospective critique	Forecast error	3DTV failure foreseeable early	Supports reassessment of forecasts
Simonetti et al. (2024)	Consumer preference	3D content demand	62% prefer 3D over 2D	Counters claims of user disinterest
Mahajan et al. (2023); Prathigadapa et al. (2024)	Infrastructure	Internet speed ($\geq 4G$)	High-speed internet supports adoption	Links infrastructure to adoption feasibility
Tadinada et al. (2022); Rao et al. (2024)	Emerging applications	VR; AR	3DTV can enable immersive technologies	Positions 3DTV as hybrid device
Carey & Elton (2010)	TV history	Replacement cycles	TV formats replace predecessors in 8–36 years	Benchmark for forecasting 3DTV timeline

Note. The studies are organized thematically to reflect their conceptual relevance to the research framework rather than alphabetically or chronologically. The synthesis integrates diffusion theory, forecasting models, technological constraints, consumer behavior, and historical benchmarks to contextualize the delayed mass adoption of 3DTV in the United States.

3. Research Methodology

3.1 Data sources used in the study

The study utilized existing literature and information resulting from an interview situation as data sources. First, the literature used comprised academic books, journal articles, news documents from reputable sources, and statistical datasets of potential relevance to the mass adoption of 3DTV or related media formats. Second, the adequacy of both methodology and findings had been discussed with an expert on marketing and consumer behavior to achieve a higher degree of validation. Therefore, a structured interview was conducted on November 4, 2021, with this expert, living in Chonburi province, Thailand. The interviewee was selected through purposive sampling, as his professional background in marketing and consumer behavior was directly relevant to the study's focus on technology adoption and consumer decision-making. At the time of the interview, the interviewee was 31 years of age, holding a

leading position in a Thai marketing company. Furthermore, the subject was male and held an MBA degree in Business Management.

An interview introduction provided by the researcher was necessary, as the topic was very specific. This introduction was used to give the subject essential information on the technical and non-technical background of 3DTV development trends, the marketing models used, and the applied consumer behavioral patterns. Within the main part of the interview, the expert discussed interview questions in three overall sections about his personal knowledge of 3DTV, the applied research methodology within the study, and the research results. His responses generated primary data, complementing the secondary data, which was obtained from existing literature. The use of both primary and secondary data sources enabled data triangulation, supporting the credibility of the findings.

3.2 Research tools used

The following research tools were used in the process of both secondary and primary data collection. Within the process of secondary data collection, Google Scholar served as a tool to identify literature of significance in the study context. Mendeley was used to organize academic books, journal articles, and news sources of relevance. Microsoft OneNote was an additional tool used by the researcher to take notes, aiding in identifying themes and patterns in the retrieved data. During primary data collection, a handwritten journal was used to take notes based on observation and interview responses. The interview questions aligned with the research questions and the theoretical framework of the study, ensuring content validity by matching the instrument with the study objectives and key theoretical concepts. The handwritten notes were subsequently analyzed to identify overarching themes and patterns, which informed the overall narrative. The structured format of the interview supported reliability by ensuring consistency in questioning across the interview process.

3.3 Data analysis employed

Data analysis comprised secondary and primary data analysis. Secondary data analysis was conducted in the form of a desk review. This framework combined Everett Rogers' diffusion of innovation model and Frank Bass' forecast model with a macroeconomic lens to determine the relationship between successful standard TV model adoption and economic stability in the United States. The results were, in a comparativist approach, used to understand why no 3DTV mass adoption had been triggered since 2022 by *Avatar: The Way of Water* (2022). This approach enabled the next step of the analysis—identifying the *Avatar* movie in the pentalogy-centered franchise, which would likely be able to kickstart the future

3DTV mass roll-out in the US. The data retrieved from the expert interview was, in the form of data triangulation, used to validate the study findings and the usefulness of the methodologically applied research models. This triangulation process strengthened credibility by comparing model-based results with practitioner insights. Considering the failed 3DTV adoption forecast of Ehret (2020), this combined use of secondary and primary data analysis aimed at achieving a higher degree of verisimilitude.

3.4 Other relevant aspects

Other relevant study aspects included the date of the primary data collection and ethical considerations. First, the primary data, collected in November 2021, remains highly relevant as the core marketing models discussed have been utilized in the current study context and the data has not been previously published. Second, the study participant was not subject to any situations raising ethical concerns. He was fully aware of his role in the study. Educational background, gender, and age were all factors that benefited an understanding of the research topic. Moreover, the interviewee specialized in digital marketing and possessed an affinity towards technology. The expert demonstrated a fast and sufficient understanding of both the topic and the interview questions. Additionally, no sensitive questions or topics were asked or discussed. Hence, neither the time of data collection nor ethical aspects concerning the interaction with human study participants were an issue in the research context.

4. Research Results

The application of an integrated theoretical lens, composed of Rogers' and Bass' models, generated two kinds of findings. Macroeconomic data on the U.S. economy helped to explain the successful mass adoption of older standard TV formats from 1946 until 2008, while it also aided in understanding why no 3DTV mass adoption was triggered in 2022. These key findings are included in **Table 2** at the end of section 4. This above approach and the first set of findings allowed for the comprehension of which movie in the Avatar franchise is likely to initiate the temporal diffusion pattern of a future, large-scale 3DTV roll-out in the US.

4.1 Macroeconomic Validation: 20th Century TV Adoption

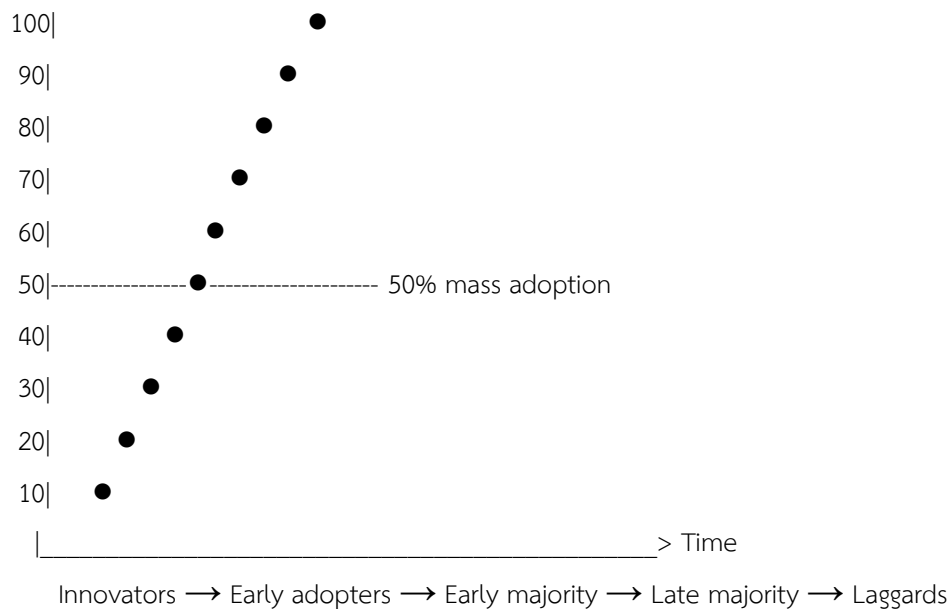
Data on the development of the American economy aligned with the 20th-century mass adoption patterns of the first two standard TV formats, black and white TV and color TV, in the United States. The beginning of black and white TV roll-out in 1946 (Carey & Elton, 2010) happened in a time of strong consumer demand, which was supported by US government policies (Kołodko, 2021). The start of the boom years during the Korean War from 1950 to 1953

(Gagnon & Rose, 2025) aligned with Rogers (2003) increased adoption rate, following Bass (2004) characteristic S-curve pattern. By 1954, a market saturation of 50% had been reached (Carey & Elton, 2010), completing mass adoption in Bass' sense (as depicted in **Figure 1**). The start of color TV mass adoption in 1954 (Ehret, 2020) aligned with US economic expansion and industrial growth after the Korean War (Gagnon & Rose, 2025). Rogers' (2003) sharp increase in adoption occurred since 1965 (Carey & Elton, 2010) during the "golden" economic boom years of the 1960s—a period marked by high growth of the gross domestic product (GDP) and rising wages (Blinder, 2022). According to Bass (2004), the strong surge in sold color TV sets reached its peak by 1968 (Ehret, 2020), which coincided with the end of the boom period by the late 1960s (Blinder, 2022). Rogers' transition from early to late majority, indicating successful mass adoption, was reached by 1972 (Carey & Elton, 2010), shortly before the oil crisis of 1973 hit hard (Blinder, 2022). The mass adoption analysis of black and white TV and color TV through a Rogerian-Bassian lens was consistently strengthened by integrating macroeconomic data from the US.

Figure 1:

Bass Diffusion Model of New Product Adoption

Cumulative adoption (% of population)



Note. This figure illustrates the Bass diffusion model, depicting the characteristic S-shaped (S-curve) cumulative adoption pattern of a new product over time. Early adoption is driven primarily by innovation effects, while later acceleration reflects imitation effects. The horizontal reference line marks the 50% adoption threshold, commonly used to indicate the transition from early adopters to late majority and the onset of mass adoption. The figure is an original conceptual redraw created for explanatory purposes and is based on the theoretical principles of the Bass model as discussed in Bass (2004).

Macro data from the American economy also aided in better understanding why, according to Bass (2004) model, the mass adoption of black and white TV lasted only eight years, while the roll-out of color TV took 18 years, more than twice as long. Black and white TV's conquest of American households occurred in a time of fewer inhibiting economic events—which were mainly concentrated in the 1940s, before the significant sales increase in Rogers (2003) sense—lasting overall only a few years (Carey & Elton, 2010; Gagnon & Rose, 2025; Kołodko, 2021). Comparatively, color TV's entrance into US homes happened in a period of more hindering economic events—especially in the 1950s, before Rogers' strong sales surge, and in the 1970s, after its end—lasting overall more years (Blinder, 2022; Ehret, 2020; Gagnon & Rose, 2025). Macroeconomic data was successfully used not only to explain similarities between TV mass adoption processes, but also their differences—precipitating the data's usefulness in examining why no American 3DTV roll-out in the early 2020s succeeded.

4.2 Economic Constraints and the Failed 3DTV Rollouts (2010–2025)

Additionally, US economic data proved applicable to examine 21st-century phenomena, such as the successful mass adoption of HDTV from 1998 to 2008, and the failed roll-out of 3DTV from 2010 onwards (Ehret, 2020). The beginning of HDTV adoption was marked by the strong economic growth of the dot-com boom years from 1998 until 2000 (Delossantos, 2023). The sharp increase in purchases (Carey & Elton, 2010), as explained by Rogers' (2003) description of an S-curve pattern, aligned with economic growth and a booming housing market from 2004 until early 2007 (Bivens, 2008). The completion of Bass' (2004) temporal diffusion pattern, by reaching a US market majority in early 2008 (Ehret, 2020), was achieved just before the economic crash of late 2008 hit America (Blinder, 2022). The decade-long roll-out of HDTV was reminiscent of the 8 years it took black and white TV to conquer American homes (Carey & Elton, 2010). Similarly, both adoption periods witnessed only a few economically hindering events—which occurred for HDTV in the 2000s. However, due to the increased financial complexities of the American 21st-century economy, a lot of structural problems already existed below the surface during the growth years of the mid-2000s (Bivens, 2008). To finally overcome the heavy impact of the 2008 stock market crash, the US economy required five to eight years (Blinder, 2022). Hence, it came as no surprise that the 3DTV market introduction from 2010 to 2013, following the cinema release of *Avatar* (2009), had to fail in this economically critical period (Blake, 2023). Macroeconomic data from the American market also proved useful in the context of successful HDTV, and failed early 3DTV, mass introduction to examine similarities and differences in TV adoption processes.

In a similar vein, macroeconomic data continued to aid in explaining the failure of *Avatar: The Way of Water* (2022) in triggering successful 3DTV mass adoption in the US during the 2020s. The time from 2022 to 2025 was marked by significant economic challenges. Two major factors were the aftermath of the Covid crisis of 2020, and the impact of the Ukraine War (since 2022), which led to high inflation, supply chain disruptions, and higher energy prices in the US (Austin, 2021; Wagner, 2024). The Iran-Israel War of 2025 only prolonged and worsened these economic strains on the American economy (Randewich, 2025). While the ultimately futile impact of *Avatar* (2009) on 3DTV popularity was at least to some extent measurable in the three following years from 2010 to 2013 (Blake, 2023)—even perceived as peak years of 3DTV—no such impact was noticeable in the years from 2023 to 2025 (Park et al., 2025; Schell, 2025), succeeding the cinema release of *Avatar: The Way of Water* (2022). Only up to 5% of all US households owned a 3DTV set by 2022 (Elagina, 2025). And while market researchers expected a growth of the 3DTV market of 5.28% annually from 2025 until 2034 (Dhapte, 2025), a growth at this speed would mark the 2060s as the decade when Bass (2004) temporal diffusion pattern would reach the critical benchmark of 50%. A hypothetical adoption requiring more than four decades was unprecedented and therefore made no sense, as the longest recorded roll-out of a new standard TV model took only 18 years in the case of color TV (Carey & Elton, 2010). Hence, macroeconomic and statistical data from the American market proved that *Avatar: The Way of Water* (2022) cannot have triggered a successful 3DTV mass adoption.

4.3 Temporal Forecast and the Avatar Franchise Trigger (2029–2042)

Despite the failure of *Avatar: The Way of Water* (2022) in bringing 3DTV sets on a massive scale to American homes, James Cameron's *Avatar* franchise remained, due to its original impact on enabling 3DTV, the biggest potential trigger for initiating such a future adoption (Ehret, 2020). The first three movies of the franchise were known for bringing technically revolutionary 3D images and effects to the cinema viewer (Lapreziosa, 2022; Nayman, 2022). Beyond that, both *Avatar* (2009) and *Avatar: The Way of Water* (2022) proved to possess tremendous mass impact for being the highest and third-highest grossing movies of all time, respectively (Box Office Mojo, 2025). However, the third installment of the series, *Avatar: Fire and Ash* (2025) (Cameron et al., 2025), will very likely also not trigger a 3DTV mass adoption. First, macroeconomic data does not necessarily predict an adoption-supportive economic improvement as of 2025, or for the remaining years of the second Trump administration (2025–2029)—citing uncertainty, unsustainable fiscal trajectories, and rising levels of budget deficit and national debt (Tran, 2025). Second, the technical 3D effects impact level of *Avatar: Fire & Ash* (2025) was expected to be

below that of its predecessor (Lapreziosa, 2022). Therefore, if the second part of the franchise could not kick off the expected roll-out, the third installment would be even less likely to achieve that. Conclusively, the study determines that the biggest potential for achieving 3DTV mass adoption in the US rests with the remaining movies, Avatar 4 or Avatar 5.

To forecast whether Avatar 4 (2029) or Avatar 5 (2031) will trigger 3DTV mass adoption in the United States, two criteria—in addition to the uncertain macroeconomic outlook—were analyzed. Avatar 5 (2031) would be the ultimate send-off of a 3D franchise that would by then have lasted for at least 22 years. It could reasonably be expected that the 3D technical and commercial impact of the last Avatar movie would exceed that of its predecessor. The time gap between the release dates of the penultimate and the final works of the franchise was only two years, expected to be the briefest of all gaps between films of this 3D series (Goslin, 2023). Therefore, Avatar 5 (2031) could benefit from the cumulative effect of both movies being scheduled that close after each other. In essence, Avatar 5 (2031) appeared to be more likely to spark a substantial 3DTV roll-out in the US.

Would the temporal diffusion pattern of Avatar 5 (2031) follow the trajectory of black and white TV, color TV, or HDTV? The previous standard TV formats needed respectively eight, 18, and ten years to be mass adopted by Americans (Ehret, 2020). As 3DTV shared, in technical terms, most similarities with HDTV, it could likewise be rolled out in a decade before achieving the critical transition from Rogers' (2003) early to late majority. This process would probably begin in 2032, after the movie's release in December 2031, and complete Bass' diffusion process by 2042. The S-curve peak of Bass' (2004) model could be reached around 2039—marking three-quarters of the time from 3DTV's market return until an adoption rate of 50%. After 2039, the adoption rate would still increase, although at a slower rate (Carey & Elton, 2010). A notable contingency is that release dates of Avatar movies have been repeatedly postponed (Goslin, 2023); should this occur again, the re-introduction of 3DTV would be delayed. In the less likely, but still possible, event that Avatar 4 (2029) could initiate the 3DTV mass roll-out, the kick-off date could also be brought forward by two years. In either case, it would be very unlikely that 3DTV would not substantially enter American homes. Historical records prove that an older standard TV format was replaced by its successor not earlier than 18 years—when color TV replaced black and white TV—and not later than 36 years—when HDTV substituted color TV (Ehret, 2020). Since HDTV has been the standard model in the US since 2008, the next replacement cycle should be completed by 2044 at the latest. The above forecast of having Avatar 5 (2031) turning 3DTV into the dominant US TV format by 2042 aligns with this assessment.

A remaining question was: How will 3DTV be adopted? Carey and Elton (2010) believed that 3D effects on TV were, for most scenes, not really necessary unless objects were close to the viewer. Admittedly, not all content would necessarily be very appealing with added depth sensation. However, statistical data proved that the majority of TV viewers were very interested in 3DTV (Simonetti et al., 2024). While 3DTV sets would likely be mass adopted as the new TV standard format, they could function as hybrid devices. While they could still be used to watch 2D content, specific content—namely AR and VR applications—would mark the niche that would make an experience in 3D appealing (Rao et al., 2024; Tadinada et al., 2022). The case of the videophone highlighted a similar adoption path for a technical device whose visual sensations were not always attractive. While videophones existed in the US since the 1960s (Carey & Elton, 2010), they were only successfully mass adopted in the form of smartphones in the 2010s (Oberlo, n.d.). Each smartphone was a videophone—due to allowing audiovisual phone calls on applications such as WhatsApp—but for most of the usage time, the phone users were more interested in other applications on their device. 3DTV would very likely become a standard TV model, popularized by VR applications, while still offering non-3D options in 2D.

Table 2:

Summary of Key Research Findings on 3DTV Mass Adoption in the United States

Finding category	Key finding	Empirical and theoretical basis	Interpretation and implications
Historical TV adoption patterns	Successful mass adoption of previous TV formats occurred during periods of economic stability and growth	Alignment of Rogers' diffusion model and Bass' forecast model with macroeconomic data for black-and-white TV, color TV, and HDTV (1946–2008)	Macroeconomic conditions are a necessary prerequisite for large-scale TV format adoption
Early 3DTV rollout failure (2010s)	3DTV introduction following Avatar (2009) did not result in mass adoption	Post-2008 financial crisis and prolonged economic recovery inhibited consumer purchasing behavior	Strong media stimuli alone cannot overcome adverse economic environments
Impact of Avatar: The Way of Water (2022)	No measurable 3DTV mass adoption	High inflation, geopolitical conflicts, and post-Covid	Confirms the overriding influence of macroeconomic

Finding category	Key finding	Empirical and theoretical basis	Interpretation and implications
	occurred after the film's release	economic disruptions between 2022 and 2025	constraints on adoption processes
3DTV market penetration	3DTV ownership remained below 5% of U.S. households by 2022	Market penetration data compared with Rogers' 50% mass adoption benchmark	Indicates failure to transition from early adopters to late majority
Role of the Avatar franchise	The Avatar franchise remains the most plausible catalyst for future adoption	Historical association with technological innovation and exceptional box-office performance	Media franchises can function as adoption triggers under supportive conditions
Most likely adoption trigger	Avatar 5 (2031) identified as the strongest potential trigger	Expected cumulative franchise impact and short release interval following Avatar 4	Final installment likely maximizes cultural, technical, and commercial influence
Forecasted adoption timeframe	3DTV mass adoption projected between 2032 and 2042	Comparison with HDTV's decade-long diffusion pattern using Bass' temporal model	Positions 3DTV within established TV format replacement cycles

Note. All findings are derived from the results presented in Section 4 and are interpreted through the integrated application of Rogers' diffusion of innovation model and Bass' new product adoption forecast model, in conjunction with U.S. macroeconomic data.

5. Conclusion and Discussion

5.1 Summary of results

The study successfully determined the temporal and economic conditions for 3DTV mass adoption by applying an integrated framework based on Rogers' and Bass' diffusion models with a macroeconomic perspective. 3DTV will likely be mass adopted by American households in the period between 2032 and 2042. A temporal diffusion pattern lasting for a decade would align with the mass adoption of HDTV, the standard TV format sharing the most similarities with 3DTV. This 3DTV product roll-out will likely be triggered by the last work in James Cameron's 3D saga, Avatar 5 (2031). Being the concluding work of the franchise, Avatar 5 is likely to have a stronger commercial impact on 3DTV adoption than its predecessor. VR and AR applications could transform into a popular niche to motivate the use of 3DTV sets as hybrid devices with both 2D and 3D functions. Macroeconomic conditions would need to support this adoption

process in the US, as they did when black and white TV, color TV, and HDTV were successfully emerging as standard TV formats from the 1940s to the 1970s, and from the 1990s to the 2000s. While the macroeconomic conditions continue to hinder 3DTV mass adoption after the cinema releases of the first three Avatar movies in 2009, 2022, and 2025, they could support such an adoption either after the release of Avatar 4 (2029) or especially Avatar 5 (2031). The 3DTV mass adoption process would need to reach the majority of American households before 2044, as exceeding this timeframe would conflict with established theoretical frameworks and historical records of standard TV format replacement cycles.

5.2 Discussion of results

The discussion of results with the marketing expert led mostly to support of the study's findings. The study participant validated the theoretical framework, consisting of Rogers' and Bass' models, confirming its suitability for deriving the study results and thereby establishing a high degree of internal validity. Referring to Bass' temporal diffusion patterns, he assessed that the roll-out of 3DTV would very likely possess more similarity with that of the technically more similar HDTV than with the more distinct color TV—confirming the researcher's assumption. The expert supported the study premise that the Avatar franchise could trigger a 3DTV mass adoption in the US. According to him, this process could reach 50% of American households by around 2040. This evaluation from 2021 was remarkable for being made before the impact of Avatar: The Way of Water (2022) on consumer behavior was known. Furthermore, the expert's evaluation was only two years divergent from the researcher's forecast. Crucially, this timeframe remained within the critical period of 2044, by which the next standard TV format replacement cycle must be completed. The expert expressed his belief that adoption-hindering factors—such as the limited amount of 3D content, detrimental effects on consumer health, poor marketing strategies, and high product prices—could all be overcome to facilitate mass adoption. He also believed that technical hurdles could remain the strongest obstacle for the roll-out of 3DTV technology. However, considering the time factor of around one and a half decades until process completion, it was reasonable to expect that this limitation could eventually be solved. After all, even 3D effects pioneer James Cameron believed that 3DTV ownership could become a reality for the masses (Jimenez, 2022). The expert discussion confirmed, in almost all essential criteria, the methodology and results of the study.

5.3 Recommendations

Future research on 3DTV should address the limitations of this study. For logistical reasons, the study conducted expert discussions with only one specialist from a marketing background.

While the discussion results are, due to their alignment with the researcher's findings, still meaningful and useful in the study context, aiding in establishing validity, future studies could expand the discussions. Future discussions could quantitatively include a larger number of study participants than just one. On a qualitative level, the discussants should possess more diverse backgrounds, such as an academic degree in media studies—to complement knowledge from a marketing and consumer behavioral perspective. Additionally, the most important limitation of the study to be addressed was the study design. As the observation point was limited to the period until the mid-2020s, future studies should use a longitudinal study design. Ideally, the 3DTV mass adoption process should be analyzed until after reaching the majority of American households—probably within the 2040s. Given the emerging potential of this technology, future longitudinal studies analyzing the adoption process until the 2040s are paramount to fully capture the dynamics of this critical TV format replacement cycle.

Beyond academic implications, the findings offer practical guidance for policymakers and industry stakeholders. Media and technology firms should coordinate hardware development with immersive content strategies—particularly AR and VR applications—to position 3DTV as a hybrid platform rather than a niche display technology. Strategic timing of market re-entry should align with periods of macroeconomic stability and major franchise releases to maximize adoption momentum. From a policy perspective, investment incentives, innovation grants, or infrastructure support for high-speed internet and immersive media ecosystems could indirectly facilitate adoption by lowering entry barriers for consumers and producers alike. Such coordinated actions may increase the likelihood that future 3DTV roll-outs translate technological potential into sustained consumer adoption.

6. References

- Alvi, H. M. U. H., Farid, M. S., Khan, M. H., & Grzegorzec, M. (2021). Quality Assessment of 3D Synthesized Images Based on Textural and Structural Distortion Estimation. *Applied Sciences*, 11(6), 1-17. <https://doi.org/10.3390/app11062666>
- Austin, C. (2021, November 10). How the Supply Chain Caused Current Inflation, and Why it Might be here to Stay. *PBS News*. <https://www.pbs.org/newshour/economy/how-the-supply-chain-caused-current-inflation-and-why-it-might-be-here-to-stay>
- Bass, F. M. (2004). Comments on “A New Product Growth for Model Consumer Durables”: The Bass model. *Management Science*, 50(12), 1833-1840. <https://doi.org/10.1287/mnsc.1040.0300>

- Bivens, J. (2008). A Feeble Recovery: The Fundamental Economic Weaknesses of the 2001-07 Expansion. *Economic Policy Institute Briefing Paper*, 214(5), 1-9.
<https://www.epi.org/publication/bp214/>
- Blake, J. (2023). *Interaction and Participation: Investigating the Impact of Mobile Technologies on Screen-based Industries and Audiences (Doctoral dissertation)*. Edinburgh Napier University. <https://napier-repository.worktribe.com/output/3050952>
- Blinder, A. S. (2022). *A Monetary and Fiscal History of the United States, 1961-2021*. Princeton University Press.
- Box Office MOJO (n.d.). *Top lifetime grosses*. https://www.boxofficemojo.com/chart/ww_top_lifetime_gross/?area=XWW&ref_=bo_cso_ac
- Cameron, J., Landau, J. (Producers), & Cameron, J. (Director). (2009). *Avatar* [Film]. 20th Century Fox, Dune Entertainment, Ingenious Film Partners, & Lightstorm Entertainment.
- Cameron, J., Landau, J. (Producers), & Cameron, J. (Director). (2022). *Avatar: The Way of Water* [Film]. TSG Entertainment, & Lightstorm Entertainment.
- Cameron, J., Landau, J. (Producers), & Cameron, J. (Director). (2025). *Avatar: Fire and Ash* [Film]. 20th Century Studios, Lightstorm Entertainment, & TSG Entertainment.
- Carey, J. & Elton, M. C. (2010). *When Media Are New: Understanding the Dynamics of New Media Adoption and Use*. University of Michigan Press.
- Carvalho, A. H., Freitas, P. G., Gonçalves, M., Homonnai, J., & Farias, M. C. (2024). Perception-Driven Point Cloud Quality Assessment Through Projections and Deep Structure Similarity. *Proceedings of the 2024 IEEE 26th International Workshop on Multimedia Signal Processing (MMSP)*, 1-6. IEEE. <https://doi.org/10.1109/MMSP61759.2024.10743953>
- Chang, C. J., Hsu, B. C. Y., & Chen, M. Y. (2021). Viewing Sports Online During the COVID-19 Pandemic: The Antecedent Effects of Social Presence on the Technology Acceptance Model. *Sustainability*, 14(1), 1-12. <https://doi.org/10.3390/su14010341>
- Clegg, J. M. (2022). *Strategy and Innovation for a Changing World. Part 2: Sustainability Through Velocity*. Troubador Publishing.
- Delossantos, C. (2023). From hype to bust: Investigating the underlying factors of the dot-com bubble and developing regression models for future market predictions. *Open Journal of Business and Management*, 11(5), 2161-2174. <https://doi.org/10.4236/ojbm.2023.115119>
- Dhapte, A. (2025). 3D TV Market Research Report. *Market Research Future*.
<https://www.marketresearchfuture.com/reports/3d-tv-market-24717>

- Ehret, M. (2020). 3DTV Mass Adoption in the United States and the National Football League. *Journal Pengajian Media Malaysia*, 22(2), 1-16. <https://doi.org/10.22452/jpmm.vol22no2.1>
- Elagina, D. (2025, November 26). 3D TV Household Penetration in the U.S. 2022, by age. *Statista*. <https://www.statista.com/statistics/1313507/3d-tv-household-penetration-by-age-us>
- Ezratty, O. (2022). *Mitigating the Quantum Hype* (arXiv:2202.01925). arXiv. <https://arxiv.org/abs/2202.01925>
- Feurer, S., Hoeffler, S., Zhao, M., & Herzenstein, M. (2023). Really New Product Launch Strategies: Prescriptive Advice to Managers from Consumer Research Insights. In L. Bstieler & C. H. Noble (Eds.), *The PDMA Handbook of Innovation and New Product Development* (pp. 247-266). John Wiley & Sons.
- Gagnon, J., & Rose, A. (2025). Why did Inflation Rise and Fall so Rapidly? Lessons from the Korean War. *Peterson Institute for International Economics Working Paper*, 25(1). 1-16. <http://dx.doi.org/10.2139/ssrn.5131529>
- Goslin, A. (2023, June 13). *What we Know about Avatar 3, 4, and 5*. Polygon. <https://www.polygon.com/23511762/avatar-3-4-5-release-cast-plot-about>
- Gunaratna, V. (2021). *Virtual Reality* (Doctoral Dissertation). *Film and TV School of the Academy of Performing Arts in Prague*. <https://dspace.amu.cz/bitstreams/69bff1ab-5a1b-4d24-92b3-63234f1450ff/download>
- Imai, M. (2021). Creation of Market Categories Through Product Strategy: A Text-Mining Approach. *Journal of Asian Finance, Economics and Business*, 8(2), 439-451. <https://doi.org/10.13106/jafeb.2021.vol8.no2.0439>
- Jimenez, J. (2022, September 20). *James Cameron Says He Knows What Led to the Downfall of 3D TVs*. PC Gamer. <https://www.pcgamer.com/james-cameron-says-he-knows-what-led-to-the-downfall-of-3d-tvs/>
- Kim, S., & Jung, C. (2023). The Effect of Communication Channel Usage on Perceived Consumer Effectiveness and Purchase Intention for Vegetable Meat Alternative Foods by Food Neophobia Levels: Focusing on the Moderating Effects of Innovation Resistance. *Journal of Social Science*, 62(3), 305-339. <https://doi.org/10.22418/JSS.2023.12.62.3.305>
- Kim, S. B., & Lee, H.-Y. (2023). Investigating the Impact of Metaverse Characteristics on User Behavior Through the Combination of PLS-SEM and NCA Within the Extended Value-based Adoption Model. *경영학연구*, 52(5), 1159-1191. <https://doi.org/10.17287/kmr.2023.52.5.1159>
- Kołodko, G. W. (2021). *Shortageflation 3.0: War Economy–state Socialism–pandemic crisis*. *Acta Oeconomica*, 71(S1), 13-34. <https://doi.org/10.1556/032.2021.00027>

- Lapreziosa, M. (2022, December 22). *Avatar 3 has a very different CGI Problem to The Way Of Water*. Screenrant. <https://screenrant.com/avatar-3-cgi-visuals-problem-after-way-water>
- Lin, C. J., Widyaningrum, R., & Prasetyo, Y. T. (2023). The Effect of 3D TVs on Eye Movement and Motor Performance. *Applied Sciences*, 13(4), 1-19. <https://doi.org/10.3390/app13042656>
- Mahajan, N., Chauhan, A., Kumar, H., & Kaushal, S. (2023). 10 Telecommunication Interventions and Opportunities in Education, Health, and Agriculture. Post COVID-19 Scenario. In R. C. Sobti, V. Sobti & A. Sobti (Eds.), *Learning from the COVID-19 pandemic: Implications on education, environment, and lifestyle* (pp. 77-86). CRC Press.
- Matloob, F., Arshad, K., & Bashir, T. Generation of Depth Map for Future Free-View TV Using Isotropic and Anisotropic Complex Diffusion De-Noising Using Depth Image Base Rendering (DIBR) (2021). *International Journal of Advances in Engineering and Management*, 3(9), 1520-1534. <https://doi.org/10.35629/5252-030915201534>
- Nayman, A. (2022, December 13). *What James Cameron and 'Avatar' did (and didn't do) for 3D Filmmaking*. The Ringer. <https://www.theringer.com/2022/12/13/movies/james-cameron-avatar-3d-filmmaking-legacy>
- Noam, E. M. (2021). Into the Next Generation of Online Video: OTT Video 3.0. *The 49th Research Conference on Communication, Information and Internet Policy* 49(1). 1-37. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3898150
- Oberlo (n.d.). *How many Americans have Smartphones (2013-2024)*. Oberlo. <https://www.oberlo.com/statistics/how-many-americans-have-smartphones?>
- Pan, B., Zhang, L., Yin, H., Lan, J., & Cao, F. (2021). An Automatic 2D to 3D Video Conversion Approach Based on RGB-D Images. *Multimedia Tools and Applications*, 67(3), 19179-19201. <https://doi.org/10.1007/s11042-021-10662-0>
- Park, K., Koo, G. Y., Kim, M., & Kim, S. (2025). Consumer Adoption of Virtual Reality for Spectator Sport: An Adopter Categorization Based on the Diffusion of Innovation and Uses and Gratification Theories. *International Journal of Sports Marketing and Sponsorship*, 26(2), 343-370. <https://doi.org/10.1108/IJSMS-04-2023-0059>
- Parvin Jr, A. J., & Beruvides, M. G. (2021). Macro Patterns and Trends of US Consumer Technological Innovation Diffusion Rates. *Systems*, 9(1), 1-22. <https://doi.org/10.3390/systems9010016>

- Prathigadapa, S., Dasika, S. R. C. M., Kakulapati, V., & Saligrama, S. (2024). Network Security and Data Privacy in 6G Environment: Impacts and Challenges. *Journal of Emerging Technologies and Innovative Research*, 11(2), 452-461. https://www.researchgate.net/publication/378400610_Network_Security_and_Data_Privacy_in_6G_Environment_Impacts_and_Challenges
- Randewich, N. (2025, June 19). *Investors See Quick Stock Market Drop if US Joins Israel-Iran Conflict*. Reuters. <https://www.reuters.com/world/middle-east/investors-see-quick-stock-market-drop-if-us-joins-israel-iran-conflict-2025-06-18>
- Rao, L., Argaman, N., Zhuang, J., Ninan, A., Kim, C., Wang, D., & Shen, S. (2024). Display and Optics Architecture for Meta's AR/VR Development. *IEEE Open Journal on Immersive Displays*, 2024(1). 71-78. <https://doi.org/10.1109/OJID.2024.3370888>
- Raza, A. (2023). Adoption Behavior Towards Advance Broadcasting Technologies: A Critical Study of PTV Sports. *Journal of Media and Communication Studies*, 3(2), 1-15. <https://doi.org/10.5281/zenodo.8196719>
- Rogers, E. M. (2003). *Diffusion of Innovations* (3rd ed.). Simon and Schuster.
- Schell, J. (2025). The metaverse: What's Now, What's Next. In B. Beil, G. S. Freyermuth, I. Hamm, V. Ossa (Eds.). *Gaming the Metaverse* (pp. 201-220). Transcript Verlag.
- Simonetti, A., Dini, H., Bruni, L. E., & Bigne, E. (2024). Conscious and Non-Conscious Responses to Branded Narrative Advertising: Investigating Narrativity Level and Device Type. *BRQ Business Research Quarterly*, 11(2). 1-19. <https://doi.org/10.1177/23409444241248191>
- Tadinada, A., Gul, G., Godwin, L., Al Sakka, Y., Crain, G., Stanford, C. M., & Johnson, J. (2023). Utilizing an Organizational Development Framework as a Road Map for Creating a Technology-Driven Agile Curriculum in Predoctoral Dental Education. *Journal of Dental Education*, 87(3), 394-400. <https://doi.org/10.1002/jdd.13131>
- Tran, H. (2025, January 30). *US Economic Outlook 2025: It's the Productivity, Stupid!* Atlantic Council. <https://www.atlanticcouncil.org/blogs/econographics/us-economic-outlook-2025-its-the-productivity-stupid/>
- Wagner, G. (2024, February 23). *The Ukraine War Blew Up the World's Energy Economy*. Heatmap. <https://heatmap.news/economy/ukraine-war-global-energy>
- Yozgat, Z., Sahin, H. K., Dumlupinar, G. I., & Sabaner, M. C. (2024). Comparative Evaluation of 2D and 3D YouTube Videos as Supplementary Educational Resources for Vitreoretinal Surgery Training. *Medicine*, 103(50), Article e40852. <https://doi.org/10.1097/MD.00000000000040852>

- Yu, M., Li, Y., & Tian, F. (2021). Responses of Functional Brain Networks While Watching 2D and 3D Videos: An EEG Study. *Biomedical Signal Processing and Control*, 68, Article 102613. <https://doi.org/10.1016/j.bspc.2021.102613>
- Zhang, Y., Zhao, Y., Wu, Y., & Zhang, X. (2022). Digital Communication of Folk Art in Urban Scenes Based on Vision Sensor Images. *Mobile Information Systems*, 2022(1), Article 2800496. <https://doi.org/10.1155/2022/2800496>