



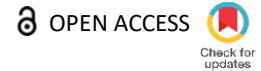
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From E-Commerce to Spatial Commerce: An Integrative Review of Consumer Experience

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ABSTRACT

Spatial Commerce represents the next stage in the evolution of digital commerce, integrating Extended Reality (XR), Artificial Intelligence (AI), spatial computing, digital twins, and related technologies to create immersive, intelligent, and interactive consumer experiences. Despite growing scholarly interest, research remains fragmented across marketing, information systems, and human-computer interaction, limiting a comprehensive understanding of its theoretical foundations and consumer implications. This review synthesizes multidisciplinary literature published primarily between 2019 and 2026, drawing on more than 130 Scopus-indexed studies. The review makes three primary contributions. First, it conceptualizes the evolution of commerce through a five-stage framework culminating in Spatial Commerce. Second, it integrates the technological foundations of Spatial Commerce into a unified ecosystem. Third, it proposes a Spatial Commerce Consumer Experience Framework, demonstrating how immersion, presence, embodiment, flow, and trust mediate the relationship between spatial technologies and consumer outcomes, including purchase intention, loyalty, and brand advocacy. The review also identifies key challenges related to interoperability, privacy, AI-driven personalization, and governance, while outlining future research priorities and managerial implications. Overall, the paper positions Spatial Commerce as a strategic transformation that requires trustworthy, human-centered, and interoperable digital ecosystems.

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INTRODUCTION

Digital commerce has evolved through a series of disruptive transitions, each redefining the spatial, sensorial, and relational architecture of consumer interaction. From early catalogue retailing through Web 1.0 storefronts to mobile and omnichannel platforms, commerce has progressively dissolved spatial constraints while simultaneously flattening sensory richness into the boundaries of a screen. The current frontier, Spatial Commerce, restores volumetric dimensionality to digital exchange, embedding consumers within shared, three-dimensional, AI-orchestrated environments that combine the immediacy of physical retail with the scalability of digital infrastructure (Chen et al., 2023; Jafar et al., 2025).

Conventional e-commerce, although transformative, exhibits well-documented experiential limitations: an inability to convey haptic, olfactory, or three-dimensional spatial cues; restricted social co-presence; and high product-uncertainty leading to elevated return rates, particularly in apparel and experiential categories (Chen et al., 2024; Liu et al., 2025). The accelerating diffusion of XR devices, large language models, generative AI, photorealistic real-time rendering, and 5G/edge-enabled spatial computing has catalyzed a structural shift from search-driven to experience-driven commerce (Jawale et al., 2024; Wang et al., 2025). In tandem, metaverse

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platforms have evolved from speculative discourse to commercially significant venues for branded experiences, virtual goods, and avatar-mediated consumption (Arya et al., 2024; Kaur et al., 2024; Spais et al., 2025).

Despite a rapidly expanding body of empirical and conceptual research, the literature remains conceptually fragmented. Studies frequently isolate single technologies (e.g., AR try-on, VR showrooms) without theorizing the systemic convergence that defines Spatial Commerce. Theoretical adaptations of S-O-R, TAM, UTAUT, Flow, and Presence have multiplied, yet integrative meta-frameworks remain scarce (Lu & Hsiao, 2022; Uhlendorf-Leo et al., 2026). Furthermore, contradictions persist regarding the role of hyper-realism, the appropriate dosage of multisensory stimuli, and the boundary conditions of AI personalization within immersive environments (Magalhães et al., 2024; Sun, Freeman, et al., 2025).

To address these gaps, this review pursues four objectives. First, it conceptualizes the historical evolution of commerce through a five-stage progression culminating in Spatial Commerce. Second, it integrates the technological ecosystem underpinning Spatial Commerce into a unified conceptual architecture. Third, it synthesizes the behavioral and theoretical literature to develop an integrative Spatial Commerce Consumer Experience Framework. Finally, it identifies key research gaps and future research priorities.

Accordingly, this review makes three primary contributions. First, it conceptualizes the evolution of digital commerce through a five-stage framework culminating in Spatial Commerce. Second, it integrates the fragmented technological foundations of Spatial Commerce into a unified ecosystem that explains how complementary technologies jointly create immersive commerce environments. Third, it proposes an integrative Spatial Commerce Consumer Experience Framework that serves as the paper's central theoretical contribution. Building on these contributions, the review synthesizes applications, identifies key challenges, and outlines future research directions for marketing, information systems, and human–computer interaction research.

EVOLUTION FROM E-COMMERCE TO SPATIAL COMMERCE

The evolution of commerce can be understood as a progression through five interrelated stages, each marked by shifts in spatial interaction, sensory richness, and consumer agency rather than by technological substitution alone. Traditional commerce relied on co-located, multisensory, and socially embedded exchanges. E-commerce removed geographical constraints by enabling screen-mediated transactions but simultaneously reduced consumer experience to primarily visual and textual information (Lazaris & Vrechopoulos, 2014). Mobile and omnichannel commerce extended accessibility through context-aware services and seamless integration across physical and digital touchpoints, yet interaction remained largely confined to two-dimensional interfaces (Artomova, 2025).

The emergence of immersive commerce, driven by augmented and virtual reality, partially restored experiential richness by enabling virtual product interaction, reducing product uncertainty, and improving purchase intentions across sectors such as fashion, beauty, and retail (Kim, 2023; Mollel & Chen, 2025; Shafa et al., 2025; Zhang et al., 2026). Building on these developments, Spatial Commerce represents a qualitative shift rather than a simple technological extension. By integrating XR, AI, spatial computing, digital twins, and persistent virtual environments, it transforms consumers from passive screen users into embodied participants who interact, navigate, and socialize within shared three-dimensional spaces (Alves et al., 2024; Harrison-Boudreau & Bellemare, 2022; Iyengar et al., 2025; Wang et al., 2025).

Viewed from this perspective, the evolution of commerce is best understood as a process of re-embodiment. Rather than replacing earlier forms of digital commerce, Spatial Commerce integrates and extends them within a multimodal ecosystem that reconnects the cognitive efficiency of e-commerce with the sensory and social richness of physical retailing (Jafar, Ahmad, & Chen, 2024; Jafar et al., 2025).

Table 1. Evolution of Commerce: Five Stages

Stage	Era	Dominant Interface	Spatial Logic	Sensory Bandwidth	Key Drivers
1. Traditional	Pre-1995	Physical store	Colocated	Multi-sensory, embodied	Geography, social proximity



2. E-Commerce	1995–2007	Desktop web	Dislocated	Visual + textual	Internet, payment systems
3. Mobile & Omnichannel	2007–2016	Smartphone, apps	Context-fluid	Visual + tactile	Mobile broadband, GPS
4. Immersive	2016–2022	AR/VR, mobile XR	Augmented/simulated	Visual + haptic + spatial audio	AR-Kit, ARCore, HMDs
5. Spatial Commerce	2022–	Spatial computing, metaverse	Volumetric, persistent, embodied	Multi-modal	XR + AI + digital twins

FOUNDATIONS OF SPATIAL COMMERCE

Spatial Commerce is not driven by a single technology but by the convergence of complementary digital infrastructures. At its foundation is spatial computing, which enables digital systems to perceive, model, and interact with three-dimensional environments through technologies such as computer vision, simultaneous localization and mapping (SLAM), and real-time rendering (Kim, 2025; Wang et al., 2025). This provides the infrastructure linking digital content, physical space, and user interaction.

Extended Reality (XR) constitutes the experiential interface of Spatial Commerce. Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) provide varying degrees of immersion, although advances in pass-through video and spatial computing increasingly blur the boundaries among these modalities (Bordegoni et al., 2023; Kojić et al., 2025; Zhang & Li, 2024). Complementing XR, Artificial Intelligence (AI) serves as the cognitive layer by enabling real-time personalization, conversational agents, scene understanding, behavioral prediction, and adaptive virtual experiences (Dong et al., 2025; Hassan et al., 2025; Wei & Bahari, 2026).

Other enabling technologies strengthen this ecosystem. Digital twins synchronize physical and virtual assets to support inventory management, customer simulation, and personalized services, while also raising ethical concerns regarding behavioral profiling (Moon & Erdem, 2026; Muschkiet, 2024; Muschkiet et al., 2022). The Internet of Things (IoT) supplies real-time sensor data, whereas edge and cloud computing provide the low latency and scalable computing capacity required for immersive, persistent environments (Hosseiniard, 2025; Scurati, 2025).

These technologies create value through their integration rather than in isolation. Spatial computing establishes the environment, XR delivers immersive interaction, AI personalizes experiences, digital twins synchronize physical and virtual states, IoT supplies contextual data, and edge–cloud infrastructures ensure responsiveness and scalability (Dias et al., 2024; Jawale et al., 2024). Emerging technologies such as Web3 and blockchain may further support digital ownership, interoperable identities, and decentralized governance, although their long-term commercial role remains uncertain (Chen et al., 2023; Ghosh et al., 2024).

Table 2. Spatial Commerce Technology Ecosystem

Technology Layer	Function	Role in Spatial Commerce
Spatial Computing	3D scene perception, SLAM, anchoring	Situates content within space
XR (VR/AR/MR)	Immersive rendering	Experiential surface
Artificial Intelligence	Personalization, vision, NLP	Cognitive layer
Digital Twins	Real-time virtual replicas	Physical–virtual sync
IoT	Sensor data streams	Animates twins
Edge Computing	Low-latency local computation	User comfort, real-time rendering



Cloud Computing

Elastic scale

Persistent worlds

Web3/Blockchain

Decentralized ownership,
identity

Digital property rights

CONSUMER EXPERIENCE IN SPATIAL COMMERCE

Core Psychological Constructs

Spatial Commerce reshapes consumer experience by extending established psychological mechanisms into immersive, three-dimensional environments. Among these, presence (the subjective feeling of "being there" in a mediated environment) emerges as the central construct, consistently predicting favorable attitudes, approach behaviors, and purchase intentions in virtual retail settings (Jang et al., 2019; Lu & Hsiao, 2022). Closely related, telepresence enhances intrinsic enjoyment and purchase intention by creating the perception of being transported into a remote commercial space (Han et al., 2020).

Flow, defined as a state of deep cognitive absorption, remains a key driver of engagement in Spatial Commerce. Evidence suggests that telepresence and flow jointly mediate the relationship between immersive environments and continued platform use, while sustained flow experiences contribute to customer loyalty and post-purchase engagement (Hosen et al., 2026; Jafar, Ahmad, & Chen, 2024; Mahnke et al., 2015; Yuan et al., 2026). Immersion, in contrast, refers to the technological capability of XR systems to provide sensory richness, whereas presence reflects the user's psychological response (Chen & Li, 2026). Embodiment, or the perception of inhabiting a virtual avatar, further strengthens self-identification, fit confidence, and brand attachment, particularly in identity-oriented categories such as fashion and luxury (Hao et al., 2025; Konale et al., 2025).

Theoretical Perspectives

Research on Spatial Commerce primarily extends established technology adoption and consumer behavior theories. The Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) continue to explain adoption intentions, although their explanatory power is enhanced when combined with experiential constructs such as hedonic motivation, social influence, and prior XR experience (Di Natale et al., 2024; Farhi, 2024; Kaya, 2026; Teng et al., 2022).

The Stimulus-Organism-Response (S-O-R) framework provides a particularly suitable lens for explaining consumer behavior in immersive environments. Spatial stimuli (including augmented realism, multisensory congruence, avatar fidelity, and AI responsiveness) influence internal psychological states such as immersion, presence, flow, and trust, which subsequently shape purchase intention, loyalty, and brand advocacy (Eroglu et al., 2003; Gao & Bai, 2014; Peng & Kim, 2014; Yu & Pan, 2026). Complementary perspectives, including the Experience Economy and the Technology Readiness Index (TRI), further explain how immersive experiences create value while accounting for individual differences in technology adoption (Chen & Li, 2010; Demirci & Ersoy, 2008; Pine & Gilmore, 2013).

An Integrative Spatial Commerce Consumer Experience Framework

Building on the preceding theoretical perspectives, this review proposes an Integrated Spatial Commerce Consumer Experience Framework that synthesizes the principal technological, psychological, and behavioral constructs identified in the literature. As illustrated in Figure 3, the framework conceptualizes Spatial Commerce as a value creation process in which spatial commerce technologies generate immersive environments that shape consumer experience, strengthen trust, and ultimately influence behavioral outcomes.

The framework begins with Spatial Commerce Technologies, comprising Extended Reality (XR), Artificial Intelligence (AI), Spatial Computing, Digital Twins, and the Internet of Things (IoT). These complementary technologies create immersive and intelligent shopping environments, with immersion representing the primary technological affordance through which consumers engage with spatial commerce. Rather than directly influencing consumer behavior, immersion facilitates a multidimensional consumer experience characterized by presence, embodiment, and flow, which collectively translate technological capabilities into meaningful psychological experiences.

The framework further proposes that trust functions as the key psychological mediator linking immersive consumer experiences to behavioral outcomes. In AI-enabled environments, trust is shaped by consumers' perceptions of platform reliability, personalization, and transparency, thereby influencing their willingness to engage in spatial commerce (Bansal & Bansal, 2026; Hassan et al., 2025; Sun, Freeman, et al., 2025). Positive consumer experiences subsequently contribute to desirable behavioral outcomes, including purchase intention, customer satisfaction, loyalty, and brand advocacy, which together reflect the long-term value generated through Spatial Commerce (Arya et al., 2024; Leong et al., 2026).

The framework also recognizes that the relationship between immersive technologies and consumer experience is contingent upon both individual and contextual moderators. Individual factors including technology readiness, prior immersive experience, and demographic characteristics, influence consumers' ability and willingness to engage with immersive environments, whereas contextual factors such as shopping context, product category, and social presence shape how these experiences are interpreted and evaluated. In addition, the framework acknowledges two important boundary conditions identified in the literature. First, multisensory congruence enhances consumer responses when visual, auditory, and haptic cues are aligned, strengthening perceived ownership and reducing decision uncertainty (Bhatt et al., 2026; Chen et al., 2023; Helmeffalk & Hultén, 2017; Istiani et al., 2026; Magalhães et al., 2024). Second, the realism paradox suggests that increasing realism enhances presence only up to an optimal threshold, beyond which excessive fidelity may induce cognitive overload or uncanny experiences. Similarly, evidence indicates that social presence often exerts a stronger influence on revisit intention than technological realism alone (Buchner et al., 2022; Chen & Li, 2026; Lekha Shree et al., 2026; Magalhães et al., 2024).

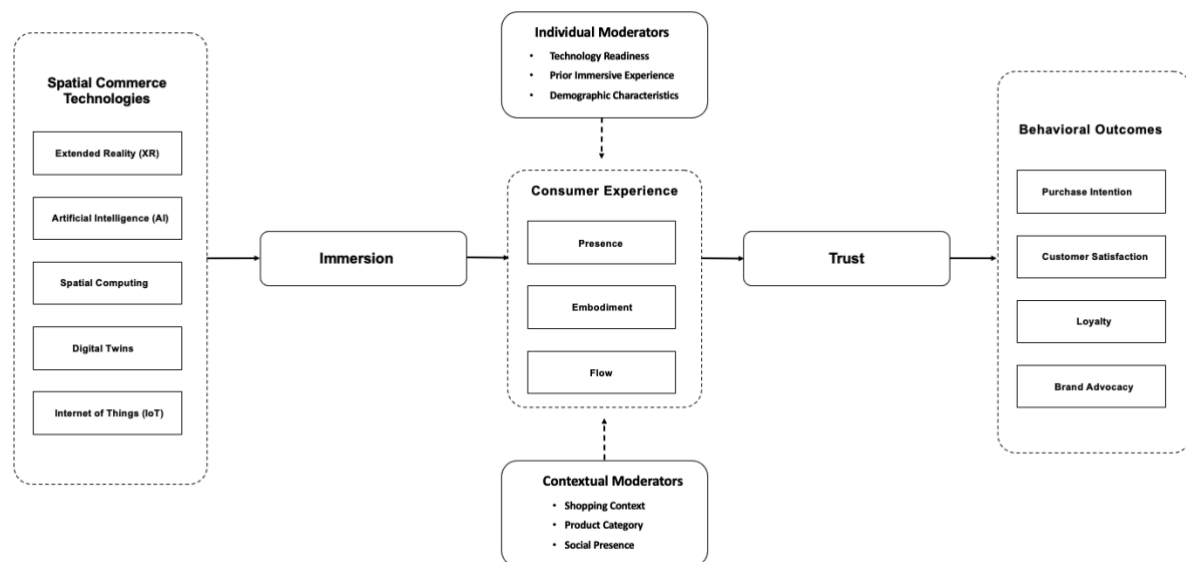


Figure 1. Proposed Spatial Commerce Consumer Experience Framework

AI AND SPATIAL COMMERCE

Artificial Intelligence (AI) serves as the cognitive engine of Spatial Commerce, transforming immersive environments into adaptive, context-aware, and personalized experiences. By analyzing multimodal data (including gaze, gestures, voice, biometrics, and behavioral signals), AI continuously adapts product recommendations, virtual environments, pricing, and avatar interactions in real time (Dong et al., 2025; Wei & Bahari, 2026). Rather than merely supporting immersive technologies, AI enhances their responsiveness and enables dynamic consumer experiences that evolve throughout the shopping journey.

In Spatial Commerce, AI-powered recommendation systems extend beyond conventional product suggestions by incorporating spatial context. AI guides consumers not only on what to purchase but also how to navigate virtual environments, interact with products, and engage with virtual sales assistants (Hassan et al., 2025). Similarly, AI-generated avatars and digital humans improve engagement and trust through natural language interaction, emotional responsiveness, and adaptive communication styles, while multimodal interfaces integrating voice, gesture recognition, and hand tracking create more intuitive consumer-brand

interactions (Chen, Ngo, et al., 2026; Hao et al., 2025; Kojić et al., 2025; Kyaw et al., 2024; Morotti et al., 2022; Wei & Bahari, 2026).

AI also enables predictive and agentic commerce. Predictive analytics anticipate consumer needs by pre-personalizing virtual environments and recommending products before explicit requests are made, whereas autonomous AI shopping agents increasingly perform purchasing tasks on behalf of consumers (Upreti et al., 2023). Combined with digital twins, these capabilities support simulation-driven personalization and customer journey optimization but simultaneously intensify concerns regarding privacy, autonomy, and algorithmic accountability (Muschket et al., 2022; Wang et al., 2025).

Despite its potential, the effects of AI-driven personalization remain contested. While many studies report positive relationships between personalization, trust, and purchase intention (Hassan et al., 2025; Ingriana & Rolando, 2025), others suggest that excessive personalization can increase perceived surveillance, intrusiveness, and consumer reactance (Sun, Freeman, et al., 2025). This tension, often described as the Transparency Paradox, indicates that personalization is most effective when accompanied by explainable AI, user control, and transparent data practices, which together strengthen trust and long-term consumer acceptance (Bansal & Bansal, 2026; Sun, Freeman, et al., 2025).

CHALLENGES AND BARRIERS

Despite its transformative potential, the widespread adoption of Spatial Commerce remains constrained by technological, organizational, consumer, and regulatory challenges. These barriers are interconnected, requiring coordinated advances in infrastructure, business strategy, consumer protection, and governance.

From a technological perspective, current XR hardware continues to face limitations in latency, battery life, device ergonomics, and field of view, all of which influence user comfort and adoption (Porcino & Clua, 2025; Scurati, 2025). Delivering photorealistic, persistent virtual environments also requires substantial computational resources, reinforcing the importance of edge and cloud computing. At the same time, limited interoperability among platforms restricts the seamless transfer of avatars, digital assets, and spatial environments, hindering the development of an open Spatial Commerce ecosystem (Chen et al., 2023; Ghosh et al., 2024).

Economic and consumer barriers remain equally significant. High implementation costs, workforce training, and integration with existing retail systems continue to limit adoption, particularly among small and medium-sized enterprises (Alves et al., 2024; Jawale et al., 2024). From the consumer perspective, device affordability, cybersickness, digital literacy, and cognitive overload may reduce acceptance, especially when highly immersive environments exceed users' cognitive capacity (Buchner et al., 2022; Smith et al., 2026; Suzuki et al., 2024). Emerging evidence suggests that adaptive XR interfaces capable of adjusting information complexity and interaction modes can mitigate these challenges and improve user experience (Zhao et al., 2017; Zhou et al., 2025).

Privacy, ethics, and governance present perhaps the most critical long-term challenges. XR devices continuously collect biometric and behavioral data (including gaze, gestures, facial expressions, and movement) raising concerns over surveillance, digital identity, algorithmic bias, and manipulative personalization (Almomani et al., 2025; Bansal & Bansal, 2026; Wang & Wang, 2023; Wu & Zhang, 2023). Accessibility also remains uneven, as the high cost of XR technologies risks widening the digital divide, while regulatory frameworks continue to lag behind advances in AI-driven advertising, biometric data protection, and virtual property rights (Aziz et al., 2025; Iyengar et al., 2025; Konale et al., 2025).

Collectively, the literature highlights three fundamental tensions shaping the future of Spatial Commerce. The first is the balance between immersion and cognitive overload, as greater sensory realism can either enhance or diminish consumer experience depending on its design (Magalhães et al., 2024; Sun & Liao, 2025). The second concerns personalization and privacy, where increasingly accurate AI-driven personalization depends on extensive data collection and raises concerns over surveillance and consumer autonomy (Hassan et al., 2025; Wu & Zhang, 2023). The third involves platform centralization versus interoperability, reflecting competing visions between proprietary ecosystems and decentralized infrastructures based on Web3 technologies (Chen et al., 2023; Gilbert, 2022). These tensions underscore that the future success of Spatial Commerce will depend not only on technological innovation but also on the development of trustworthy, inclusive, and interoperable ecosystems.

**Table 3.** Challenges and Opportunities in Spatial Commerce

Category	Challenge	Counter-Opportunity	Source
Technological	Latency, hardware limitations	Edge computing, cloud XR	Scurati (2025)
Economic	High implementation cost	Cloud-based SaaS XR	Jawale et al. (2024)
Consumer	Cognitive overload, cybersickness	Adaptive feedback	Buchner et al. (2022); Sun & Liao (2025)
Privacy	Biometric surveillance	Privacy-preserving design	Wu & Zhang (2023)
Ethics	AI manipulation, transparency paradox	XAI, user control	Bansal & Bansal (2026)
Accessibility	Digital divide	Mobile/web XR	Iyengar et al. (2025)
Interoperability	Walled gardens	Web3 open standards	Ghosh et al. (2024)
Regulation	Fragmented frameworks	Cross-jurisdictional governance	Mitrushchenkova (2023)

FUTURE RESEARCH DIRECTIONS

The continued evolution of Spatial Commerce presents significant opportunities for future research across theory, methodology, technology, and governance. Advancing the field will require moving beyond isolated investigations of individual technologies toward integrated frameworks that explain how immersive environments reshape consumer behavior and value creation.

From a theoretical perspective, future studies should develop unified models that integrate presence, immersion, embodiment, flow, and trust within a comprehensive explanation of consumer experience. Greater attention should also be given to identity construction, avatar-mediated relationships, and embodied consumption by drawing on perspectives from consumer psychology, phenomenology, and human–computer interaction (Arghashi, 2025; Chen & Li, 2026; Kaur et al., 2024). Longitudinal research is particularly needed to understand how repeated exposure to immersive environments influences consumer behavior, brand relationships, and well-being over time (Hao et al., 2025; Konale et al., 2025).

Methodologically, the literature remains dominated by laboratory experiments using convenience samples and short-term exposure. Future research should employ longitudinal field studies, cross-cultural comparisons, and mixed-method designs that better capture real-world consumer experiences (Magalhães et al., 2024; Suzuki et al., 2024). Advances in eye tracking, electroencephalography (EEG), and other biometric measures offer promising opportunities to deepen understanding of consumer responses, although their use should be accompanied by careful ethical safeguards (Dong et al., 2025).

Technological research should focus on scalable and interoperable Spatial Commerce infrastructures, including web-based XR, cross-device experiences, lightweight rendering, federated learning for privacy-preserving personalization, and standardized digital twin architectures (Porcino & Clua, 2025; Wang et al., 2025). At the application level, important opportunities remain in underexplored domains such as financial services, B2B commerce, healthcare, and circular economy initiatives (Hosseinifard, 2025; Kaya, 2026).

Finally, greater attention should be devoted to the broader societal implications of Spatial Commerce. Existing evidence is concentrated in North America, Europe, and East Asia, highlighting the need for cross-cultural research that examines the influence of cultural values, social norms, and religious contexts on immersive consumer behavior (Shatnawi et al., 2020; Yu & Chatpunyakul, 2025). Future studies should also investigate the long-term consequences of AI-driven personalization, autonomous shopping agents, digital identity, and virtual ownership, while developing governance frameworks that balance innovation with transparency, accountability, and consumer protection (Bansal & Bansal, 2026; Chen et al., 2023; Mitrushchenkova, 2023; Sun, Freeman, et al., 2025; Wu & Zhang, 2023).

Table 4. Future Research Agenda

Research Area	Current Gap	Future Opportunity
Theoretical integration	Fragmented use of presence, flow, embodiment	Unified embodied-commerce theory
Methodology	Lab-bound short-term studies	Longitudinal, biometric, field designs
Technology	Walled gardens, latency	Web-XR, federated learning, edge AI
Industries	B2B, finance, circular economy understudied	Domain-specific empirical work
Cross-cultural	Western/East Asian dominance	Global South, indigenous, religious contexts
AI integration	Curvilinear personalization effects	XAI, trust calibration
Consumer psychology	Avatar identity effects	Longitudinal identity studies
Governance	Legal patchwork	Metaverse governance frameworks
Digital ownership	Volatile Web3	Robust property/identity standards

IMPLICATIONS

The emergence of Spatial Commerce requires organizations to move beyond simply adopting XR technologies toward redesigning customer experiences around immersion, presence, and AI-driven personalization. Rather than treating XR as a standalone feature, firms should integrate immersive technologies into the entire customer journey, prioritizing applications where product uncertainty is high, such as apparel, beauty, furniture, and automotive retail, where immersive experiences generate the greatest value (Chen et al., 2024; Uhlendorf-Leo et al., 2026).

For businesses, successful implementation depends on balancing technological capability with organizational readiness. Cloud-based and web-XR platforms reduce adoption barriers for small and medium-sized enterprises (SMEs), while marketers must shift from message-centric communication to environment-centric brand experiences that emphasize interactive storytelling, virtual brand worlds, and avatar engagement (Alves et al., 2024; Arya et al., 2024; Iyengar et al., 2025). Luxury brands can further strengthen exclusivity through immersive storytelling and carefully managed digital scarcity (Hao et al., 2025; Liu et al., 2025).

The broader Spatial Commerce ecosystem also requires coordinated action from technology providers and policymakers. Platform providers should prioritize interoperability, digital identity portability, and creator ecosystems to encourage long-term network growth, while developers should optimize immersive experiences through adaptive interfaces, low-latency rendering, and human-centered design that minimizes cognitive overload (Chen et al., 2023; Ghosh et al., 2024; Smith et al., 2026; Sun & Liao, 2025). Policymakers, meanwhile, must establish governance frameworks addressing biometric privacy, AI transparency, and immersive advertising, while ensuring that innovation remains balanced with consumer protection (Almomani et al., 2025; Wu & Zhang, 2023). Finally, educational institutions should develop interdisciplinary curricula that combine marketing, design, computer science, ethics, and psychology to prepare future professionals for the evolving Spatial Commerce ecosystem (Di Natale et al., 2024).

CONCLUSION

This review examined the evolution of digital commerce from traditional retail to Spatial Commerce, an emerging paradigm in which Extended Reality (XR), Artificial Intelligence (AI), spatial computing, digital twins, IoT, and edge computing converge to create immersive, intelligent, and persistent consumer experiences. Rather than representing a simple technological upgrade, Spatial Commerce redefines the consumer–brand relationship by combining the sensory richness of physical retail with the scalability and personalization of digital commerce (Harrison-Boudreau & Bellemare, 2022; Jafar et al., 2025; Wang et al., 2025).



The review makes three primary contributions. First, it conceptualizes the evolution of commerce through a five-stage framework that positions Spatial Commerce within the broader trajectory of digital transformation. Second, it integrates the fragmented technological foundations of Spatial Commerce into a unified ecosystem. Third, it advances an integrative Spatial Commerce Consumer Experience Framework, highlighting how immersion, presence, embodiment, flow, and trust mediate the relationship between spatial technologies and consumer behavioral outcomes while extending established perspectives such as S-O-R, TAM, UTAUT, Flow Theory, Presence Theory, and the Experience Economy to immersive commerce (Eroglu et al., 2003; Han et al., 2020; Jang et al., 2019).

The findings also underscore important managerial implications. Organizations should view Spatial Commerce not as an incremental digital innovation but as a strategic transformation requiring the integration of immersive technologies, AI-driven personalization, organizational capabilities, and responsible governance. At the same time, realizing its full potential depends on addressing challenges related to interoperability, privacy, ethics, accessibility, and consumer trust.

As Spatial Commerce continues to evolve, future progress will depend on interdisciplinary research that integrates technological innovation with consumer psychology, marketing, and governance. Ultimately, the long-term success of Spatial Commerce will be determined not only by advances in immersive technologies but also by the ability of businesses, researchers, and policymakers to develop trustworthy, inclusive, and human-centered digital ecosystems.

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Conflict of Interest

The authors declare that there are no financial, professional, or personal relationships that could be perceived as influencing the research reported in this article.

REFERENCES

- Almomani, A., Alqerem, A., Alauthman, M., et al. (2025). Ethical foundations of AI-driven avatars in the metaverse for innovation and user privacy. IEEE Access. <http://doi.org/10.1109/ACCESS.2025.3589714>
- Alves, C., Machado, J., & Reis, J. L. (2024). Spatial computing and augmented reality—Challenges in e-commerce. Smart Innovation, Systems and Technologies. http://doi.org/10.1007/978-981-97-1552-7_57
- Arghashi, V. (2025). Exploring users' fluidity and adaptation in virtual worlds: Metaverse features and interaction of awe and realism. Asia-Pacific Journal of Business Administration. <http://doi.org/10.1108/APJBA-05-2024-0303>
- Artomova, A. (2025). E-commerce 3.0: Integrating mobile, social and omnichannel trade into digital entrepreneurship. Social Development: Economic and Legal Issues. <https://doi.org/10.70651/3083-6018/2025.10.14>
- Arya, V., Sambyal, R., Sharma, A., et al. (2024). Brands are calling your AVATAR in metaverse: A study to explore XR-based gamification marketing activities & consumer-based brand equity in virtual world. Journal of Consumer Behaviour. <https://doi.org/10.1002/cb.2214>
- Aziz, N. A. A. A., Mohamed, H., Isa, N., & Ismail, Z. (2025). A mobile-based virtual fitting room with 3D avatars and augmented reality integration. 2025 IEEE 15th International Conference on System Engineering and Technology. <http://doi.org/10.1109/ICSET65917.2025.11283708>
- Bansal, P., & Bansal, R. (2026). The transparency paradox: Rebuilding trust in AI shopping agents through explainability. In Reshaping e-commerce through AI shopping agents. <http://doi.org/10.4018/979-8-3373-7330-0.ch013>
- Bhatt, V., Fatma, A., Nand Jha, S., & Sinha, B. (2026). Touch influencing purchases: The role of haptic technology in retail. International Journal of Human-Computer Interaction. <http://doi.org/10.1080/10447318.2025.2575891>
- Bordegoni, M., Carulli, M., & Spadoni, E. (2023). Multisensory interaction in eXtended Reality. SpringerBriefs in Applied Sciences and Technology. http://doi.org/10.1007/978-3-031-39683-0_4



- Buchner, J., Buntins, K., & Kerres, M. (2022). The impact of augmented reality on cognitive load and performance: A systematic review. *Journal of Computer Assisted Learning*, 38(1), 285–303. <https://doi.org/10.1111/jcal.12617>
- Chen, H., Duan, H., Abdallah, M., Zhu, Y., Wen, Y., et al. (2023). Web3 metaverse: State-of-the-art and vision. *ACM Transactions on Multimedia Computing, Communications, and Applications*. <https://doi.org/10.1145/3630258>
- Chen, H., Li, H., & Pirkkalainen, H. (2024). How extended reality influences e-commerce consumers: A literature review. *Electronic Commerce Research and Applications*. <http://doi.org/10.1016/j.eelerap.2024.101404>
- Chen, J., Xi, N., Pohjonen, V., & Hamari, J. (2023). Paying attention in metaverse: An experiment on spatial attention allocation in extended reality shopping. *Information Technology & People*, 36(8), 255–278. <https://doi.org/10.1108/ITP-09-2021-0674>
- Chen, J. W. C., Ngo, R. C., Yu, C. M., et al. (2026). Beyond faders: Understanding 6DoF gesture ecologies in music mixing. *Conference on Human Factors in Computing Systems - Proceedings*. <http://doi.org/10.1145/3772363.3799265>
- Chen, S. C., & Li, S. H. (2010). Consumer adoption of e-service: Integrating technology readiness with the theory of planned behavior. *African Journal of Business Management*, 4(16). <https://academicjournals.org/journal/AJBM/article-full-text-pdf/EC1210321485>
- Chen, Y., & Li, M. (2026). Beyond immersion: Disentangling the technological and social drivers of visitor satisfaction in XR art exhibitions. *Frontiers in Psychology*. <http://doi.org/10.3389/fpsyg.2026.1793811>
- Dağ, K., Çavuşoğlu, S., & Durmaz, Y. (2024). The effect of immersive experience, user engagement and perceived authenticity on place satisfaction in the context of augmented reality. *Library Hi Tech*, 42(4), 1331–1356. <https://doi.org/10.1108/LHT-10-2022-0498>
- Demirci, A. E., & Ersoy, N. F. (2008). Technology readiness for innovative high-tech products: How consumers perceive and adopt new technologies. *The Business Review*, 11(1).
- Di Natale, A. F., Bartolotta, S., Gaggioli, A., Riva, G., et al. (2024). Exploring students' acceptance and continuance intention in using immersive virtual reality and metaverse integrated learning environments. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-023-12436-7>
- Dias, J. A., Boavida, M., & Estima, J. (2024). Exploring the frontiers of communication with extended reality (XR): Applications, challenges, and future directions. In *Impact of digitalization on communication dynamics*. <http://doi.org/10.4018/979-8-3693-3579-6.ch002>
- Dong, Z., Han, B., Zhang, J., et al. (2025). An exploratory study on AI-driven visualisation techniques on decision making in extended reality. *OzCHI 2024*. <http://doi.org/10.1145/3726986.3727036>
- Eroglu, S. A., Machleit, K. A., & Davis, L. M. (2003). Empirical testing of a model of online store atmospherics and shopper responses. *Psychology & Marketing*, 20(2), 139–150. <https://doi.org/10.1002/mar.10064>
- Farhi, F. (2024). Examining the factors fostering metaverse experience browser acceptance under unified theory of acceptance and use of technology (UTAUT). *Journal of Infrastructure, Policy and Development*. <https://doi.org/10.24294/jipd.v8i3.2594>
- Gao, L., & Bai, X. (2014). Online consumer behaviour and its relationship to website atmospheric induced flow: Insights into online travel agencies in China. *Journal of Retailing and Consumer Services*, 21(4), 653–665. <https://doi.org/10.1016/j.jretconser.2014.01.001>
- Ghosh, A., Hassija, V., Chamola, V., & El Saddik, A. (2024). A survey on decentralized metaverse using blockchain and Web 3.0 technologies, applications, and more. *IEEE Access*. <http://doi.org/10.1109/ACCESS.2024.3469193>
- Gilbert, S. (2022). *Crypto, Web3, and the metaverse*. Bennett Institute for Public Policy, Cambridge, Policy Brief. <https://sitic.org/wordpress/wp-content/uploads/Crypto-web3-and-the-Metaverse.pdf>
- Han, S. L., An, M., Han, J. J., & Lee, J. (2020). Telepresence, time distortion, and consumer traits of virtual reality shopping. *Journal of Business Research*, 118, 311–320. <https://doi.org/10.1016/j.jbusres.2020.06.056>
- Hao, Y., Shao, W., Quach, S., & Zhang, Y. (2025). Digital luxury: How avatar marketing drives consumer engagement for luxury brands. *Asia Pacific Journal of Marketing and Logistics*. <https://doi.org/10.1108/APJML-02-2025-0225>
- Harrison-Boudreau, J.-P., & Bellemare, J. (2022). Going above and beyond eCommerce in the future highly virtualized world and increasingly digital ecosystem. *Lecture Notes in Mechanical Engineering*. http://doi.org/10.1007/978-3-030-90700-6_90



- Hassan, N., Abdelraouf, M., & El-Shihy, D. (2025). The moderating role of personalized recommendations in the trust–satisfaction–loyalty relationship: An empirical study of AI-driven e-commerce. *Future Business Journal*. <https://doi.org/10.1186/s43093-025-00476-z>
- Helmeffalk, M., & Hultén, B. (2017). Multi-sensory congruent cues in designing retail store atmosphere: Effects on shoppers' emotions and purchase behavior. *Journal of Retailing and Consumer Services*, 38, 1–11. <http://doi.org/10.1016/j.jretconser.2017.04.007>
- Hosen, M., Taheri, B., Gannon, M. J., et al. (2026). How flow drives engagement and loyalty. *International Journal of Contemporary Hospitality Management*, 38(13), 113–135. <https://doi.org/10.1108/IJCHM-05-2025-0699>
- Hosseinfard, M. (2025). Extended reality in warehousing: Bridging Industry 4.0 and 5.0 for smart logistics. In *Smart logistics in Industry 5.0*. <http://doi.org/10.1201/9781003466451-6>
- Ingriana, A., & Rolando, B. (2025). Revolutionizing e-commerce: Investigating the effectiveness of AI-driven personalization in influencing consumer purchasing behavior. *Jurnal Ilmiah Manajemen dan Bisnis*. <https://doi.org/10.33998/jumanage.2025.4.1.2040>
- Istiani, N. F. F., Logren, N., Masullo, M., et al. (2026). Sweetening the experience: How designed immersive multisensory environments modify yogurt taste and mouthfeel perception. *Food Quality and Preference*. <http://doi.org/10.1016/j.foodqual.2026.105902>
- Iyengar, V., Pabalkar, V., & Pillai, S. (2025). The growth of extended reality. In *Introduction to extended reality (XR) technologies*. <http://doi.org/10.1002/9781119857716.ch12>
- Jafar, R. M. S., Ahmad, W., & Chen, Y. (2024). Metaverse in human behavior: The role of telepresence and flow experience on consumers' shopping behavior in the metaverse. *Sage Open*, 14(2). <https://doi.org/10.1177/21582440241261256>
- Jafar, R. M. S., Jabeen, M., Hussain, S., Niu, B., et al. (2025). Cyber shopping beyond boundaries: The Metaverse revolution in e-commerce and consumer behavior. *Human Behavior and Emerging Technologies*. <https://doi.org/10.1155/hbe2/5559234>
- Jang, J. Y., Hur, H. J., & Choo, H. J. (2019). How to evoke consumer approach intention toward VR stores? Sequential mediation through telepresence and experiential value. *Fashion and Textiles*, 6(1). <https://doi.org/10.1186/s40691-018-0166-9>
- Jawale, S., Bondade, A., Sontakke, M., et al. (2024). Extended reality e-commerce: The evolution of e-commerce through XR based technologies. *OTCON 2024*. <http://doi.org/10.1109/OTCON60325.2024.10687746>
- Kaur, J., Mogaji, E., Paliwal, M., Jha, S., et al. (2024). Consumer behavior in the metaverse. *Journal of Consumer Behaviour*. <https://doi.org/10.1002/cb.2298>
- Kaya, H. (2026). Extending TAM and UTAUT for meta-banking adoption intention: Roles of technostress, AR/VR experience, and perceived value. *Sakarya University Journal of Computer and Information Sciences*. <https://doi.org/10.1002/cb.2298>
- Kim, D.-J. (2025). A study on the spatial visual elements in extended reality content. *Edelweiss Applied Science and Technology*. <http://doi.org/10.55214/25768484.v9i3.5554>
- Kim, S. J. (2023). Virtual fashion experiences in virtual reality fashion show spaces. *Frontiers in Psychology*, 14. <https://doi.org/10.3389/fpsyg.2023.1276856>
- Kojić, T., Vergari, M., Warsinke, M., et al. (2025). Multimodal user experience in extended reality: Exploring hand tracking, voice, and passthrough interactions. *MMVE 2025*. <http://doi.org/10.1145/3712677.3720459>
- Konale, M., Panakaje, N., Parvin, S. M. R., et al. (2025). Exploring the fusion of virtual fitting rooms and social media: A study on consumer behaviour and purchase intentions. *Journal of Fashion Marketing and Management*. <http://doi.org/10.1108/JFMM-05-2024-0195>
- Kyaw, A. H., Spencer, L., Zivkovic, S., & Lok, L. (2024). Gesture recognition for feedback based mixed reality and robotic fabrication. *Computational Design and Robotic Fabrication*. <http://doi.org/10.1109/OTCON60325.2024.10687746>
- Lazaris, C., & Vrechopoulos, A. (2014). From multichannel to “omnichannel” retailing: Review of the literature and calls for research. *2nd International Conference on Contemporary Marketing Issues (ICCM)*. <https://doi.org/10.13140/2.1.1802.4967>
- Leimontaitė, L., & Naimavičienė, J. (2023). Virtual 3D tour assistance in real estate management. *Baltic Journal of Real Estate Economics and Construction Management*. <https://doi.org/10.13140/2.1.1802.4967>
- Lekha Shree, S., Menaka, B., Ravindran, D., & Geetha, C. (2026). Metaverse marketing: Social meets sales. *Studies in Systems, Decision and Control*. http://doi.org/10.1007/978-3-032-10016-0_73
- Leong, M. K., Koay, K. Y., Azman, A., et al. (2026). Virtual brand experience and brand evangelism in the metaverse: Mediating role of brand coolness and moderating role of tech savviness. *Asia-Pacific Journal of Business Administration*. <https://doi.org/10.1108/APJBA-04-2025-0315>



- Liu, T., Tan, C. S. L., & Quintero Rodriguez, C. (2025). Virtual reality in the luxury fashion industry: A systematic literature review. *Spanish Journal of Marketing - ESIC*, 29(3), 312–334. <https://doi.org/10.1108/SJME-07-2023-0203>
- López-Ojeda, W., & Hurley, R. A. (2021). Extended-reality technologies: An overview of emerging applications in medical education and clinical care. *The Journal of Neuropsychiatry and Clinical Neurosciences*, 33(3), A4–177. <https://doi.org/10.1176/appi.neuropsych.21030067>
- Lu, X., & Hsiao, K.-L. (2022). Effects of diffusion of innovations, spatial presence, and flow on virtual reality shopping. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.941248>
- Magalhães, M., Melo, M., Coelho, A. F., & Bessa, M. (2024). Affective landscapes: Navigating the emotional impact of multisensory stimuli in virtual reality. *IEEE Access*. <http://doi.org/10.1109/ACCESS.2024.3499858>
- Mahnke, R., Benlian, A., & Hess, T. (2015). A grounded theory of online shopping flow. *International Journal of Electronic Commerce*, 19(3), 54–89. <https://doi.org/10.1080/10864415.2015.1000222>
- Mitrushchenkova, A. N. (2023). Personal identity in the metaverse: Challenges and risks. *Kutafin Law Review*, 10(1), 130–159. <https://doi.org/10.17803/2313-5395.2022.4.22.793-817>
- Mollet, J., & Chen, Y. (2025). Does AR virtual try-on boost online apparel purchase intentions? An integration of TAM, IDT, FIT perception and body esteem. *Young Consumers*. <http://doi.org/10.1108/YC-08-2024-2196>
- Moon, J., & Erdem, M. (2026). From pixels to plates: Generation Z's psychological decision-making in blockchain-based digital twins of quick-service restaurants. *Journal of Hospitality and Tourism Insights*. <http://doi.org/10.1108/JHTI-09-2025-1091>
- Morotti, E., Stacchio, L., Donatiello, L., et al. (2022). Exploiting fashion x-commerce through the empowerment of voice in the fashion virtual reality arena. *Virtual Reality*, 26(3), 887–905. <http://doi.org/10.1007/s10055-021-00602-6>
- Muschkiet, M. (2024). Analysis and design of customer experiences in an omnichannel context using customer digital twins [Doctoral dissertation, University of Duisburg-Essen]. <http://doi.org/10.1007/s10055-021-00602-6>
- Muschkiet, M., Paschmann, J. W., & Nissen, A. (2022). Towards human digital twins for improving customer experience. *ICIS 2022 Proceedings*. https://aisel.aisnet.org/icis2022/serv_science/serv_science/4
- Peng, C., & Kim, Y. G. (2014). Application of the stimuli-organism-response (S-O-R) framework to online shopping behavior. *Journal of Internet Commerce*, 13(3–4), 159–176. <https://doi.org/10.1080/15332861.2014.944437>
- Pine, B. J., & Gilmore, J. H. (2013). The experience economy: Past, present and future. In *Handbook on the experience economy* (pp. 21–44). Edward Elgar. <https://doi.org/10.4337/9781781004227.00007>
- Porcino, T., & Clua, E. (2025). Challenges in data visualization with extended reality devices. *Lecture Notes in Computer Science*. http://doi.org/10.1007/978-3-031-74353-5_24
- Scurati, G. W. (2025). A roadmap for XR integration in industry: Challenges and opportunities. *Proceedings - 2025 IEEE International Symposium on Mixed and Augmented Reality Adjunct, ISMAR-Adjunct 2025*. <http://doi.org/10.1109/ISMAR-Adjunct68609.2025.00049>
- Shafa, A. R., Rosiana, N. J., & Ratnapuri, C. I. (2025). Try before you buy: The effectiveness of augmented reality virtual try-on in e-commerce. *10th International Conference on Informatics and Computing, ICIC 2025*. <http://doi.org/10.1109/ICIC68054.2025.11309656>
- Shatnawi, T., Ashour, L., & Kakeesh, D. (2020). Investigating the impact of atmospherics and online flow cues on visiting intentions: The case of Jordan's virtual tourist centre. *International Journal of Electronic Marketing and Retailing*. <http://doi.org/10.1504/IJEMR.2020.106430>
- Smith, C., Rafferty, K., Sharma, V., & Rainey, E. (2026). Toward efficient mixed reality: Cognitive load mitigation and performance enhancement in mixed reality tasks. *SN Computer Science*. <http://doi.org/10.1007/s42979-026-04894-w>
- Spais, G., Jain, V., Dwivedi, Y. K., Viglia, G., et al. (2025). A new walk in the future of the metaverse: Marketing implications for consumer behavior. *Journal of Consumer Behaviour*. <https://doi.org/10.1002/cb.2446>
- Sun, J., & Liao, T. (2025). Designing adaptive feedback systems for managing cognitive load in augmented reality. *Design Science*. <http://doi.org/10.1017/dsj.2025.10040>
- Sun, Y., Freeman, J., Shoenberger, H., & Shen, F. (2025). To tell or not to tell: Investigating the persuasive appeal of information transparency for AR-powered e-commerce sites. *International Journal of Human-Computer Interaction*. <http://doi.org/10.1080/10447318.2025.2495847>
- Suzuki, Y., Wild, F., & Scanlon, E. (2024). Measuring cognitive load in augmented reality with physiological methods: A systematic review. *Journal of Computer Assisted Learning*, 40(3), 1027–1049. <https://doi.org/10.1111/jcal.12882>



- Teng, Z., Cai, Y., Gao, Y., Zhang, X., et al. (2022). Factors affecting learners' adoption of an educational metaverse platform: An empirical study based on an extended UTAUT model. *Mobile Information Systems*, 2022. <https://doi.org/10.1155/2022/5479215>
- Uhlendorf-Leo, K., Uhrich, S., & Völckner, F. (2026). Getting hands on(line)? A meta-analysis of the effectiveness of extended realities in online retailing. *International Journal of Research in Marketing*. <http://doi.org/10.1016/j.ijresmar.2026.04.003>
- Upreti, K., Gangwar, D., Vats, P., Bhardwaj, R., et al. (2023). Artificial neural networks for enhancing e-commerce: A study on improving personalization, recommendation, and customer experience. *International Conference on Electrical and Electronics Engineering*. https://doi.org/10.1007/978-981-99-8661-3_11
- Wang, J., Mo, F., Qiao, S., Feng, H., & Lyu, Z. (2025). Spatial computing in digital twins. *Digital Twin*. <https://doi.org/10.1080/27525783.2025.2508268>
- Wang, S., & Wang, W. (2023). A review of the application of digital identity in the metaverse. *Security and Safety*, 2. <https://doi.org/10.1051/sands/2023009>
- Wei, W., & Bahari, M. B. (2026). Adaptive deep learning-based interactive virtual digital human system for enhanced customer engagement in the metaverse. *Journal of Circuits, Systems and Computers*. <http://doi.org/10.1142/S0218126626920027>
- Wu, H., & Zhang, W. (2023). Digital identity, privacy security, and their legal safeguards in the metaverse. *Security and Safety*, 2. <https://doi.org/10.1051/sands/2023011>
- Yu, L., & Chatpunyakul, C. (2025). Perceived augmented realism and technology fluidity: Enhancing purchase intentions in mobile augmented reality shopping among Chinese consumers. *Proceedings - 2025 6th International Conference on Computer Science, Engineering, and Education, CSEE 2025*. <http://doi.org/10.1109/CSEE64583.2025.00023>
- Yu, L., & Pan, C. (2026). The effects of perceived augmented realism and technology fluidity on purchase intention in AR virtual try-on: An S-O-R perspective. *Proceedings of SPIE*. <http://doi.org/10.1117/12.3109749>
- Yuan, D. H., Deng, R., & Lin, Z. (2026). When the thrill lingers: How post-purchase flow consciousness shapes live-stream shopping engagement. *European Journal of Marketing*. <https://doi.org/10.1108/EJM-09-2024-0783>
- Zhang, S., & Li, W. (2024). Applying eXtended Reality (XR) technology in commerce, management, and business applications: A survey. *2024 4th International Conference on Computer, Control and Robotics, ICCCR 2024*. <http://doi.org/10.1109/ICCCR61138.2024.10585599>
- Zhang, X., Yang, P., Guo, C., & He, P. (2026). Research on the influencing factors and mechanism of AR e-commerce consumers' purchase intention. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0351158>
- Zhao, X., Shi, C., You, X., & Zong, C. (2017). Analysis of mental workload in online shopping: Are augmented and virtual reality consistent? *Frontiers in Psychology*, 8. <https://doi.org/10.3389/fpsyg.2017.00071>
- Zhou, L., Niu, L., Wang, C. L., Wu, B., et al. (2025). Bridging the mental gap: The impact of augmented reality multiproduct presentation and recommendation strategy on consumer satisfaction. *International Journal of Consumer Studies*. <https://doi.org/10.1111/ijcs.70082>