Technology Integration in India's Real Estate Sector: Measuring Awareness of Virtual Reality and Closed-Loop Marketing

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Abstract:

This study aimed to explore the influence of virtual reality and closed-loop marketing as data-driven strategies for optimizing real estate sector performance. This study focused on identifying the factors that influenced the level of awareness of these technologies in the real estate sector. This study explored the perspectives of key stakeholders, namely, developers and agents, in both the commercial and residential sectors. Four latent variables and measures were identified through an extensive literature review. Based on this, a survey instrument was developed, distributed online, and 209 responses were received, including from developers and real estate agents. Exploratory factor analysis was used to validate the latent variables, and covariance-based structural equation modelling was used to measure their influence on the level of awareness. Information accessibility ($\beta = 0.626$) strongly influenced awareness of VR and CLM. Other factors, such as interactive experience quality ($\beta = 0.322$), social influence ($\beta = 0.291$), and system integration complexity ($\beta = 0.207$), had moderate influences. This study contributes to the body of knowledge by providing a validated scale and latent variables that real estate practitioners can use to develop change management strategies.

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Introduction

The rapid integration of digital and immersive technologies across industries had changed the way businesses operate nowadays (Azmi et al., 2021; Knight Frank, 2023). It allowed businesses to operate more efficiently, improved communication across different areas, and empowered data-driven decisions to be made faster and easier (Pleyers & Poncin, 2020). Hence, it was necessary for real estate companies to understand and adapt to these technology advancements to stay competitive and engage effectively with customers in an increasingly digital marketplace. In the past decade, real estate business had experienced significant growth in developing countries like India. This is the reason why it was predicted that the real estate market would cross USD 1 trillion by December 2030 and the sector would have a share of 13% in GDP (Knight Frank, 2023). And to achieve this target it was essential to use state-of-art technology e.g. virtual reality, closed loop marketing (Azmi et al., 2021; Knight Frank, 2023). In this context it was observed from extant literature that use of immersive technology in market research and customer engagement played a significant role in estimating market trends (Pleyers and Poncin, 2020; Mauri et al., 2023). These tools also helped to real estate developers to analyse user experience and optimise their property offering (Pleyers and Poncin, 2020; Mauri et al., 2023).

To address the increasing demand for digital solutions virtual reality (VR) was a tool that disrupted the property viewing experience in real estate sector and provided a competitive edge to the firms (Starr et al., 2020; Mauri et al., 2023). This was ensured by immersive feature of the VR which increase the level of interaction between properties and customer (Chen et al., 2024; Sahebzamani and Forcada, 2025). Since this tool empower the customers to seamlessly inspect properties a there was a significant increase in virtual property inspections (Pleyers & Poncin, 2020). On the other hand, CLM servers as a data capturing tool which retrieves user experience and process in real time which manifested strategy development (Dias

Garcia et al., 2024). It collected information e.g. engagement time, navigation paths, and the points of interest in a virtual tour to generate customer specific strategies for the real estate developers (Tähtinen and Toivonen, 2024; Zhang et al., 2024). Despite the high demand in the automotive and pharmaceutical industries, it had not yet been extensively used in real estate (Stoyanov et al., 2023). Powered by interaction data and feedback from customers, CLM was an addition to VR in the sense that it enhances a real estate firm's ability to engage with customers and supports them in personalizing their marketing campaigns (Dehghani et al., 2020; Jafar et al., 2023; Tekic and Füller, 2023).

Despite offering several advantages in the field of marketing effectiveness and customer engagement, the implementation of VR and CLM in the real estate sector had raised several issues. Key barriers are attributed to the cost of technology, differences in user knowledge, and concerns about stakeholder patriotism to current practices and dominant routines (Chen et al., 2024; Tähtinen and Toivonen, 2024; Sahebzamani and Forcada, 2025). Moreover, traditional real estate business models relied on personal relationships between developers, agents, and buyers, which was a major constraint in adoption of digital systems (Liu and Chen, 2025). Additionally, the sector's long-standing dependence on face-to-face interactions was completely different from that of technology-driven property sales (Zhang et al., 2024; Liu and Chen, 2025). These constraints affected the process of technology adoption in the real estate section because of which extensive planning and efforts are required to implement such technologies and overcome change resistance (Chen et al., 2024; Tähtinen and Toivonen, 2024). This necessitates raising awareness of VR and CLM technologies to ensure their successful implementation. Furthermore, from the extant literature, it was identified that VR and CLM had been examined as two different technologies (Dias Garcia et al., 2024; Liu and Chen, 2025; Sahebzamani and Forcada, 2025).

Within the real estate sector, past research had observed VR as an immersive tool that improved user's interactive experience (Balali et al., 2020; Allam and Jones, 2021; Babalola et al., 2023). Furthermore, researchers have argued that the adoption of immersive technology notably contributed to a company's profitability (Abbas et al., 2019; Allam and Jones, 2021). In addition, CLM was in its nascent stages of adoption in the real estate sector and there was limited evidence on how to incorporate it with current VR setups. But the adoption of CLM provided a data-driven approach to understand the buyer's requirements and their expectations during virtual property tours. This indicates a gap in the knowledge regarding the adoption and integration of VR and CLM in the real estate sector. Exploring this gap would enhance the performance of real estate developers and agents. This necessitated exploration of the perspective of key stakeholders in real estate sector on developing a tool that integrates VR and CLM. And for this reason, it was essential to measure the level of awareness of stakeholders about integration of VR and CLM.

Therefore, the study aimed to *identify the determinants of level of awareness of VR and CLM technologies in real estate sector and among its stakeholders i.e. real estate developers (RED), and real estate agents.* For this purpose, a validated scale was developed to measure the level of awareness of key stakeholders regarding the integration of VR and CLM for property sales. Hence, this study contributed to practice by developing a pre-validated scale that can be used globally by stakeholders to assess their readiness to adopt the combination of VR and CLM. Additionally, the importance of the factors was identified using structural equation modelling (SEM). Based on this, a roadmap for change management was provided for real estate developers and policymakers.

This study not only considered commercial implications, but wider strategic issues. By focusing integration between VR and CLM the study promoted innovation in real estate sector. These innovations played a significant role in enhancing customer's trust on real estate developers who were a key stakeholder. Therefore, the proposition of integrating VR and CLM was also a compliance with UNSDG 9 that targets resilient infrastructure, inclusive and sustainable industrialization, and fostering innovation. The study contributed to both real estate sector operationally by providing a framework for integration of VR and CLM. It advanced academic research on real estate digital marketing by providing strategies for operationalization of CLM and increasing awareness of integrating VR and CLM by providing a collaborative learning framework. This framework would play a vital role in improving operational efficiency, enhancing customer engagement, and promoted sustainable practices.

Operationalisation of Closed-Loop Marketing in Real Estate

In the real estate sector, Closed-Loop Marketing (CLM) was discerned as a feedback - based digital approach enabling real estate developers (RED) to interact and immerse potential buyers through behavioural insights gleaned from online and virtual interactions, (Dias Garcia et al., 2024; Ivanov and Webster, 2024). Unlike traditional industries such as pharmaceuticals where customer behaviours were discerned from product usage, the real estate field derived behavioural data solely from virtual engagements, (Deep et al. 2023). As a result, virtual tours and navigation patterns within virtual environments grew more frequent and user responses to promotional content also evolved, revealing new insights (Das et al., 2023; Knight Frank, 2023). Real-time feedback was collected through digital forms and chatbot interfaces (Tekic and Füller, 2023; Chen et al., 2024). This behavioural information was uploaded into Customer Relationship Management (CRM) systems, which were then used to automatically initiate personalized campaigns, reminders, or follow-ups (Tekic and Füller, 2023; Chen et al., 2024).

In India, developers also employed WhatsApp-based customer acquisition, dynamic e-mail campaigns, and content personalization on listing portals (Knight Frank, 2023). Although these systems were in the early stages of integration, their implementation was limited to developers based in metropolitan cities (Das et al., 2023; Shenoy, 2023). These developers had implemented digital marketing dashboards that combined site engagement data with sales CRM systems (Deep et al., 2023). This indicated an immature implementation of CLM concepts, where real estate firms had begun experimenting with data-driven marketing tools. But there was requirement of a systematic framework to capture, process, and utilize customer interaction data for automated decision-making. Lack of sophistication in processes and poor cross-functional integration indicated that most firms had not yet institutionalized CLM as a strategic capability.

Literature Review

International research on VR and CLM in real estate and marketing

Technologies in the Industry 5.0 era are making organizations interact and communicate differently with their customers (Adami et al., 2021). In this context, VR had enhanced property visualization, urban simulation, and remote decision-making in real estate (Tähtinen and Toivonen, 2024; Zhang et al., 2024; Liu and Chen, 2025). Its benefits included improved spatial perception by providing an immersive experience to the buyer, resulting in reduced transaction time (Lyu et al., 2023; Chen et al., 2024; Ivanov and Webster, 2024). This had been acknowledged globally in various studies conducted across countries e.g., USA, UK, Europe, and China (Yu et al., 2022; Lyu et al., 2023). Closed-Loop Marketing (CLM) is a popular tool in the pharmaceutical and retail industries for understanding consumer behavior (Stoyanov et al., 2023; Dias Garcia et al., 2024). This allowed targeted communication that aligned user behavior with marketing strategies through automation and data. In real estate, it can automate marketing responses and track customer engagement, and this data was used by developers to create customer-specific marketing strategies. From the extant literature, it was observed that these technologies have been explored separately in the past. Additionally, few studies have explored the application of CLM in the real estate sector.

Furthermore, in the case of integrating VR and CLM, VR was mainly adopted to display virtual tours, and CLM captured the facial expressions and reactions of buyers (Yu et al., 2021; Stoyanov et al., 2023). While this combination of technology was designed to enhance marketing, client engagement, and decision-making, there has been limited discussion of its application in real estate. Most previous research had focused on technical features and paid little attention to stakeholders' perspectives. Hence, the present level of understanding of this integration was unclear. Therefore, this study aimed to fill this gap, particularly during the digitalization period.

Digital innovation and adoption in India's real estate sector

According to recent predictions, the Indian real estate sector was set to experience significant growth. By 2030, it was projected to achieve a market size of 1 trillion US dollars and account for 13 percent of the national GDP by 2025 (Das et al., 2023; Knight Frank, 2023). This growth was predominantly driven by increasing demand from commercial real estate, especially the office and retail segments ((Das et al., 2023). Technology firms are also transitioning to co-working spaces, which added to the transformation of the sector (Das et al., 2023; Shenoy, 2023). These trends emphasized the importance of exploring the sector's evolving practices with respect to emerging technologies.

India's real estate sector was a mix of evolving digital initiatives and traditional systems. Visualization tools and property technology platforms have introduced Virtual Reality, but its adoption had been limited to developers in metropolitan cities (Das et al., 2023; Knight Frank, 2023). The high compliance cost of legislation, such as the Real Estate (Regulation and Development) Act and the Goods and Services Tax, act as significant barriers to the adoption of digital technologies, alongside a fragmented market and low digital awareness (Financial, 2022; Lawkins, 2023; Sobha, 2023). Peer decisions and short-term business value typically drive technology choices. The Indian context remains focused on building information Modelling, enterprise systems, and e-governance (Deep et al., 2023; Lawkins, 2023; Shenoy, 2023). Tools for immersive and integrated marketing are never mentioned, and there was no validated framework to measure the level of awareness of developers and agents.

Immersive technologies in construction and real estate

Immersive technologies such as virtual reality (VR), augmented reality (AR), and extended reality (XR) have played a significant role in transforming real estate marketing and construction processes. These technologies have transformed marketing strategies by improving customers' property viewing experience. Balali et al. (2020) developed a VR-based material selection that enabled real-time cost estimation and facilitated design visualization. Research has also found that VR positively influenced consumer experience, which influences their property purchase intentions (Pleyers and Poncin, 2020; Azmi et al., 2021). In this scenario, the use of CLM helps create a feedback system that records the sentiments of buyers, which can be used to predict the chances of purchase in real time (Allam and Jones, 2021).

However, the high cost of installations, lack of well-trained manpower, compatibility, and cybersickness limit the application and implementation of VR and CLM in real estate (Davila Delgado et al., 2020; Li et al., 2022). Therefore, to optimize operational efficiency and truly benefit from the use of VR and CLM, it was necessary to create a framework that addresses these limitations. This framework would help real estate developers improve customer acquisition through data-driven strategies. Moreover, this would enhance the decision-making capabilities of both developers and agents, resulting in transparency and enhanced customer satisfaction. The following reasons informed the study’s aim to develop a framework for policymakers and process owners to address the barriers faced by real estate developers by understanding their level of awareness:

- Virtual tours provide immersive experiences, and CLM analytics track customer interactions that improved the effectiveness of marketing strategies (Zhang et al., 2024; Liu and Chen, 2025).
- System integration was a complex issue due to limited skill availability (Tähtinen and Toivonen, 2024; Sahebzamani and Forcada, 2025).
- Improving property buyer experiences increased the acceptance of VR and CLM integration among developers (Deep et al., 2023; Flathmann et al., 2023; Mauri et al., 2023).

Based on the above arguments, it can be stated that variables e.g. Information accessibility and interactive experience quality influenced the behavioural approach of real estate firms. System integration complexity and social influence served as reasons that influenced the actions (business decisions) of the organizations. Hence, to measure the influence of these factors on awareness of VR and CLM among real estate firms, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2012) was a suitable theoretical lens.

Theoretical Lens

According to Venkatesh et al. (2012), unified theory of acceptance and use of technology framework provided a useful lens to understand the processes that determine how individuals adopt and utilize new technology. The conceptual model comprised of constructs that were mapped to performance expectancy, effort expectancy, social influence and facilitating conditions attributes (Venkatesh et al., 2012). These factors were developed to measure the acceptance of new technologies by individuals or organizations. The element of performance expectancy was operationalized in the variable information access that measured the influence of information availability on level of awareness of VR and CLM. Because in some cases, it was found that when employees were provided with specific training in the application of VR and CLM, their contribution level increased, which help the real estate developers to increase property sales (Renigier-Bilozor et al., 2020).

Similarly, effort expectancy was related to interactive experience quality, as the ease of business that VR property tours offer influenced firms' perceived ease of adopting such technologies (Lyu et al., 2023). Additionally, social influence showed the impact of peer influence and social networks on technology adoption within organizations (Mauri et al., 2023). Finally, facilitating conditions were demonstrated by the variable of system integration complexity. This variable focused on the operational and logistical aspects that facilitated the successful implementation and use of new technologies (Yu et al., 2021). Additionally, it ensured efficient change management that supported the sustained use of VR and CLM technologies in the real estate industry.

Reinforcing Research gap

Existing studies had analyzed VR and CLM as different technologies, and there had been limited investigation on the integration of these technologies and how they influence real estate practices (see figure 1). In addition, understanding how professionals in this sector make sense of and respond to the incorporation of these tools was limited. In India, most studies on adoption had focused on compliance with government policies or enterprise systems, with a limited focus on technologies for customer engagement. Empirical analyses often exclude developers and agents who affected sales decisions through direct interaction with clients. This study addresses this gap through a conceptual model that explored the factors influencing the level of awareness of VR and CLM integration. These factors include access to information experience, quality technical integration, and peer influence. This study provides new insights by integrating these factors within a framework and addressing the gap of integrating VR and CLM in the real estate sector.

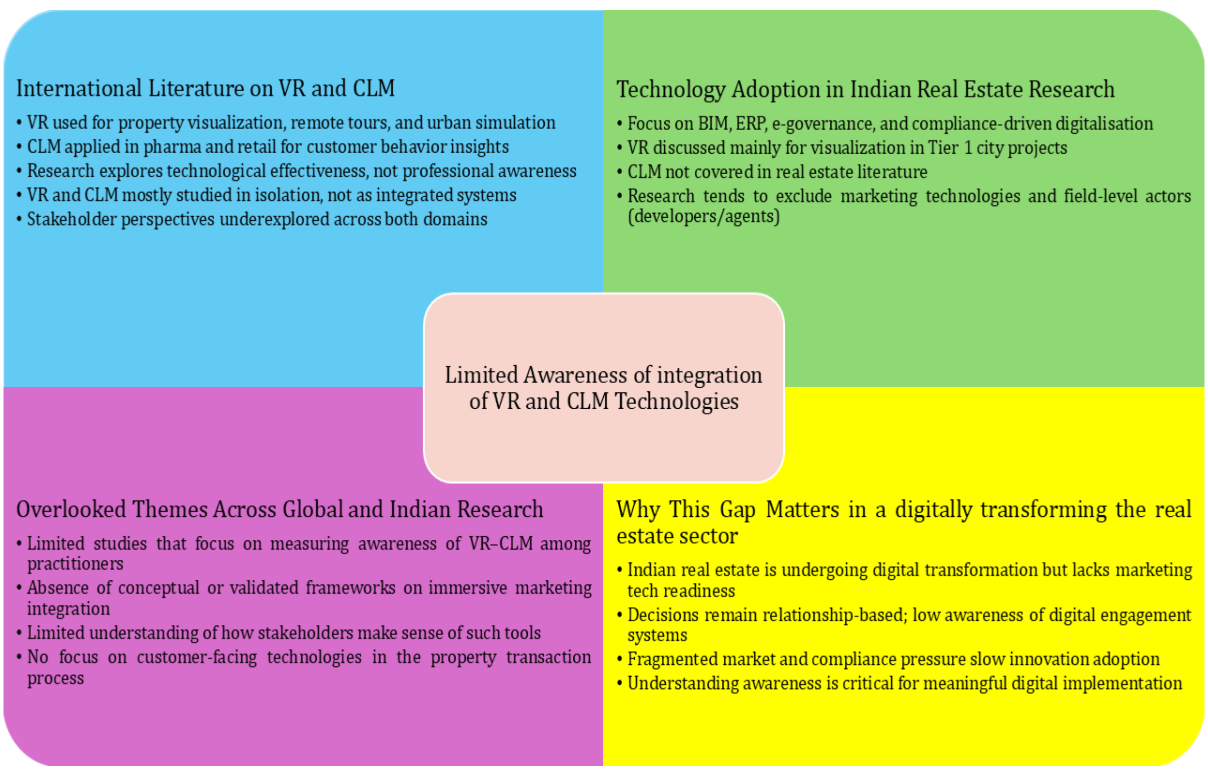

Figure 1 The gap in body of knowledge

Variable Definition and Hypothesis Development

Level of VR and CLM awareness

To contextualise VR and CLM in the context of the real estate sector, the measures for evaluating awareness were developed using the suggestions of Cai et al. (2009) as well as the findings of Azmi et al. (2021) and Yu et al. (2021). A basic understanding of VR and CLM was represented by a general acquaintance with these technologies. Their use in creating virtual property tools and automated client communications was demonstrated by application recognition. The factor benefit comprehension explored the perceived value of integrating VR and CLM in the context of increased savings and enhanced customer satisfaction.

Customer engagement insight and marketing strategy knowledge were employed as metrics to ascertain the facets of the application of these technologies to improve marketing communications by REDs (Li et al., 2022). Furthermore, to understand the perceptions of RED and agents on the importance of feedback, measure e.g., the level of understanding about real-time data collection, the value of behavioral data collected were added to the questionnaire (Yılmaz Altuntaş and Yalçın, 2023). Lastly, personalization perception and sales improvement perception reflected RED's VR and CLM perception for personalized client interaction to achieve sales target (de Regt et al., 2021).

Information Accessibility

According to the extant literature, Information Accessibility (IA) was found to impact VR and CLM Awareness in real estate. Measures of this variable were taken from Flathmann et al. (2023) and were adapted to real estate. Measures have been revised based on the findings of Marikyan et al. (2019) and Davila Delgado et al. (2020). Source diversity was a measure used to examine how the relationship between availability of more than one channel of information may affect choices of the customer (Stoyanov et al., 2023). In addition, the ease with which a user learns how to operate VR environments and instructions for creating content are the two most important measures for assessing the userfriendliness of the technology (Pleyers and Poncin, 2020). Furthermore, the use of VR and CLM enhanced the level of engagement and developed the collaborative learning environment (Mauri et al., 2023). This allowed RED to democratize its approach, particularly for affordable housing projects. Consequently, IA had an impact on the cognition of VR and CLM technology of the real estate industry. Therefore, the following hypothesis can be proposed:

H1: Information Accessibility influences the level of awareness of VR and CLM.

Interactive Experience Quality

The adoption of VR and CLM by RED and agents provided an interactive and immersive experience for customers (Azmi et al., 2021). Therefore, it influenced the quality of user engagement and interaction, which influenced the reputation of RED (Renigier-Bilozor et al., 2020). The application of VR-aided RED enhanced the quality of engagement and use of information, while CLM allowed emotion tracking for the client, leading to more customization (Pleyers and Poncin, 2020). Similarly, property navigation ease provided by VR and the faster response time of CLM helped RED to streamline their interaction with customers (Mauri et al., 2023).

Moreover, according to Babalola et al. (2023), the immersive experience offered by VR was important for better consumer engagement, and the use of CLM helped RED develop their marketing content. In addition, the interaction responsiveness provided by VR and content relevance provided by CLM increased the interactive quality of property tours (Flathmann et al., 2023). Finally, cross-platform compatibility and the performance of adaptive techniques are important indicators of VR and CLM adoption, which significantly influenced user behavior (Li et al., 2022). Therefore, the following hypothesis can be proposed:

H2: Interactive experience quality influences the level of awareness of VR and CLM.

System Integration Complexity

In the real estate setting, evidence showed that SIC affected the knowledge of VR and CLM, as it played a vital role in change management (Diego-Mas et al., 2020; de Regt et al., 2021). The degree to which technology can be integrated into current system applications was key to successful technology adoption. In this context, software compatibility and the flow of data complexes were influential factors for adopting VR and CLM technologies (Lu et al., 2013; Lyu et al., 2023). In addition to software, for system integration, problems with hardware integration and alignment with multiple channels using a mix of VR and CLM were further factors that affected system integration (O'Brien et al., 2018; Mauri et al., 2023).

The complexities in the integration of VR and CLM were influenced by challenges in producing VR content and analysing data in real time due to the limited training of workers (Marikyan et al., 2019; Lyu et al., 2023). These aspects influenced the acceptance of the VR-CLM combination that impacted its interoperability and maintainability (Spielmann and Mantonakis, 2018). Moreover, complexity was increased by designing specialized VR systems and capturing relevant feedback from CLM (Diego-Mas et al., 2020). Additionally, in the case of using a combination of VR and CLM to achieve system integration, synchronization, and customization of the CLM operation platform for VR data increased the complexity of the system, which impacted the change management process (Azmi et al., 2021). Therefore, the following hypothesis can be proposed:

H3: System Integration Complexity influences the level of VR and CLM awareness.

Social Influence

Social influence was reflected in the interest of competitors in an application and was another influencer of VR and CLM adoption in real estate (Lyu et al., 2023). In this context, technology perceived by peers and the influence of industry leaders were stimuli for professionals because of their effect on RED and agents' curiosity about a technology (Cai et al., 2009). Since VR and CLM were new, there was pressure from a social context due to client expectations and competitors' roll-out to benefit from a market leader advantage (Babalola et al., 2023).

Moreover, the dimension of legal compliance regarding privacy and legal issues of technology use influenced adoption (Li et al., 2022). Herein, community participation and cooperation at the industry level developed nurturing ecosystems for the adoption and implementation of such technologies (Mauri et al., 2023). In this context, media play was crucial for both the public and organizations dealing with technology adoption. Media attention to VR and CLM has also contributed to their increased application. Finally, a training session on VR and CLM technology in this organizational culture affected its application (Lyu et al., 2023). Therefore, the following hypothesis can be proposed:

H4: Social Influence affects the level of awareness of VR and CLM.

Based on the hypothesis derived from the above discussion, the conceptual model developed was tested as part of this study (Figure 2), and the indicators of the variables are presented in Table 1.

Table 1 Variable and their Measures

Variable	**Measures**		**References**
VR and CLM Awareness	VCLA1	General Acquaintance	Li et al. (2018); Renigier-Bilozor et al. (2020); de Regt et al. (2021); Yılmaz Altuntaş and Yalçın (2023)
	VCLA2	Application Recognition	
	VCLA3	Benefit Comprehension	
	VCLA4	Customer Engagement Insight	
	VCLA5	Marketing Strategy Knowledge	
	VCLA6	Feedback Importance	
	VCLA7	Real-time Data Collection Understanding	
	VCLA8	Personalization Perception	
	VCLA9	Behavioural Data Value	
	VCLA10	Sales Improvement Perception	
Information Accessibility	IA1	VR Source Diversity	Azmi et al. (2021); (2021; 2022); Babalola et al. (2023); Mauri et al. (2023)
	IA2	CLM Source Diversity	
	IA3	VR Instructions Understandability	
	IA4	CLM Strategy Clarity	
	IA5	Availability of VR Guides	
	IA6	CLM Practice Guides	
	IA7	VR Community Support	
	IA8	CLM Community Engagement	
	IA9	VR Information Reliability	
Interactive Experience Quality	IA10	CLM Method Relevance	Abbas et al. (2019); Allam and Jones (2021); Yu et al. (2021); Mauri et al. (2023)
	IEQ1	VR Engagement Quality	
	IEQ2	CLM Personalized Interaction	

	IEQ3	VR Navigation Ease	
	IEQ4	CLM Response Timeliness	
	IEQ5	VR Visual Realism	
	IEQ6	CLM Customer Insight Accuracy	
	IEQ7	VR Interaction Responsiveness	
	IEQ8	CLM Content Relevance	
	IEQ9	VR Cross-Platform Compatibility	
	IEQ10	CLM Adaptive Strategy Efficiency	
System Integration Complexity	SIC1	VR Software Compatibility	Marikyan et al. (2019); Balali et al. (2020); Diego-Mas et al. (2020); Lyu et al. (2023)
	SIC2	Data Flow Complexity	
	SIC3	VR Hardware Integration Difficulty	
	SIC4	Multichannel Coordination	
	SIC5	VR Content Development Complexity	
	SIC6	Real-Time Analysis Difficulty	
	SIC7	VR Interface Design Challenge	
	SIC8	Feedback Loop Complexity	
	SIC9	VR & CLM Integration Synchronization	
	SIC10	CLM Customization Challenge	
Social Influence	SI1	Peer Adoption Influence	Abbas et al. (2019); Marikyan et al. (2019); Diego-Mas et al. (2020); Mauri et al. (2023); Yılmaz Altuntaş and Yalçın (2023)
	SI2	Industry Leader Endorsement	
	SI3	Client Expectation Alignment	
	SI4	Competitive Pressure	
	SI5	Regulatory Compliance Influence	
	SI6	Community Engagement Impact	
	SI7	Collaborative Network Effect	
	SI8	Media Coverage and Public Perception	
	SI9	Cultural Alignment with VR and CLM	
	SI10	Influence of Educational Workshops	

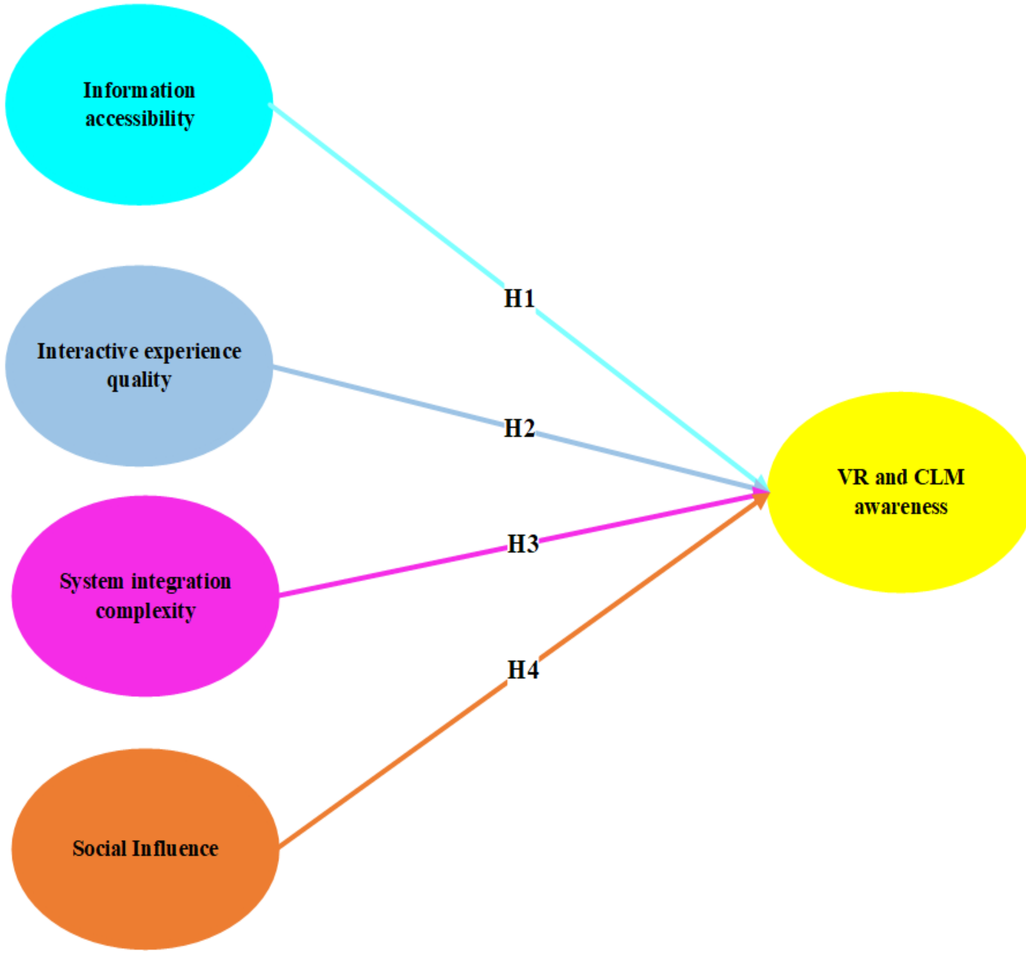

Figure 2 Conceptual Framework

Research Methodology

The study employed a quantitative method with a structured questionnaire survey from previous literature. A structured survey served as an efficient approach to gather expert opinions and perspectives (Roopa and Rani, 2012). It also encouraged an analysis of complex issues based on many respondents (Creswell and Creswell, 2017). The research problem was addressed using a theory-based research framework and methodology namely the Unified theory of acceptance and use of technology (UTAUT). Four latent variables, such as Information Accessibility (IA), Interactive Experience Quality (IEQ), System Integration Complexity (SIC), and Social Influence (SI) were proposed in the conceptual model to test their impacts directly or indirectly on the extent of awareness for the integrated VR and CLM technologies. The sub sections below explain the design and pre-testing of the survey, the sampling strategy, the data collection and the statistical analyses.

Instrument Development and Pre-testing

The survey instrument was developed by modifying the survey instruments of Cai et al.. (2009), Flathmann et al. (2023), O'Brien et al. (2018) and recommendations of Venkatesh et al. (2012) and Fishbein and Ajzen (2005). The questionnaire consisted of two sections, first section collected demographic information e.g. experience, job role, and area of work. In the second section, the respondents were required to rate the survey items comprising variable measures on a Likert scale of (1 "strongly disagree" to 5 "strongly agree"). This study was conducted in accordance with the institutional ethical guidelines, and informed consent was obtained from all participants. To obtain the consent of the participants, a participant information statement was provided to the participants on the first page of the survey, where they had to record their consent to participate before answering the questionnaire.

As the instrument was developed from the literature, pre-testing was essential. For this purpose, a pilot study was conducted to measure the internal consistency of the instrument. For the pilot study, 40 highly experienced RED and agents were approached, but only 35 responded to the study. Therefore, the pilot study results were analyzed using the responses of 35 participants. Fifteen of the participants had between 10 and below 15 years of experience, 13 between 15 and below 20 years of experience, and 7 possessed above 20 years of industry experience. The group consisted of 10 real estate developers and 25 agents who represented different roles based on decision-making responsibilities and direct involvement in property sales. In relation to their working area, 28 participants worked in commercial real estate and 7 were working in the residential areas. The Cronbach's alpha value for the entire scale was 0.89, confirming the internal consistency of the scale. With these informative suggestions, some minor tweaks were made to the wording, while construct definitions were not changed. To facilitate interpretation and transparency, the full list of questions asked in the survey were published in the appendix A, alongside the variable codes and the 5-point Likert scale for responses. In addition, Appendix B presented item-wise survey results, including means, standard deviations, and standard errors for all constructs.

Sampling and Data Collection

The sample size was established using G-Power software calculations to guarantee validity and reduce the likelihood of sampling bias (Faul et al., 2009). In this analysis, a significance level of 0.05 and a confidence interval of 0.95 with an error margin of 0.05 were assumed. From this calculation, it was found that a minimum of 200 responses was required for the study. This was in accordance with the recommendation of Hair et al. (2016) and Kline (2023) regarding the minimum sample size for SEM-based studies. Data were collected from August 2022 to December 2023 using an online structured questionnaire in two tranches. In the first tranche e.g. from August 2022 to April 2023, the survey was conducted using random sampling to reach a wide population of real estate professionals, but only 115 responses were received, of which 30 were incomplete. The response rate in this tranche of the survey was extremely low, primarily due to the RED's, and agents were not aware of VR tools for property inspections and CLM. Therefore, a purposive sampling approach was chosen, where RED and agents associated with medium-to large-scale real estate firms were approached through the Confederation of Real Estate Developers of India (CREDAI). Additionally, it was ensured that the minimum qualification of all the RED workers and real estate agents had at least a bachelor's degree. This ensured that the participants had knowledge of these tools. The second tranche of the survey was conducted from May 2023 to December 2023. This included all developers and agents who were previously exposed to digital, platforms, marketing tools, etc., where 135 responses were received, of which 11 responses were incomplete. In this survey, 250 responses were received, of which 41 were incomplete; therefore, the remaining 209 responses were used for analysis. Since the response rate was low (17 %), sampling and selection biases were checked following the recommendations of Wang and Jentsch (1998) and Panzeri et al. (2008).

Biases such as social desirability, non-responsiveness, and recall were tested following the recommendations of Armstrong and Overton (1977) and Kreitchmann et al. (2019). To evaluate non-responsiveness bias, a chi-square test was performed. Experience ($\chi^2 = 2.17$, $p = 0.704$), Job Role ($\chi^2 = 1.38$, $p = 0.240$), and Area of Work ($\chi^2 = 0.005$, $p = 0.945$) showed no statistically significant association, as the p-values exceeded the threshold of 0.05; hence, there was no non-responsiveness bias. A skewness test was performed to assess social desirability bias. The skewness values for experience (0.054), job role (-0.30), and area of work (0.20) were within the range of -1 to 1; hence, there was no social desirability bias. Furthermore, the recall bias was assessed using experience as a variable whose skewness was 0.054, which was again between -1 and 1; hence, there was no recall bias. These findings imply that the respondents perceived the content of the questionnaires and had informed opinions; thus, there would be little sampling bias. Various approaches had been used to reduce common method bias in surveys, such as well-constructed items and separating items from the constructs (Podsakoff et al., 2003). Harman's one-factor test showed that the first factor accounted for 23.213% of the total variance, which was below the 50% cut-off value, demonstrating that common method bias was not a major issue (Harman, 1976; Anderson and Gerbing, 1988).

Data Analysis Strategy

The analysis method was structured to confirm the conceptual structure and examine the relationships between the constructs applied in the model using a staged procedure in a multistage process. The analysis procedure was similar to that of Chen et al. (2024), who used two statistical methods to verify a literature-generated conceptual model. First, an EFA was conducted to investigate the structure of the items and loadings. A confirmatory analysis was conducted to test both the reliability and validity of the measure and the structural paths. To ensure methodological rigor, the model was evaluated using CB-SEM and PLS SEM. The model was confirmed with CB-SEM to confirm correct model specification and to ensure robustness of results with PLS-SEM, as the sample size was small. The choice of the joint estimation method is based on a comparison of the different capabilities of the methods in terms of estimation, error assessment, and latent effect examination. This section presents the motivations for the analysis methods, their application, and the steps performed. The proposed analysis structure was shown in figure 3.

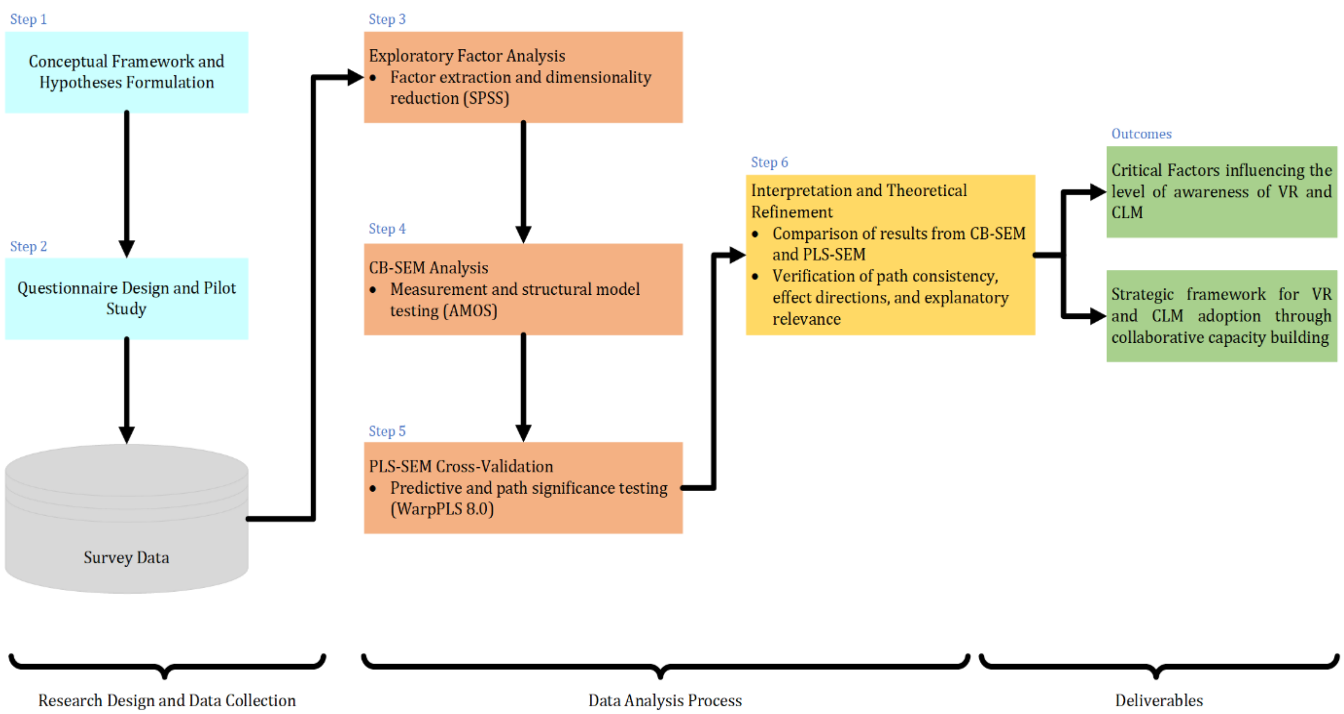

Figure 3 Proposed Procedure of Analysis

Structural Equation Modelling Using CB-SEM

The goodness-of-fit of the model was validated using covariance-based structural equation Modelling (CB-SEM) for the relationships between dependent and independent factors. CB-SEM was considered an important tool for confirmatory research, where measurement and structural models were evaluated simultaneously, accounting for measurement errors. The validity of the model was tested using AMOS software, and convergent and discriminant validity was determined based on the most influential measures, i.e., factor loadings, AVE, and CR.

PLS-SEM for Cross-Validation

To overcome the limitations associated with the sample size, the CB-SEM results were cross-validated using partial least square structural equation modelling (PLS-SEM). PLS-SEM was particularly well-suited for research environments encoding complex models with several constructs and little demand in terms of the normal distribution of the data and sample size. To perform PLS-SEM analysis Warp-PLS 8.0 software was used. The measurement model's construct validity was assessed based on CR, AVE, and indicator loadings. All CR values were higher than 0.90, and the AVE values surpassed the threshold of 0.50, confirming consistency and convergent validity. The HTMT (Heterotrait–Monotrait) ratio was used to examine discriminant validity, and values were less than 1 for all pairs of constructs. The predictivity of the models was evaluated using Stone-Geisser's Q^2, calculated by means of leave-several-out cross-validation. The results obtained from the PLS-SEM were consistent with the results of the CB-SEM and reaffirmed the reliability of the model, hence increasing the construct validity of the theoretical constructs.

Result and Analysis

Demographic profile of respondents

The respondents included 209 professionals in the Indian real estate industry, comprising 89 REDs and 120 agents. Among the respondents, 82 reported 5–10 years of experience in the industry, 44 reported 10–15 years, 60 reported 15–20 years, and 23 reported more than 20 years of experience. This suggests a sample with considerable domain knowledge. In terms of their field of work, 115 were in commercial real estate and 94 were in the residential real estate sector. Additionally, 70 respondents were from small-scale firms, 85 worked in medium-sized firms, and 54 belonged to large-scale firms. The demographic profiles were shown in Table 2.

Table 2 Demographic Profile of Respondents

Control Variable	***Categories***	***Frequency***
Role	Real Estate Developers (RED)	89
	Agents	120

Experience	5-10 years	82
	10-15 years	44
	15-20 years	60
	20+ years	23
Field of Work	Commercial Real Estate	115
	Residential Real Estate	94
Firm Size	Small (Less than 50 employees)	70
	Medium (more than 50 to less than 250 employees)	85
	Large (250+ employees)	54

Sample-Level Variation in Awareness Scores

To examine whether professional or organisational characteristics influenced awareness of Virtual Reality and Closed-Loop Marketing Awareness (VCLA), one-way ANOVA tests were conducted using job role, years of experience, and firm size as factors. No statistically significant variation was found across job roles ($F = 1.838$, $p = 0.177$) or experience levels (Tukey-adjusted p-values: 0.188–0.929). A marginal difference emerged across firm size categories ($F = 2.537$, $p = 0.082$), with participants from small firms reporting higher mean awareness than those from medium-sized firms ($p = 0.067$). These results did not reach the standard thresholds for statistical significance and were therefore treated as indicative rather than conclusive.

This absence of strong group-level variation aligns with the early-stage nature of CLM implementation. This was consistent with the literature, which shows that real estate firms in India had only recently begun experimenting with behavioural data capture and CRM integration, primarily within metro-based firms. The lack of a structured or institutionalized approach to CLM adoption limited the extent to which awareness was stratified by organizational role or seniority level. Instead, awareness appeared to emerge in more ad hoc and exposure-dependent ways, shaped by interactions with pilot systems or isolated digital initiatives rather than by embedded institutional processes. These patterns reinforce the view that VCLA was affected by incomplete and uneven system development, not differences between demographic groups.

Reliability and Validity

Before proceeding with hypothesis testing, construct validity was established using Cronbach's alpha and composite reliability. The values of Cronbach's alpha and composite reliability were found to be more than the threshold of 0.70, signifying an acceptable internal consistency among the indicators Hair et al. (2019) (Table No. 2). As recommended by Hair et al. (2019), to establish convergent validity, the value of factor loadings and composite reliability should be above 0.70, and the AVE must be larger than 0.50. The results of the study satisfied the required criteria, as the value of CR varied from 0.901 to 0.97, and the AVE ranged from 0.53 to 0.78, thereby establishing convergent validity (see Table 2). Moreover, discriminant validity was also established as the square root values of AVE (bold diagonal elements) were found to be more than the correlation coefficients' off-diagonal elements Fornell and Larcker (1981) (Table No. 3)

Table 3 Results of reliability and validity

Variables	CA-Pilot	CA-Main	CR	AVE	IEQ	SIC	SI	VCLA	IA
IEQ	0.822	0.945	0.970	0.780	**0.883**				
SIC	0.895	0.925	0.968	0.769	0.67	**0.877**			
SI	0.912	0.955	0.967	0.768	0.32	0.41	**0.876**		
VCLA	0.865	0.978	0.932	0.579	0.17	0.45	0.31	**0.761**	
IA	0.880	0.961	0.901	0.533	0.42	0.64	0.28	0.259	**0.730**

Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) was performed using principal component analysis with varimax rotation in SPSS, following the recommendations of Pallant (2020). The Kaiser-Meyer-Olkin (KMO) measure was 0.912, and Bartlett's test of sphericity was significant ($\chi^2 = 8731.293$, $df = 1035$, $p < 0.001$), which showed that the sample was adequate for factor analysis. Five components with eigenvalues above

1 were extracted, contributing to 61.286% of the total variance. The first four components explained more than 14% of the variance, and the fifth accounted for 8.951% of the variance. The factor loadings indicated good construct separation. The first component was Interactive Experience Quality (IEQ), followed by System Integration Complexity (SIC), Social Influence (SI), VR–CLM Awareness (VCLA), and Information Accessibility (IA). The loadings of each construct surpassed the 0.50 threshold, which supported construct validity. These results confirmed a latent structure consistent with a theoretical model and the existing literature and provided empirical support for the inclusion of these variables in the confirmatory analysis. The results of EFA were shown in in table 4

Table 4 Results of Exploratory Factor Analysis

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.				0.912
Bartlett's Test of Sphericity		Approx. Chi-Square		8731.293
		df		1035
		Sig.		0.000
		Initial eigen values	**% Variance**	**Factor Loadings**
CLM Personalized Interaction	IEQ2			.906
VR Navigation Ease	IEQ3			.901
VR Engagement Quality	IEQ1			.900
CLM Customer Insight Accuracy	IEQ6			.898
VR Cross-Platform Compatibility	IEQ9	7.982	15.818	.898
VR Interaction Responsiveness	IEQ7			.892
CLM Content Relevance	IEQ8			.887
VR Visual Realism	IEQ5			.886
CLM Response Timeliness	IEQ4			.878
CLM Data Flow Complexity	SIC2			.906
VR & CLM Integration Synchronization	SIC9			.897
VR Hardware Integration Difficulty	SIC3			.894
VR Software Compatibility	SIC1			.893
CLM Real-Time Analysis Difficulty	SIC6	7.652	15.645	.891
VR Content Development Complexity	SIC5			.888
CLM Feedback Loop Complexity	SIC8			.885
CLM Multichannel Coordination	SIC4			.883
VR Interface Design Challenge	SIC7			.880
Cultural Alignment with VR and CLM	SI9			.906
Client Expectation Alignment	SI3	6.989	15.629	.901
Industry Leader Endorsement	SI2			.900

Competitive Pressure	SI4			.893
Collaborative Network Effect	SI7			.891
Peer Adoption Influence	SI1			.889
Media Coverage and Public Perception	SI8			.888
Regulatory Compliance Influence	SI5			.873
Community Engagement Impact	SI6			.870
Benefit Comprehension	VCLA3	6.442	13.661	.815
General Acquaintance	VCLA1			.802
Sales Improvement Perception	VCLA10			.789
Personalization Perception	VCLA8			.785
Customer Engagement Insight	VCLA4			.785
Real-time Data Collection Understanding	VCLA7			.777
Feedback Importance	VCLA6			.774
Marketing Strategy Knowledge	VCLA5			.771
Application Recognition	VCLA2			.758
Behavioural Data Value	VCLA9			.746
VR Information Reliability	IA9	4.117	11.379	.818
VR Community Support	IA7			.798
CLM Method Relevance	IA10			.796
CLM Community Engagement	IA8			.780
VR Instructions Understandability	IA3			.746
VR Source Diversity	IA1			.728
CLM Strategy Clarity	IA4			.713
CLM Practice Guides	IA6			.702

Model fit and hypothesis testing

The validity of the latent constructs was evaluated using confirmatory factor analysis (CFA) Table 4). The analysis began with the measurement of the goodness-of-fit indices (GFI) and the following results were derived: chi-square/df ($\chi 2$/df) = 0.861<3 by McIver and Carmines (1981); comparative fit index (CFI) = 0.996>0.90, GFI = 0.935>0.90 by Browne and Cudeck (1992); and the root mean square error of approximation (RMSEA) 0.015= <0.08, by Hu and Bentler (1999). All estimates met or exceeded the recommended thresholds, indicating excellent model fit across the indices. The results of the confirmatory factor analysis were shown in figure 4. The conceptual model developed from the literature was tested using CBSEM observations.

- IA (β = 0.489) has a strong influence on VR and CLM awareness, H1 was accepted

- IEQ (β = 0.241) moderately influences VR and CLM awareness, H2 was accepted
- SIC (β = 0.192) moderately influences VR and CLM awareness, H3 was accepted
- SI moderately (β = 0.212) influences VR and CLM awareness, H4 was accepted

The results were shown in Table 5, and figure 5 shows the results of the CB-SEM analysis.

Table 5 Result of Model Evaluation

Model Fit Indices	**Estimate**		**Threshold**	**Interpretation**
CMIN/DF	0.861		< 3.0	Excellent
GFI	0.935		> .90	Excellent
TLI	0.986		> .90	Excellent
CFI	0.996		> .90	Excellent
RMSEA	0.015		< .08	Excellent
SRMR	0.033		< .06	Excellent
Model Evaluation using CB-SEM				
R^2 for the dependent variable			0.62	Acceptable
Independent Variable	**path coefficient**	**Standard Error**	**p value**	**Hypothesis**
IEQ	0.241	0.068	0.013	Supported
SIC	0.197	0.053	0.002	Supported
SI	0.212	0.087	0.000	Supported
IA	0.489	0.052	0.000	Supported
Standardized Regression Weights				
Variable and their measures	**Path**			**Estimate**
CLM Personalized Interaction	IEQ2	←	IEQ	0.905
VR Cross-Platform Compatibility	IEQ9	←	IEQ	0.877
CLM Content Relevance	IEQ8	←	IEQ	0.887
CLM Response Timeliness	IEQ4	←	IEQ	0.869
VR & CLM Integration Synchronization	SIC9	←	SIC	0.892
VR Software Compatibility	SIC1	←	SIC	0.882
Real-Time Analysis Difficulty	SIC6	←	SIC	0.872
Feedback Loop Complexity	SIC8	←	SIC	0.858
Multichannel Coordination	SIC4	←	SIC	0.873
Cultural Alignment with VR and CLM	SI9	←	SI	0.901
Client Expectation Alignment	SI3	←	SI	0.895
Industry Leader Endorsement	SI2	←	SI	0.891
Competitive Pressure	SI4	←	SI	0.873
Collaborative Network Effect	SI7	←	SI	0.867

Media Coverage and Public Perception	SI8	←	SI	0.879
Community Engagement Impact	SI6	←	SI	0.855
General Acquaintance	VCLA1	←	VCLA	0.802
Personalization Perception	VCLA8	←	VCLA	0.773
Customer Engagement Insight	VCLA4	←	VCLA	0.784
Real-time Data Collection Understanding	VCLA7	←	VCLA	0.733
Feedback Importance	VCLA6	←	VCLA	0.752
Application Recognition	VCLA2	←	VCLA	0.736
VR Information Reliability	IA9	←	IA	0.792
CLM Method Relevance	IA10	←	IA	0.747
VR Source Diversity	IA1	←	IA	0.690
CLM Practice Guides	IA6	←	IA	0.680

PLS-SEM Results

The predictive validity of the model was evaluated using partial least squares structural equation modelling (PLS-SEM) with WarpPLS 8.0. The average path coefficient (APC) was 0.362 ($p < 0.001$), the average R-squared (ARS) was 0.656 ($p < 0.001$), and the average adjusted R-squared (AARS) was 0.649 ($p < 0.001$). Again, these results indicate that the model explained a significant amount of variance in the outcome variable. The Tenenhaus goodness-of-fit index was well over the cut-off value for a large effect size (0.705). Collinearity was acceptable with AVIF = 1.006 and AFVIF = 1.825. Other recommended standards for metrics of model quality were also satisfied, such as the Simpson's paradox ratio (SPR = 1.000), R-squared contribution ratio (RSCR = 1.000), statistical suppression ratio (SSR = 1.000), and nonlinear bivariate causality direction ratio (NLBCDR = 1.000). The HTMT ratios, ranging from 0.056 to 0.081 across construct pairs, indicated that items intended to measure different constructs were appropriately distinct, establishing discriminant validity (Fornell & Larcker, 1981). These values were below the highly conservative cutoff of 0.85, demonstrating good construct separation. Therefore, the findings indicate that the model was statistically appropriate and robust for this analysis.

Among the predictors, Information Accessibility (IA, β = 0.626, f² = 0.406) had the strongest effect on VR–CLM awareness, followed by Interactive Experience Quality (IEQ, β = 0.322, f² = 0.122), Social Influence (SI, β = 0.291, f² = 0.102), and System Integration Complexity (SIC, β = 0.207, f² = 0.045), all of which were significant at $p < 0.001$. These findings confirmed the conceptual relevance of UTAUT-based constructs in explaining awareness and highlight IA as a critical factor in shaping adoption perspectives in real estate contexts. Based on the effect sizes (f²), it can be stated that:

- Information Accessibility (IA) strongly influenced the level of VR–CLM awareness
- Interactive Experience Quality (IEQ) and Social Influence (SI) had a moderate influence, and System Integration Complexity (SIC) had a small influence on the level of VR–CLM awareness.
- The R^2 of 0.659 established that the model was not overfitting due to the small sample size, and the Stone Geisser indicator Q^2, whose value was 0.643, indicated that the model had a strong predictability.

The PLS-SEM model was shown in figure 6, and the indicator weights were shown in Table 6.

Table 6 Indicator weights for PLS-SEM

	SI	SIC	IEQ	IA	VCLA	SE	P value	VIF	WLS	ES
SI2	0.171	0	0	0	0	0.067	<0.001	3.395	1	0.15
SI3	0.169	0	0	0	0	0.067	<0.001	3.131	1	0.147
SI4	0.152	0	0	0	0	0.067	<0.001	2.078	1	0.118
SI6	0.168	0	0	0	0	0.067	<0.001	2.965	1	0.145
SI7	0.178	0	0	0	0	0.067	0.004	4.513	1	0.163
SI8	0.167	0	0	0	0	0.067	0.001	2.913	1	0.143
SI9	0.161	0	0	0	0	0.067	0.001	2.448	1	0.134
SIC1	0	0.22	0	0	0	0.066	<0.001	2.485	1	0.186
SIC4	0	0.24	0	0	0	0.066	<0.001	4.596	1	0.222
SIC6	0	0.242	0	0	0	0.066	<0.001	4.807	1	0.225
SIC8	0	0.21	0	0	0	0.066	<0.001	2.055	1	0.17
SIC9	0	0.227	0	0	0	0.066	<0.001	2.817	1	0.197
IEQ2	0	0	0.281	0	0	0.066	<0.001	2.402	1	0.243

IEQ4	0	0	0.28	0	0	0.066	<0.001	2.396	1	0.243
IEQ8	0	0	0.289	0	0	0.066	<0.001	2.829	1	0.259
IEQ9	0	0	0.287	0	0	0.066	<0.001	2.722	1	0.255
IA1	0	0	0	0.275	0	0.066	<0.001	2.719	1	0.243
IA6	0	0	0	0.273	0	0.066	<0.001	2.632	1	0.24
IA9	0	0	0	0.285	0	0.066	<0.001	3.639	1	0.261
IA10	0	0	0	0.282	0	0.066	<0.001	3.437	1	0.256
VCLA8	0	0	0	0	0.194	0.067	0.002	2.297	1	0.161
VCLA7	0	0	0	0	0.184	0.067	0.003	1.981	1	0.145
VCLA6	0	0	0	0	0.209	0.067	<0.001	3.408	1	0.186
VCLA4	0	0	0	0	0.199	0.067	0.002	2.517	1	0.168
VCLA2	0	0	0	0	0.2	0.067	0.002	2.64	1	0.17
VCLA1	0	0	0	0	0.2	0.067	0.002	2.656	1	0.17

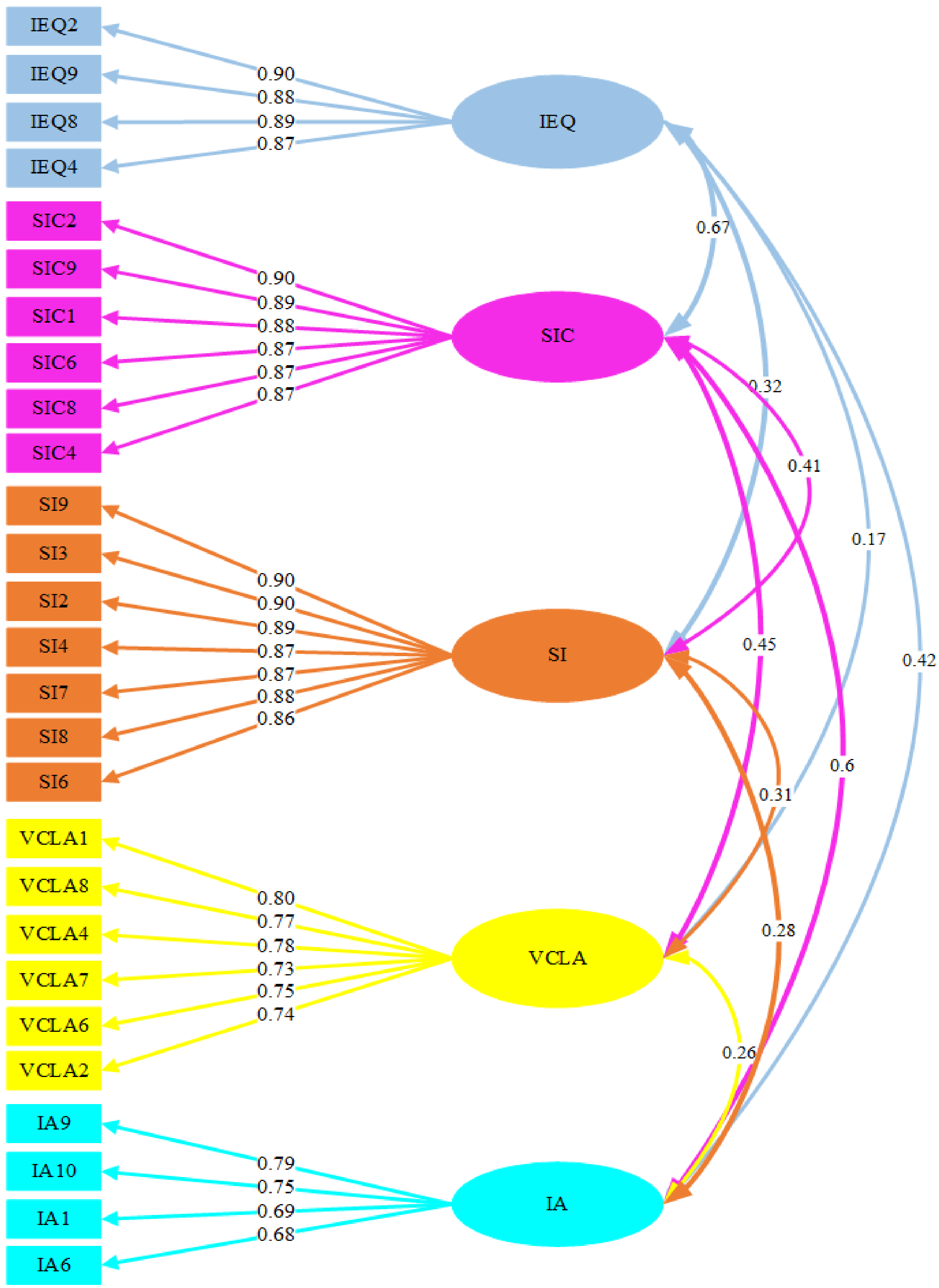

Figure 4 Measurement Model

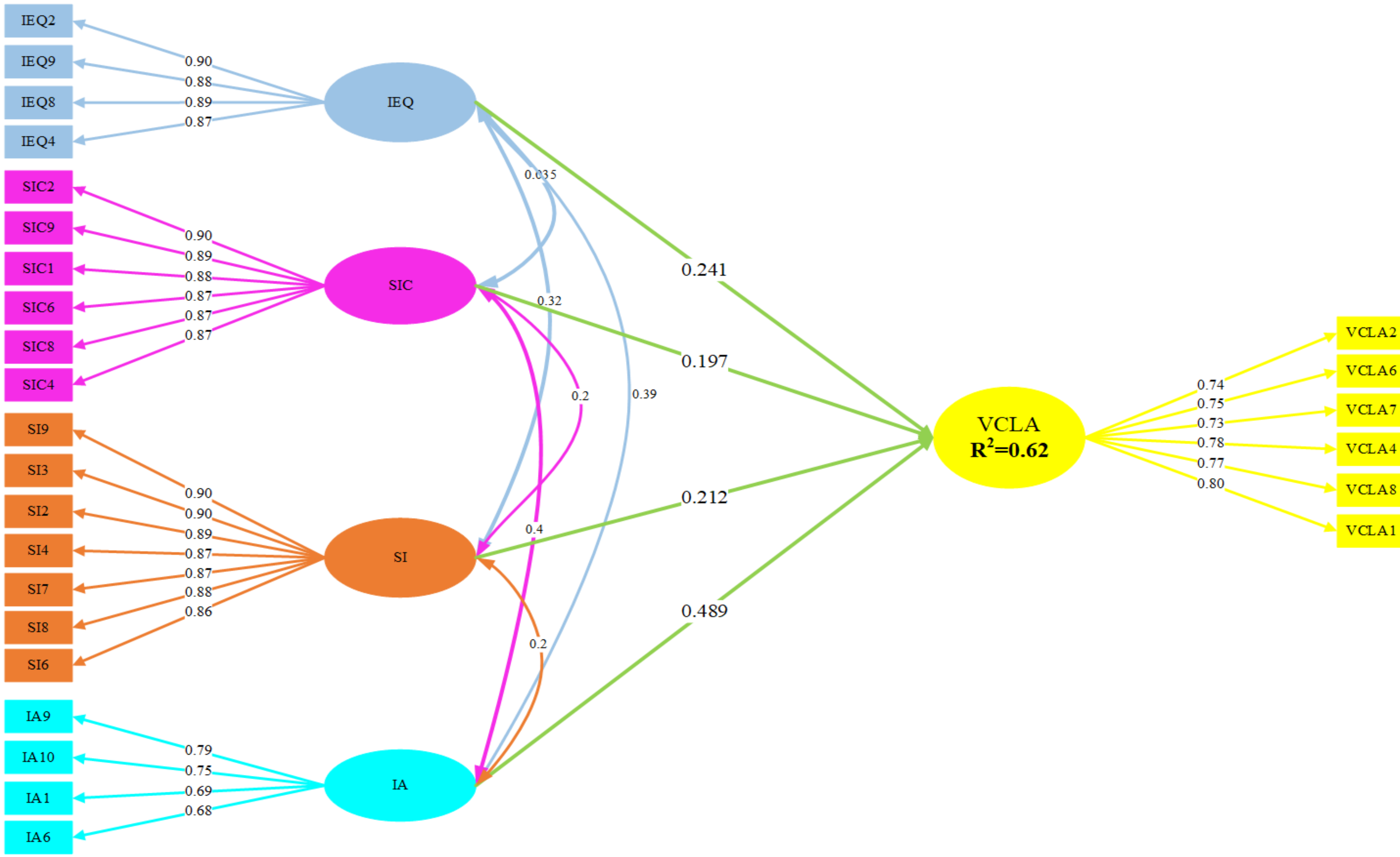

Figure 5 Structural Model

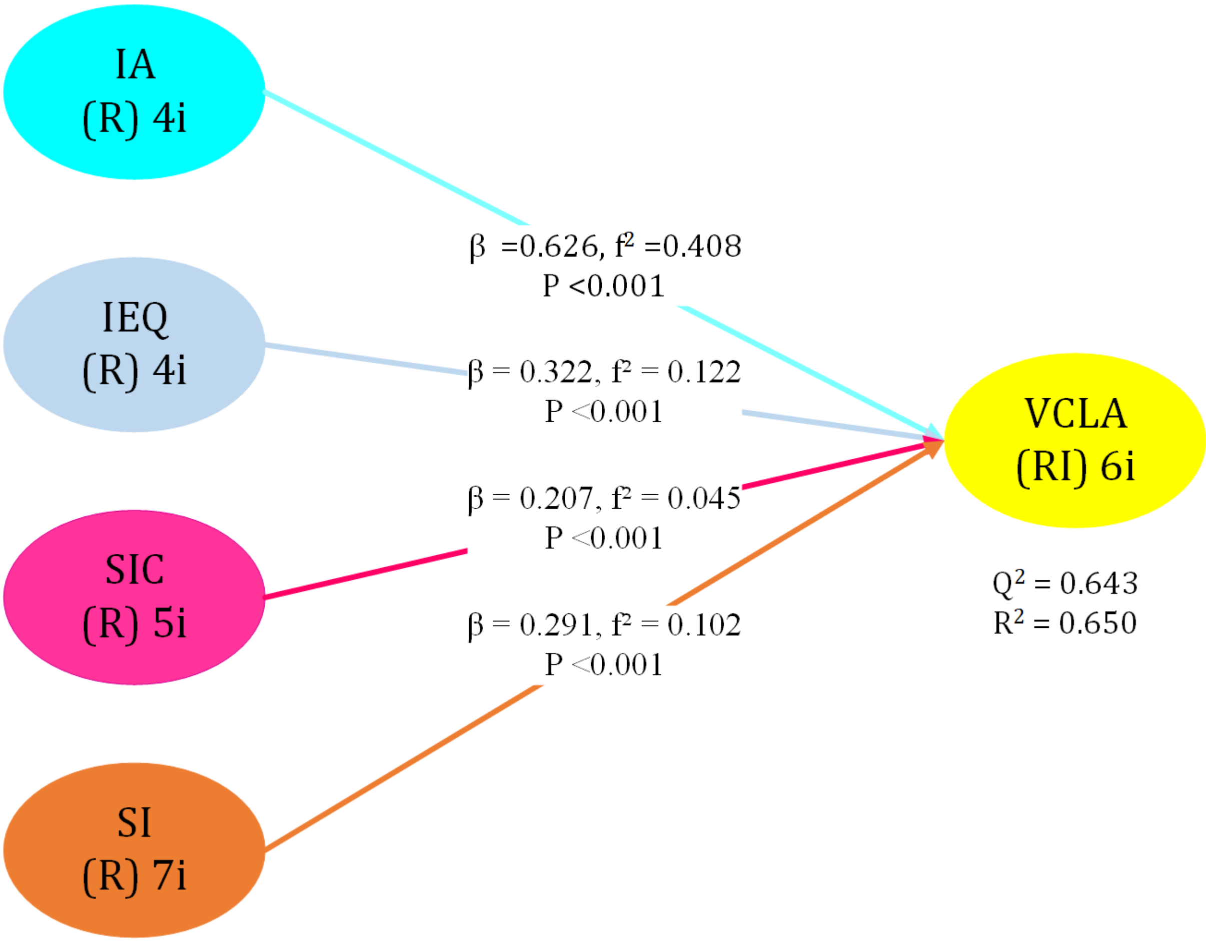

Figure 6 PLS-SEM results (Source: WarpPLS 8.0)

Interpretation and Theoretical Refinement

The analysis compared the structural paths derived from the CB-SEM and PLS-SEM. In the CB-SEM, Information Accessibility was the strongest predictor of awareness ($\beta = 0.489$), followed by Interactive Experience Quality ($\beta = 0.241$), Social Influence ($\beta = 0.212$), and System Integration Complexity ($\beta = 0.192$). In the PLS-SEM model, Information Accessibility again demonstrated the highest influence ($\beta = 0.626$, $f^2 = 0.406$), followed by Interactive Experience Quality ($\beta = 0.322$, $f^2 = 0.122$), Social Influence ($\beta = 0.291$, $f^2 = 0.102$), and System Integration Complexity ($\beta = 0.207$, $f^2 = 0.045$). Both methods preserved the rank order and direction of influence, with PLS-SEM producing slightly higher path coefficients. This consistency in the directional relationships across methods supports the reliability of the proposed structural model. The use of PLS-SEM alongside CB-SEM strengthens the empirical foundation of the findings, offering additional support for the model's explanatory relevance without relying solely on a single estimation approach. The PLS-SEM model yielded an R^2 value of 0.659 and a Q^2 value of 0.643, indicating acceptable explanatory and predictive relevance. The consistency of the results across the two modelling techniques supports the structural stability of the proposed framework. The convergence of the results from CB-SEM and PLS-SEM not only strengthens the structural validity of the model but also reflects the patterns observed during interactions with the respondents. Their responses frequently emphasized themes that echoed the statistical findings, particularly the relevance of information access, peer influence, and experiential clarity in shaping awareness. The following observations help interpret the statistical relationships more meaningfully.

- The significance of Information Accessibility across both models indicates the importance of timely, reliable, and relevant information in shaping stakeholder awareness
- The influence of Social Influence points to the importance of relational networks, informal cues, and collective endorsement in shaping expectations
- Respondents indicated higher receptiveness to technologies that facilitated immersive and interactive decision-making
- The relative weakness of System Integration Complexity suggests that perceived challenges in integration may not be a critical barrier to awareness at this stage
- The findings support the use of UTAUT in contexts where digital adoption was contingent not only on functional performance but also on social validation and information accessibility

These insights contributed to clarify how knowledge of integrated technologies had developed through professional experience and exposure to them.

Discussion

The PLS-SEM results indicated that Information Accessibility (IA) exerts the strongest influence on stakeholder awareness of integrated VR-CLM technology in real estate. IA demonstrated a substantial path coefficient ($\beta = 0.626$, $f^2 = 0.406$), highlighting the importance of timely and broad access to relevant property information in shaping the awareness. VR-CLM platforms that provide virtual property tours, real-time analytics, and on-demand informational content effectively engaged stakeholders and reduced traditional barriers (Zhang et al., 2024). Interactive Experience Quality (IEQ) was the second most influential factor ($\beta = 0.322$, $f^2 = 0.122$). Immersive realism and intuitive design within the VR environment shaped stakeholders' perceptions of the technology's relevance (Tähtinen and Toivonen, 2024). Lifelike walkthroughs and interactive interfaces enhanced the memorability and perceived utility of VR-CLM, encouraging wider consideration within organizational settings (Dias Garcia et al., 2024). Social Influence (SI) also had a significant effect ($\beta = 0.291$, $f^2 = 0.102$), suggesting that peer endorsement and network-based positioning enhanced technology awareness.

Real estate sector is a relationship-based sector here the perception and behavior of other market participants significantly influences the intention to use digital tools (Mauri et al., 2023; Liu and Chen, 2025). Therefore, the adoption of an integrated VR-CLM platform by leading real estate organizations would enhance the trust of small-scale firms also. Secondly, the systems integration complexity (SIC, $\beta = 0.207$, $f^2 = 0.045$) had a weak but significant effect on the level of awareness of VR and CLM. The weak effect was observed because of compatibility issues with existing property databases and customer relationship management systems (Azmi et al., 2021; Deep et al., 2023). However, these features were not primary drivers of VR-CLM awareness, instead it was influenced by the immersive features and information availability offered by these technologies (Pleyers and Poncin, 2020).

Instead, initial adoption was more determined by immersive properties and ease of access to information, which provided further insight into the awareness of digital technology development in the real estate sector (Starr et al., 2020; Azmi et al., 2021). These results add to the existing knowledge regarding the real estate digital technology awareness. This focus on information and experience contributes to new aspects of digital technology understanding within real estate, for integrated solutions such as the VR-CLM. This suggests that perceived ease, subjective norm, and perceived usefulness were antecedents not only of adoption but also of awareness.

The results showed that ease of use was influenced by information availability which in turn regulated the extent of technology use (Sahebzamani and Forcada, 2025). Early stakeholder involvement was obtained using enhanced transparency of the operations provided by VR-CLM based solutions that enabled enhanced interaction with clients (Tähtinen and Toivonen, 2024). And in these cases, perception from the industry leaders and market beasts, and championing by peers enhance the functional worth of things. Under this scenario, the role of integration support was instrumental as it added value from a functional dimension of the aspect of initial interest that contributed to the actualization of interest for the integration of technology in the classroom (Chen et al., 2024). This illustrates that stakeholder engagement and integration support will facilitate digital innovation in the accessibility of information of integration VR and CLM.

This research emphasizes the need for a specific type of knowledge for the respective stakeholders, rather than general readiness towards or post-adoption behavior. This provides a better understanding of adoption, especially in industries that were digitally fragmented, such as real estate. The primary contribution of this study lies in providing an empirical understanding of the influences on stakeholder knowledge of integrated immersive and marketing technologies. This model enables the prediction of awareness challenges and opportunities in relation to the digital transformation of property. Enhancing information clarity and interactive quality, as well as the functions of social networking and reducing technical resistance, may help facilitate broader and more persistent engagement in the use of VR-CLM systems.

2.1. Roles of Regulatory Bodies

Regulators play a major role in technology perception and can also drive market leadership. The Real Estate Regulatory Authority (RERA) represents an initiative to institutionalize the protection of home buyers while simultaneously enhancing investment in the sector. Extended project timelines, ambiguous progress, and limited access to information contribute to the mistrust among property buyers. Accordingly, the crucial facilitators of CSF in this study (IEQ, IA, SIC, and SI) were vital to enhance the acceptance rate of VR and CLM in real estate companies. Regulatory authorities, such as RERA, should adopt a strategic approach to promote the integration of VR and CLM in the real estate sector. Moreover, the REDs would benefit from developing technology and a technical workforce capable of effectively integrating VR and CLM, thereby enhancing the overall experience for home and real estate buyers from the initial search to project delivery and possession.

Adequate use of training programs, collaborative alliances with technology companies, rewards and recognition, and establishing a code of conduct would help minimize resistance to RED. This framework would also facilitate smooth implementation and change management processes with respect to the integration of VR and CLM in the real estate sector. The role of regulatory bodies in facilitating the adoption of VR and CLM was presented in Table 7.

Table 7 Recommendations for the Regulators and policy makers

Construct	Recommendations for regulators	Recommendations for Policy Makers
Information Accessibility	• Provide accurate and current information on VR and CLM technologies. • Identify the quality and credibility of the sources of information, and supervise and control it, and in doing so, it is unlikely to be exposed to a misleading. • Recommendations are provided, to handle the problem of information overload when considering stakeholders.	• The requirements of transparency and accessibility of information should be supported by policies. • Promoting the establishment of information centres for stakeholders. • Effective education programmes should focus on increasing the stakeholders' skill in making use of information.
Interactive Experience Quality	• Establish guidelines for the quality of VR and CLM interactive experiences to make sure they are user-friendly and accessible. • Tracking and assessing the complexity of conversational explorations can help avoid stakeholder frustration and disengagement.	• Formulate policies to incentivize developing intuitive and user centric interactive technologies. • Promote R&D for the development of balanced, high-quality, interactive experiences that deepen user involvement.
System Integration Complexity	• Establish the frame works to make the VR/CLM-integrated technologies easy for integrating into the existing systems. • Interoperability should be guaranteed by the creation of technical standards and protocols.	• Financial and technical assistance for system integration should be formulated. • Foster cooperation between technology providers and real estate companies to facilitate the integration.
Social Influence	• Establish and optimize relationships with relevant real estate influencers who can increase the discussion and consideration of VR and CLM in a positive light. • Counteract and prevent the proliferation of negative or false information spread by leaders. • Organize roundtables and other forums for stakeholders to exchange experiences and best practices with respect to the use of VR and CLM technologies.	• Create policies that are stimulating the adoption and the consciousness raising toward new technologies. • Promote educational campaigns and efforts to demonstrate the value and usage of VR and CLM. • Support collective societal events to positively promote the social life and use of technology.

6.0. Contributions and Implications

This study addressed the knowledge gap of the lack of a unified framework that increased the level of awareness of the integration of VR and CLM technologies. Previous research had limited focus on the possibility of integrating VR and CLM and has considered the tools in isolation. The primary contribution of this study was to understand the perspectives of key stakeholders on the integration of these technologies. Additionally, this study advances the theoretical understanding of how awareness drives technology adoption in real estate. It refines how stakeholder awareness i.e., among real estate developers and agents, influences the adoption of new technologies and integrates them to develop buyer-centric marketing strategies.

This study extends the Unified Theory of Acceptance and Use of Technology (UTAUT) by introducing and validating key constructs tailored to this context: Information Accessibility (IA), Interactive Experience Quality (IEQ), System Integration Complexity (SIC), and Social Influence (SI). These constructs form an extended UTAUT-based framework specific to real estate, providing a nuanced model of how awareness influences the acceptance of technology. By offering this integrative framework, this study enhances academic discourse and creates a foundation for developing strategies to promote VR and CLM use, thereby helping to foster innovation across the sector.

Practically, the results provide guidelines for promoting VR and CLM adoption in real estate (Figure 7). Increasing the accessibility of information, enhancing immersive and interactive experiences, and generating endorsements from peers can enhance stakeholder engagement. In addition, the proposed framework would help mitigate the complexity of system integration through training, support, and smooth processes that simplify the operation. Combined, these approaches will contribute to a more inclusive, innovation-focused environment, ensuring industry-wide awareness and successful uptake.

The adoption of these measures enhances stakeholder confidence and preparedness for the acceptance of VR and CLM in real marketing strategies. Collectively, these contributions to practice were consistent with the objectives of the United Nations Sustainable Development Goal (SDG) 9 (Industry, Innovation, and Infrastructure), as they contribute to technological innovation and enhance digital infrastructure in the real estate sector. Crucially, SDG 9 was about building qualities and design for resilient infrastructure, support of innovation, and digital transformation, and the innovation drive towards digital transformation supported by the insights of this study were aligned with the intention of those qualities in real estate.

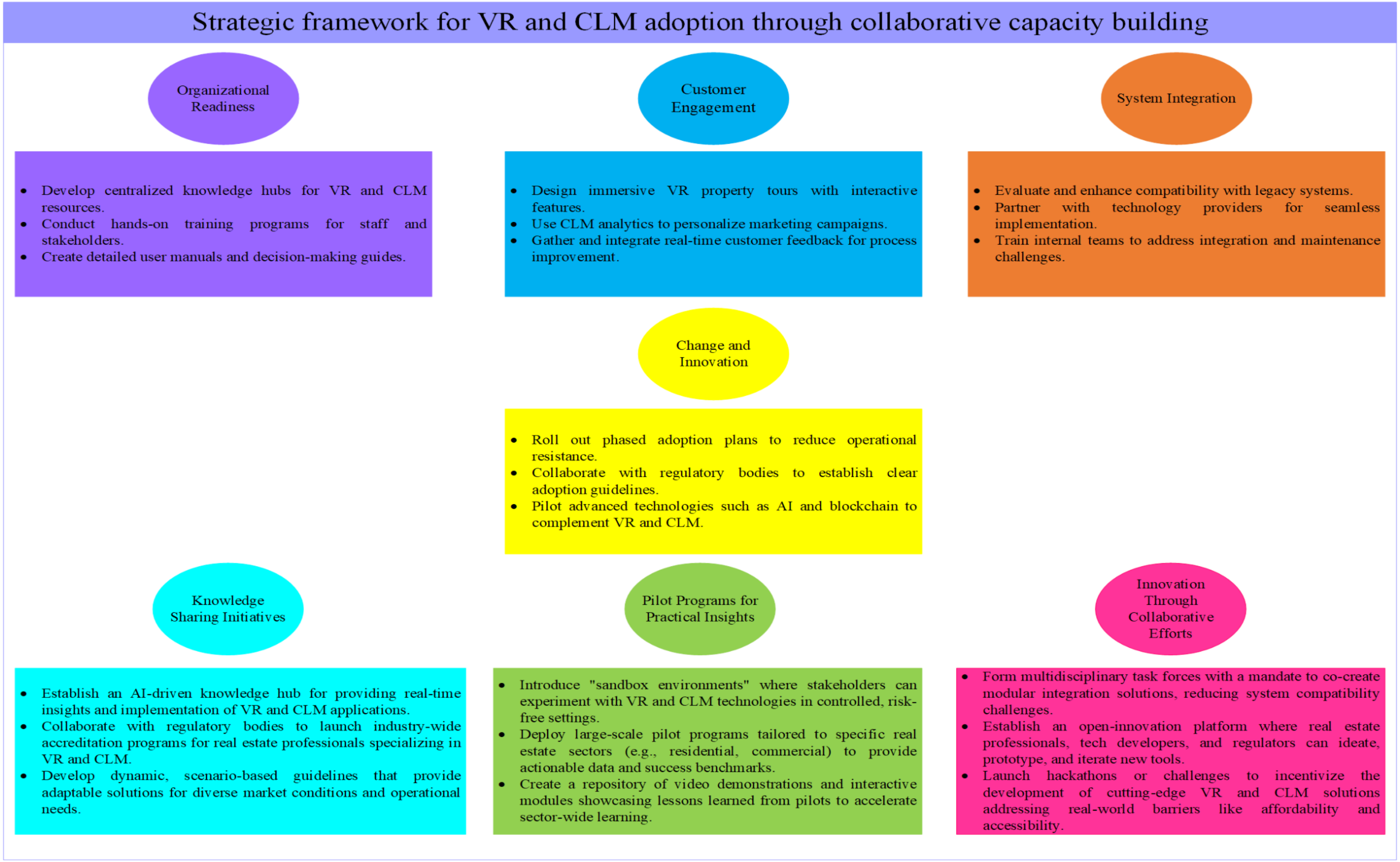

Figure 7 Strategic framework for VR and CLM adoption through collaborative capacity building

Operationalization Strategy for CLM in Real Estate Sector

This study also outlines an operationalization strategy for Closed-Loop Marketing (CLM) that reflects the distinctive technological and institutional conditions in the real estate sector. The proposed approach was structured as a multi-layered pathway, beginning with digital interaction tracking at the user interface level, where prospective buyers engage with virtual tours, chat systems, or embedded response forms. These interactions form the informational foundation for connecting user behavior to backend systems, thus reflecting the visibility and clarity required for data-led awareness. The second layer involves system-level integration, where interaction data were systematically routed to CRM environments that support rule-based campaign triggers, segmentation logics, and interface refinements. This stage was related to infrastructure complexity and interoperability challenges that often shape technological decision-making. The final layer pertains to organizational readiness, which includes structured capability-building efforts, the use of low-cost software environments, and the alignment of implementation with operational teams across sales and IT. These processes engage with social influence dynamics, including informal peer learning and institutional guidance, which contribute to framing both expectations and norms. Initial rollouts may benefit from metro-based pilots with higher digital maturity levels. Institutions can reinforce these efforts by offering training pathways, compliance frameworks, and connectivity infrastructure. This strategy aligns with the contextual patterns of awareness, where the structure of access, quality of user interaction, challenges of system integration, and influence of stakeholder networks operate in overlapping ways to shape readiness. The model encourages firms to transition from isolated digital features to continuous, feedback-enabled marketing systems that progressively reduce manual interventions and support adaptive engagement architectures. The detailed operational strategy was shown in Figure 8.

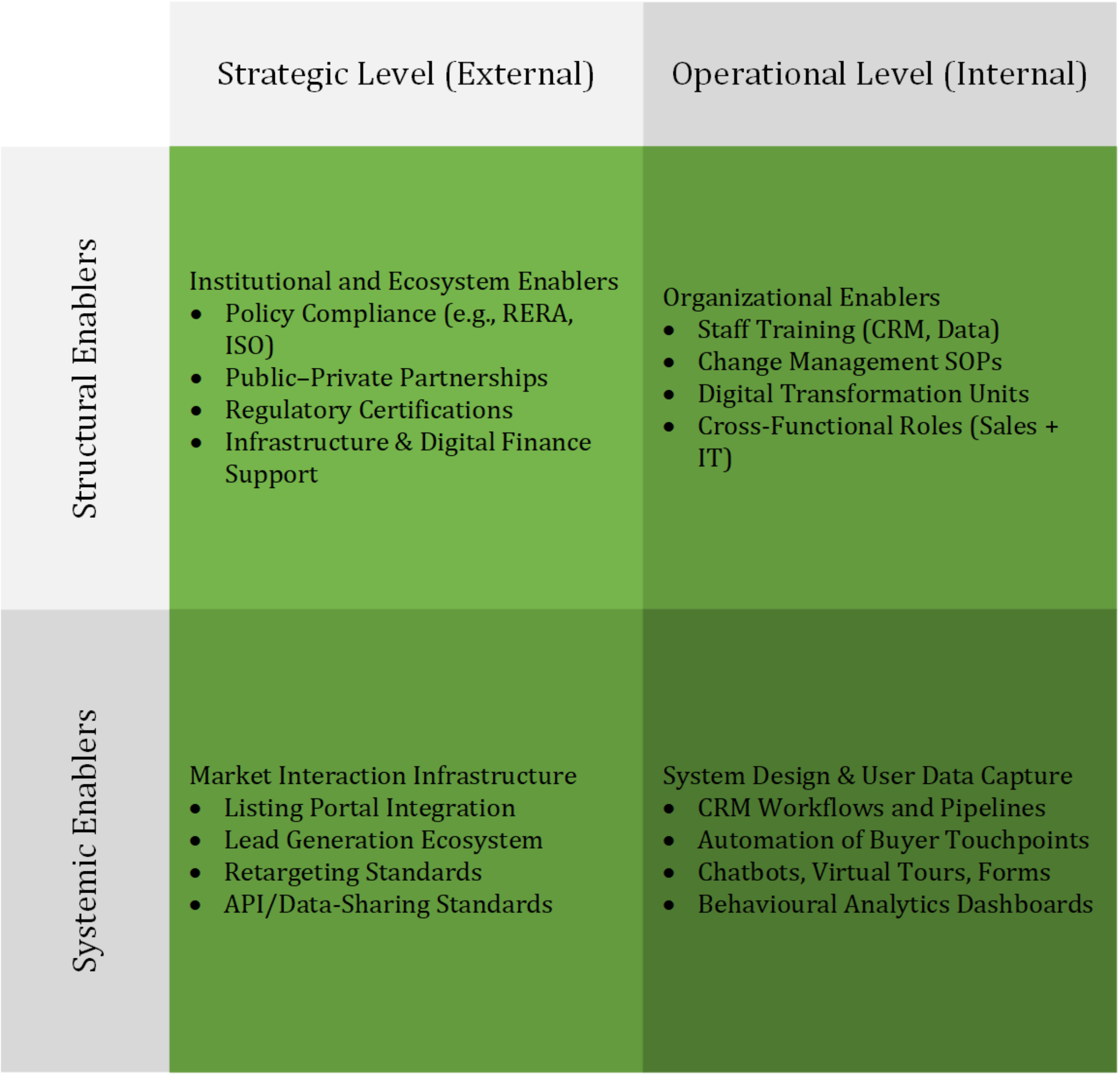

Figure 8 Operational strategy for CLM enablement for real estate Sector

Conclusion

This study investigated the factors influencing the awareness and adoption of VR and CLM technologies in the real estate sector using the Unified Theory of Acceptance and Use of Technology (UTAUT) as the theoretical framework. A comprehensive literature review identified Information Accessibility (IA), Interactive Experience Quality (IEQ), System Integration Complexity (SIC), and Social Influence (SI) as key variables. The structural model results highlighted that IA had the strongest influence on awareness, indicating that access to relevant and reliable information was critical for promoting VR and CLM use. The role of the

IEQ emphasized the importance of immersive and user-friendly environments to engage diverse client groups and enhance communication strategies. SIC poses operational challenges that can be managed through targeted compatibility assessments and collaborative workflows. SI demonstrated that peer endorsement and sector-wide support play important roles in promoting technology acceptance. These findings suggest that a strategic and data-driven approach to VR and CLM deployment can strengthen operational resilience, customer satisfaction, and competitive advantage across the real estate sector.

Limitations and directions for future research

In addition to the limited availability of literature on CLM, there were other limitations that should be noted. First, the limited familiarity with VR and CLM among real estate developers and agents constrained the survey responses, potentially affecting stakeholder insights. Additionally, the findings may not fully reflect awareness patterns in Tier-2 and rural markets, where digital exposure and infrastructure differ; for this purpose, a qualitative study in the positivist realism paradigm was recommended. Although the purposive sampling approach was useful for targeting informed respondents, it may introduce selection bias and overstate awareness levels. Future studies should apply random sampling to ensure a more representative understanding of VR and CLM awareness across varied exposure levels. Second, this study focused exclusively on the Indian real estate context, restricting the generalizability of the results to other regional markets. Future research should consider comparative studies involving regions such as the USA, Europe, and the Middle East to assess the contextual variations in technology awareness and adoption. Further exploration through social cost–benefit analysis using case study methodologies would provide deeper insights into the practical implications of the integration of VR and CLM. Additionally, future studies should qualitatively explore the impact of infrastructural disparities across different organizational scales and the role of regulatory frameworks in influencing technology adoption in the real estate sector. Future research could also focus on developing integrative frameworks that combine blockchain and artificial intelligence with VR and CLM technologies to promote collaborative capacity building and sustainable digital transformation within the real estate sector.

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials. The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Disclosure of interest

No potential conflict of interest was reported by the author(s).

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