

# Enhancing Consumer Decision-Making in Shopping 4.0: The Impact of Augmented Reality on Emotional Engagement and Purchase Behavior.

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## Abstract

Augmented Reality (AR) technology, a pivotal element of Industry 4.0, is revolutionizing consumer engagement and purchasing decisions, heralding the advent of Shopping 4.0. This study which is based on technology acceptance model (TAM), investigates five key factors influencing the AR shopping experience: prior AR use, product complexity, AR accessibility, product visualization, and price sensitivity. Through a survey involving 861 participants, 744 valid responses were analysed using SMART-PLS software to construct a structural equation model. Our findings reveal that product visualization quality exerts the most significant influence, while product complexity has the least. Emotional engagement emerges as a crucial mediator in the relationship between AR and consumer purchase behaviour as outcome variable. These insights provide valuable guidance for marketers aiming to enhance consumer interaction and drive sales in the competitive retail landscape.

**Keywords:** product visualization quality, emotional engagement, augmented reality, product complexity, accessibility, price sensitivity, consumer purchase behaviour.

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## 1. Introduction

As retail changes at lightning speed, technology keeps transforming how buyers engage with products and make purchasing choices. Augmented Reality (AR) has emerged as a game-changing tool that elevates the shopping experience beyond anything we imagined. This thrilling blend of digital elements with the real world produces a shopping space that feels both captivating and hands-on. Retailers can boost customer involvement by displaying items in an immersive virtual reality (VR) shopping environment (Peukert et al., 2019).

According to (Farshid et al., 2018), augmented reality (AR) denotes the unification of the tangible world with digital details about it, whereas virtual reality (VR) is a whole digital simulation of the tangible world and mixed reality (MR) denotes the blending of real world online models with computer-built models that are either actual or feasible. AR—also known as mixed reality—fuses actual settings with computer-generated images, sound effects, and other stimuli. It layers digital details over the physical world, creating a lively, enriched user environment. No doubt, as immersive technologies evolve, they offer retailers new ways to engage customers more deeply and interactively, setting the stage for a future where tech and retail become one (Uwaoma et al., 2023). Consumers' buying behaviour in retail and other sectors depends on factors such as previous AR experience, product complexity, AR availability, visualization quality, price sensitivity, and emotional engagement. However a comprehensive study to measure the impact of various factors described above on emotional engagement is lacking. This research is trying to fulfil that gap. Integration of augmented reality, emotional engagement and consumer behaviour is also a major gap, this study is trying to address. Also the gap with regards to relative impact of these factors on consumer behaviour has been addressed by this research, which will ultimately help the marketing and research professional to direct their resources and efforts for better emotional engagement and consumer behaviour. AR keeps advancing, and users' familiarity varies—those with good AR experiences find it easier and more enjoyable to use. How complex a product is can affect how much AR improves the purchase process. As AR and VR develop rapidly, an increasing number of retailers adopt these technologies to create fun, efficient, and engaging online shopping experiences (Wedel et al., 2020). For instance, AR is highly valuable for products you can examine interactively before buying, though it may be less needed for routine groceries. When products are shown online with AR, they give real-world cues for clear impressions and memorable experiences, allowing live interaction with virtual items

(Javornik, 2016). Instant feedback via AR enhances the user experience by providing clear, interactive, and immersive digital interactions (Hilken et al., 2018). Emotions are central to shopping behaviour. Feelings heavily influence buying decisions, actions, and interactions with services or products, which is why this area has seen much research focus lately (Sharma et al., 2023). The role of emotions in judgment and decision-making has also been a major research topic in psychology and consumer studies (Winter, 2022). Emotionally engaged shoppers form stronger bonds with products and brands. Emotional engagement directly impacts actual purchase behaviour—the definitive test of AR’s success in shopping. AR’s power to guide and mold buying decisions is nothing short of remarkable. Thus, this research is based on “Technology acceptance model (TAM) which states that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) determine user acceptance of new technology. The reason for employing TAM is its parsimonious nature, wide validation, and alignment of its component’s (PU, PEOU) with the constructs under consideration. The other reason for using TAM over other contemporary models is due to its simplicity yet the originality and rigour it brings to the research process. For example Web-based AR (WebAR) allows users to access experiences instantly via a URL or QR code without downloading apps, significantly increasing accessibility and lowering the effort barriers. Users with higher prior experience find AR interfaces more intuitive, easy to use, reducing the mental effort needed to learn the system. High-quality visualization directly aids in making a purchase decision, reduces product returns and increases purchase confidence, making the tool useful for consumers. This combination of high-quality, interactive visualization (high PU) and ease of use (high PEOU) leads to a positive attitude and higher behavioural intention to use the technology for shopping. AR Technology Accessibility (ARTA) helps in operationalization of perceived ease of use (PEOU) and in lowering perceived efforts whereas Customers Previous AR Experience (CPE) helps in operationalization of Perceived ease of use (PEOU)

and in reducing the cognitive friction. Product Visualization Quality (PVQ) reflects perceived usefulness (PU), and increases the functional utility of AR for decision making on the other hand, Price sensitivity (PS) connects both perceived usefulness (PU) and perceived ease of use (PEOU). Lastly, Product complexity (PC) reflects perceived usefulness and increases the functional utility of AR for decision making. In conclusion, Augmented Reality has launched a new Shopping 4.0 era, blending tech and emotion into an immersive, memorable retail adventure.

This research contributes not only to the interests of consumers but also the marketers and other stake holders' involved. By identifying the factors influencing the emotional engagement of consumers in AR environments, this study offers actionable insights. It highlights the need for marketers to focus on creating immersive and emotionally engaging experiences through AR technology. This understanding can guide strategies aimed at enhancing product visibility and consumer interaction, ultimately driving sales. Practical applications include the development of tailored AR marketing campaigns that resonate with consumer emotions, thereby potentially increasing product adoption and customer loyalty in a competitive market landscape. From a social perspective, this research contributes to the ongoing evolution of consumer behaviour in digital and retail spaces. Exploring the emotional dynamics within AR-enhanced shopping experiences sheds light on broader societal trends toward digital immersion and interactive commerce. The findings underscore the potential for AR technologies to reshape consumer interactions with electronic products, fostering deeper emotional connections between consumers and brands. This shift towards more engaging digital experiences May influence societal norms around shopping behaviours and expectations, potentially accelerating the adoption of AR in retail environments. Moreover, by emphasizing emotional engagement, the study encourages ethical

considerations in marketing practices, promoting consumer trust and satisfaction in the digital marketplace.

This study brings many novelties with its findings. The research explicitly examines the impact of AR technology (part of Industry 4.0) on consumer behaviour within the context of "Shopping 4.0," a concept that signifies a new era of online shopping experiences. The study also reveals the significant impact of price sensitivity and the accessibility of AR technology on emotional engagement, emphasizing the importance of both affordability and ease of use in driving customer engagement. The research highlights the significant positive impact of product visualization quality, particularly when enhanced by AR, on consumer emotional engagement, suggesting that a good visualization creates an immersive and engaging experience. The research demonstrates that previous AR experiences also significantly influence emotional engagement, implying that familiarity with the technology can enhance subsequent engagement and purchase behaviour. The research utilizes SMART-PLS and bootstrapping methods to establish a structural equation model, analysing the relationships between these constructs and their impact on emotional engagement. The study identifies five main constructs – AR technology accessibility, customers' previous AR experiences, price sensitivity, product complexity, and product visualization quality – that influence emotional engagement and purchase behaviour.

Thus, the study strengthens and broadens the current knowledge in this field by combining measurable data with structural equation modelling (SEM) and importance-performance analysis. The main objectives of this research are, to examine consumer behaviour in online shopping with a particular focus on AR Technology, to evaluate the various factors that impact consumers' emotional engagement during purchase decisions, to identify the key factors with high importance and performance value for better decision-making in Shopping 4.0, to study the impact of AR technology related factors on consumer

purchase behaviour. As far as practical utility is concerned, AR's utility varies substantially across product types. For simple, visually-driven products (e.g., apparel, accessories), product visualisation quality (PVQ) would naturally dominate Emotional engagement (EE), which aligns with the current findings. For high-complexity products (e.g., consumer electronics, medical devices), PC would theoretically exert a stronger influence on EE because AR's ability to simplify technical understanding becomes the key value proposition.

The rest of the research paper is arranged as follows. 2) Literature Review and identification of constructs, 3) Methodology, 4) Data Analysis (Measurement Model, Structural Equation Model, Importance-performance map analysis), 5) Conclusion, 6) Research Limitations 7) Declarations, 8) References.

## **2. Literature Review**

### **2.1 AR Technology Accessibility (ARTA)**

AR Technology Accessibility refers to the ease with which consumers can access and use AR technology, influenced by factors such as device compatibility, internet connectivity, and user interface design. Accessibility of AR technology is an important aspect in the study of shopping 4.0. Whether accessed through smartphones, AR glasses, or other devices, widespread availability ensures that a broader spectrum of consumers can enjoy the benefits of AR-enhanced shopping. Moreover, the quality of AR visualizations directly influences how consumers perceive products. High-quality visual presentations can make products more appealing and help shoppers make more informed purchasing decisions. So it is AR technology and the effect of augmented reality technology which should reach the end consumers. An important area of research involves grasping the effects of revolutionary applications of AR services and exploring ways to enhance their accessibility as this is crucial for understanding the significance of these transformative uses (Heller et al., 2021).

To fully harness the advantages that progress in the AR field can offer to society, it's essential to consider the availability of various products and services in development (Žilak et al., 2022). According to some researcher, AR systems are easily accessible without any special devices and common devices like mobile phone can be easily used to access the same. The accessibility of AR has increased because it no longer needs special equipment and can be easily used on mobile devices (Akçayır et al., 2017). But there are some challenges as well. AR systems generate large amount of data and handling the amount of data using mobile or any other devices also presents its own challenges. One of the challenges of AR systems is the large amount of data that needs to be managed and accessed in a distributed system (Panou et al., 2018). Using the information from this literature review, a hypothesis is suggested as

**H1:** AR Technology Accessibility (ARTA) has a significant relation with the Emotional Engagement of Consumers (EE).

## **2.2 Customers Previous AR Experience (CPE)**

Customers' Previous AR Experience describes consumers' familiarity and comfort levels with AR applications, impacting their perceptions and behaviors toward AR-enabled products or services. Previous experiences with AR significantly impact how users navigate and interact within augmented shopping environments. Positive past encounters with AR can lead to smoother interactions and more positive overall experiences. After using augmented reality (AR) apps for virtual try-ons, influenced by their prior experiences with images, users gain greater familiarity with these previous images in their minds and understanding (Nhan et al., 2022). As more and more people will start using AR technology, there is a great need to study about its interaction with consumer and its effect on consumer purchase behavior. As more people use augmented reality, there is a growing requirement to comprehend how it affects customer behavior, its intended use, and the quality of the experience it provides

(Javornik, 2016). AR-applications allow users to have a 'test before purchasing' encounter, potentially connecting the divide between shopping online and in person (Baek et al., 2018). Many other studies endorse this view. The impact of digital human technology, incorporating AI and virtual reality, will extend deeply into sports training, event presentation, and fan engagement (Suo et al., 2025). Previous experience with AR try-on services as a moderator could influence how the AR experience creates a sense of immersion (Song et al., 2020). An AR technology that is vibrant, interactive, and innovative offers users one-of-a-kind experiences, leading traditional consumers to see AR as suitable for enhancing their visual experiences (McLean et al., 2019). Using the information from this literature review, a hypothesis is suggested as

**H2:** Customers' Previous AR experience (CPE) has a significant relation with the Emotional Engagement of consumers (EE)

### **2.3 Product Visualization Quality (PVQ)**

Product Visualization Quality encompasses the clarity, realism, and interactivity of AR-generated visualizations, which can significantly influence consumers' assessments and purchase intentions. Augmented reality enhances the product experience by providing additional information, making it easier to understand and visualize the subject (Udiono, 2021). Numerous recent research studies have concentrated on how well-augmented reality (AR) tools enhance the visual experience of online shopping websites (Merle et al., 2012). Image-driven virtual try-on technology provides a superior shopping experience for online customers and holds immense commercial value (Tong et al., 2025). AR helps users visualize products in their actual surroundings, making it easier to make informed buying choices. This feature lowers the doubts people have about shopping online and boosts their confidence in their purchases (Carmigniani et al., 2011). The advanced AR technology connects the digital and physical worlds, giving consumers engaging and interactive product

displays (Ngo et al., 2025). The real-time interactive system employs 3D human visualization, which displays sensor data and identifies human actions as 3D models instantly, giving accurate and detailed visual feedback to assist users in comprehending and evaluating human motion's features and details. The 3D visualization platform offers high-quality graphics along with an interactive experience (Jiang et al., 2024). Using the information from this literature review, a hypothesis is suggested as

**H3:** Product Visualization Quality (PVQ) has a significant relation with the Emotional Engagement of Consumers (EE).

## **2.4 Price sensitivity (PS)**

Price Sensitivity reflects consumers' responsiveness to price changes when considering AR-enhanced products, influenced by perceived value, affordability, and competitive pricing. Price sensitivity is influenced by AR. When consumers can visualize the value of a product through AR, they may be more willing to invest, even if the price is higher. Prior research has connected users' sensitivity to prices in the digital realm, encompassing virtual or augmented reality (Dhruv et al., 2017). Even though AR devices and software from companies like Microsoft and Google are not very common among regular users right now, mainly because of their high cost, they are expected to grow in popularity soon (Roesner et al., 2014). Some researcher suggested links of psychological ownership of AR devices with reduced price sensitivity. Advanced technologies like Augmented Reality (AR) and Virtual Reality (VR) have the potential to enhance consumers' sense of psychological ownership while reducing their sensitivity to prices (Meißner et al., 2020). However, some studies do not support the effect of price sensitivity on consumer responsiveness. When AR Smart Glasses and Robotic technologies are presented in a way that emphasizes how easy they are to use, it makes consumers less sensitive to the price

(Erdmann et al., 2023). Using the information from this literature review, a hypothesis is suggested as

**H4:** Price sensitivity (PS) has a significant relation with the Emotional Engagement of consumers (EE)

## **2.5 Product complexity (PC)**

Product Complexity refers to the intricacy and comprehensibility of AR-integrated products or services, affecting consumers' perceived utility and adoption decisions. The complexity of a product plays a crucial role in determining how effectively AR can enhance the shopping experience. For example, AR is exceptionally valuable in electronics where customers can virtually explore intricate product features before committing to a purchase, whereas its utility might be limited to simpler everyday items. AR may work differently depending on the product being presented virtually, however, more research is needed to understand how AR can help with purchasing complex products (Tarafdar et al., 2019). There is still limited understanding when it comes to assessing the effectiveness of AR solutions in enhancing the information quality and influencing the purchase choices for complex and potentially valuable products (Riar et al., 2023). Using AR technology to try a product helps reduce uncertainty about it, which results in a more positive attitude toward the product (Sun et al., 2022). The Virtual Try-On technology will improve the shopping experience for customers, reduce returns, lower sales costs, and help expand the online clothing market (Chen et al., 2025). AR assists customers in grasping complicated systems and helps them recognize the worth of products more clearly (Tan et al., 2022). Using the information from this literature review, a hypothesis is suggested as

**H5:** Product complexity (PC) has a significant relation with the Emotional Engagement of consumers (EE).

## **2.6 Emotional Engagement (EE)**

Emotional Engagement captures consumers' affective responses and emotional connections evoked by AR experiences, influencing brand loyalty, satisfaction, and purchase behaviors. Emotional engagement further enhances the shopping experience, acting as a bridge between the technological aspects of AR and consumer behavior. More emotionally engaged the customer, greater is the chance of him/her showing positive consumer behavior and making likely purchase. The Stimulus-Organism-Response (SOR) theory, developed by (Mehrabian et al., 1974), proposes that external environmental cues (Stimulus) affect an individual's internal emotional/cognitive state (Organism), which subsequently determines their behavioral outcome (Response). Thus, it is emotional engagement (Stimulus) which shows the level of measurement of consumer connectedness (Organism) to the products or services and which leads to a higher chance of consumer making actual purchase of the AR supported goods (Response). Thus 'Emotional engagements' acts as a mediator between augmented realities related constructs and consumer purchase behavior. When shoppers emotionally connect with products and brands through AR experiences, they are more likely to form stronger attachments and make purchases based on those connections (Hollebeek et al., 2019). Other researchers also supported this view of emotional engagement. A crucial element is the caliber of the user's encounter within the Augmented Reality system, gauged through emotional involvement and the feeling of being there (ChicchiGiglioliet al., 2015). It is crucial to examine the duration for which a mobile augmented reality application effectively maintains the emotional involvement of its users. This is directly linked to the long-term usage of the application (Dirin et al., 2018). The visual appeal of AR boosted its enjoyment value, as users found the virtual try-on process both fun and emotionally captivating (Sung, 2021). Among the many innovations, augmented reality (AR) technology is a powerful force in transforming marketing and

customer engagement (Du et al., 2022). AR immersive technology helps in creating a better user experience and in establishing the emotional connection of user with the product. XR systems bring together VR, AR, and MR elements to provide users with an immersive and interactive experience. This allows them to perform real-life actions and responses within virtual spaces that closely resemble the real world (Huang et al., 2025). In immersive VR applications, the avatar's facial expressions and lip-syncing can profoundly impact a user's overall experience (Luo et al., 2023). Using the information from this literature review, a hypothesis is suggested as

**H6:** Emotional Engagement of consumer (EE) has a significant relation with consumer purchase behavior (CPB).

## **2.7 Consumer Purchase Behavior (CPB)**

Consumer Purchase Behavior encompasses the decision-making process leading to the acquisition of products or services, shaped by attitudes, preferences, and external influences like marketing efforts and peer recommendations. At the core of research into AR-enhanced shopping lies consumer purchase behavior. This is the ultimate metric of AR's impact – how effectively it influences consumers' decisions and shapes their purchasing patterns. AR has proven to be a powerful tool in driving consumer behavior, offering a transformative shopping experience that blends technology with emotion. Consumer purchase behavior is the aspect that every product and service organization wants to know more about to improve their customer service and increase and retain their consumer base. Augmented reality (AR) has been demonstrated to enhance consumers' shopping choices and interactions (Barta et al., 2023). More individuals utilize augmented reality, and there is an increasing need to grasp its impact on customer behavior, its intended use, and the quality of the experience it offers. The usage of Augmented Reality (AR) in the retail industry, along with the advantages it offers to both shoppers and businesses is being explored

(Caboniet al., 2019).

A theoretical model is proposed in Figure 1, drawing upon insights gathered from a literature review.

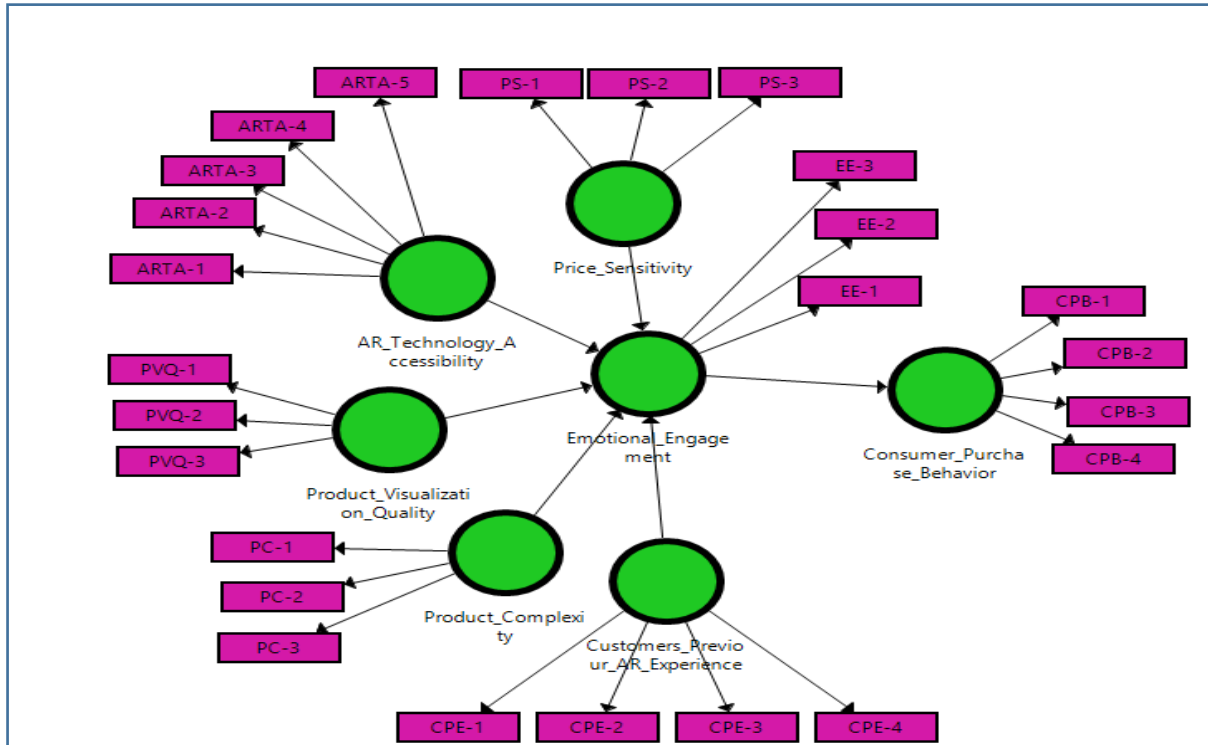


**Figure 1 The Theoretical Model (Source: Author's own work & Smart PLS Output)**

### 3. Methodology

The data collection process uses a structured questionnaire method, mainly because it is efficient in collecting a large number of responses quickly. This approach is selected to measure and evaluate the proposed relationships. The questionnaire was designed in such a way, that each construct get at minimum three items and maximum five items in order to maintain optimum effort and time utilisation. Initially 5 to 6 items per construct was added but later on when factor loading was not sufficient, some of them were removed. The reason was mainly statistical problems like low loading due to item overlap, shared variance etc. For example, product complexity were having 5 components initially but factor loading was below threshold value (less than 0.6) and hence those components were removed. Same is

the case with the price sensitivity and product visualization quality. One item is linked to one question and question is designed in such a way that it links one idea at a time, so that respondents also have clarity without any confusion. While designing the each item, care with regards to neutrality of item and avoidance of double negatives and bias were taken into consideration. In this study, around 861 questionnaires were sent out via Google Forms and the pen-paper method, using judgmental sampling. About 798 responses were collected. After screening, 744 valid responses were kept. The structured questionnaire uses a measurement scale based on the following constructs: AR Technology Accessibility (ARTA), Price sensitivity (PS), Customers Previous AR experience (CPE), Product Visualization Quality (PVQ), Product complexity (PC), Emotional Engagement (EE), and Consumer Purchase Behaviour (CPB). The sample size was determined using Cochran's formula from 1963, aiming for a 95% confidence level.

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where sample size ( $n_0$ ) is determined by the formula where  $z$  represents the critical value for a specific confidence level (1.96 for a 95% confidence interval),  $p$  is the estimated proportion of a feature in the population (0.5),  $q = 1 - p = (0.5)$ , and 'e' is the desired level of accuracy (0.05). This results in  $n_0 = 385$ . With 744 valid responses, we accurately represented the entire population. The main reason for the use of judgmental sampling being the low response received upon use of probability sampling. The measurement used was a 5-point Likert scale, where 5 means "strongly agree," 4 means "agree," 3 means "neutral," 2 means "disagree," and 1 means "strongly disagree." SMART-PLS was the statistical modeling tool used to create a structural equation model (SEM) and test hypotheses by analyzing p-values,

t-values, and beta values to assess the effect of constructs on Emotional Engagement (EE) and Consumer Purchase Behavior (CPB).

#### **4. Data Analysis**

Data Analysis was carried out in 3 steps. (1) Building the Measurement model, (2) Developing structural equation modelling (SEM), and (3) Importance-Performance Analysis (IPMA).

##### **4.1 Building the Measurement model**

Before analyzing data, it's essential to first review it. During this review, we identified 744 valid responses by detecting missing data and outliers. The main goal was to maintain consistency in the collected data. After this review, the next step was to confirm the reliability and validity of the scales used for a dependable and consistent analysis. Based on the viewpoint expressed by researcher, it can be stated that, in the context of general studies, a Cronbach's alpha value greater than 0.6 is considered satisfactory (Hair et al., 2009) (Malhotra, 2001). Our data demonstrated good reliability with Cronbach's alpha ranging from 0.605 to 0.766 (Table 1). Also the high composite reliability values strengthens the reliability. According to Table 1, all the variables have an Average Variance Extracted (AVE) value greater than 0.5, and the composite reliability (CR) ranges from 0.783 to 0.865, suggesting that convergent validity is at an acceptable level (Fornell et al., 1981). Also  $R^2$  and adjusted  $R^2$  values of the key dependent variables are as shown in Table 1, suggesting that 46.6 % variation in emotional engagement and 36.2 % variation in consumer purchase behavior is attributed to the independent constructs. The remaining (53.1%) of the variance is unexplained by the model, likely due to other variables not included or random noise.

|                                  | R <sup>2</sup> /Adjusted<br>R <sup>2</sup> | Cronbach<br>'s Alpha | rho_A | Composite<br>Reliability | Average<br>Variance<br>Extracted (AVE) |
|----------------------------------|--------------------------------------------|----------------------|-------|--------------------------|----------------------------------------|
| AR_Technology_Accessibility_     | --                                         | 0.694                | 0.727 | 0.8                      | 0.549                                  |
| Consumer_Purchase_Behavior       | 0.362 /<br>0.361                           | 0.708                | 0.727 | 0.815                    | 0.526                                  |
| Customers_Previous_AR_Experience | ---                                        | 0.688                | 0.715 | 0.809                    | 0.518                                  |
| Emotional_Engagement_            | 0.469 / 0.466                              | 0.766                | 0.776 | 0.865                    | 0.681                                  |
| Price_Sensitivity                | ---                                        | 0.747                | 0.757 | 0.856                    | 0.665                                  |
| Product_Complexity               | ---                                        | 0.708                | 0.723 | 0.836                    | 0.63                                   |
| Product_Visualization_Quality    | ---                                        | 0.605                | 0.588 | 0.783                    | 0.547                                  |

**Table 1 Convergent Validity and R<sup>2</sup> Values (Source: Smart PLS Output)**

Similarly, for the variable “Consumer Purchase Behaviour”, the model explains only 36.2% of the variance in the outcome variable (‘Consumer Purchase Behaviour’, leaving roughly 63.8% of the variance unexplained (i.e., due to other factors not in the model or random noise). The closeness of the R-squared (36.2) and Adjusted R-squared (36.1) is a positive sign. It indicates that the independent variables are relevant and that the model is not over fitting. The variables have a statistically relevant relationship (they are not random), but they are not the only factors driving the outcome.

Next, the discriminant validity was then calculated according to the study (Chin et al., 1997). The factor loadings for each indicator in Table 2 (shaded figures) are higher than their loadings with other constructs, showing that there are no cross loadings between the measured variables or error terms, confirming a satisfactory level of discriminant validity. According to the research (Hair et al., 2019), the square roots of AVEs (shown by the highlighted values in Table 3) are higher than the correlation between the model’s latent variables in the lower part of the table. This confirms satisfactory discriminant validity. A

HTMT value below 0.9 also indicates satisfactory discriminant validity (Hair et al., 2019) (Table 4). It effectively identifies whether two constructs are empirically distinct or not. For HTMT values  $>0.9$ , it would have been difficult to conceptually distinguish between the two constructs but that is not the case, in this study.

|        | AR_Technology_Accessibility | Consumer_Purchase_Behaviour | Customer_Previous_AR_Experience | Emotional_Engagement | Price_Sensitivity | Product_Complexity | Product_Visualization_Quality |
|--------|-----------------------------|-----------------------------|---------------------------------|----------------------|-------------------|--------------------|-------------------------------|
| ARTA-1 | 0.628                       | 0.259                       | 0.324                           | 0.287                | 0.231             | 0.225              | 0.173                         |
| ARTA-2 | 0.678                       | 0.246                       | 0.224                           | 0.307                | 0.512             | 0.328              | 0.425                         |
| ARTA-3 | 0.807                       | 0.303                       | 0.361                           | 0.413                | 0.381             | 0.277              | 0.336                         |
| ARTA-4 | 0.537                       | 0.342                       | 0.036                           | 0.172                | 0.018             | 0.278              | 0.172                         |
| ARTA-5 | 0.67                        | 0.263                       | 0.211                           | 0.29                 | 0.263             | 0.454              | 0.385                         |
| CPB-1  | 0.287                       | 0.751                       | 0.183                           | 0.516                | 0.311             | 0.246              | 0.433                         |
| CPB-2  | 0.246                       | 0.794                       | 0.225                           | 0.502                | 0.17              | 0.241              | 0.354                         |
| CPB-3  | 0.409                       | 0.708                       | 0.165                           | 0.371                | 0.137             | 0.388              | 0.287                         |
| CPB-4  | 0.267                       | 0.632                       | 0.116                           | 0.295                | 0.295             | 0.317              | 0.363                         |
| CPE-1  | 0.186                       | 0.179                       | 0.651                           | 0.266                | 0.183             | 0.08               | 0.269                         |
| CPE-2  | 0.303                       | 0.183                       | 0.855                           | 0.377                | 0.345             | 0.218              | 0.396                         |
| CPE-3  | 0.334                       | 0.19                        | 0.606                           | 0.236                | 0.327             | 0.397              | 0.26                          |
| CPE-4  | 0.284                       | 0.178                       | 0.78                            | 0.384                | 0.525             | 0.302              | 0.434                         |
| EE-1   | 0.292                       | 0.5                         | 0.288                           | 0.767                | 0.252             | 0.249              | 0.47                          |
| EE-2   | 0.364                       | 0.459                       | 0.384                           | 0.861                | 0.505             | 0.41               | 0.548                         |
| EE-3   | 0.461                       | 0.53                        | 0.414                           | 0.842                | 0.549             | 0.386              | 0.506                         |
| PC-1   | 0.349                       | 0.306                       | 0.211                           | 0.358                | 0.403             | 0.785              | 0.284                         |
| PC-2   | 0.441                       | 0.352                       | 0.371                           | 0.376                | 0.296             | 0.845              | 0.458                         |
| PC-3   | 0.272                       | 0.268                       | 0.194                           | 0.27                 | 0.326             | 0.747              | 0.402                         |
| PS-1   | 0.312                       | 0.242                       | 0.475                           | 0.446                | 0.832             | 0.323              | 0.482                         |
| PS-2   | 0.351                       | 0.321                       | 0.394                           | 0.473                | 0.854             | 0.38               | 0.537                         |
| PS-3   | 0.467                       | 0.186                       | 0.318                           | 0.397                | 0.756             | 0.348              | 0.314                         |
| PVQ-1  | 0.253                       | 0.395                       | 0.323                           | 0.427                | 0.258             | 0.226              | 0.671                         |
| PVQ-2  | 0.387                       | 0.357                       | 0.488                           | 0.522                | 0.587             | 0.434              | 0.805                         |
| PVQ-3  | 0.373                       | 0.366                       | 0.229                           | 0.418                | 0.352             | 0.394              | 0.751                         |

**Table 2 Matrix cross loadings of discriminant validity (Source: Smart PLS Output)**

In order to strengthen the robustness of the structural model assessment, effect sizes ( $f^2$ ) and predictive relevance ( $Q^2$ ) values were calculated. It was found that with effect sizes ( $f^2$ ) values of 0.012 and 0.008, the constructs customers' previous AR experience and product complexity respectively have small effect, whereas AR Technology Accessibility ( $f^2=0.021$ ), 'Price Sensitivity ( $f^2=0.044$ )' and Product Visualization Quality ( $f^2=0.142$ ) have a medium

effect on endogenous construct (i.e. Emotional Engagement). However, with ( $f^2 = 0.566$ ), ‘Emotional Engagement’ is having a large effect on ‘Consumer Purchase Behavior’. Also ‘Q<sup>2</sup> –Value’ for ‘Emotional Engagement’ and ‘Consumer Purchase Behavior’ were found to be (0.311) and (0.181) showing large and medium predictive relevance respectively.

|                                 | AR_Technology_Accessibility | Consumer_Purchase_Behaviour | Customer_Previous_AR_Experience | Emotional_Engagement | Price_Sensitivity | Product_Complexity | Product_Visualization_Quality |
|---------------------------------|-----------------------------|-----------------------------|---------------------------------|----------------------|-------------------|--------------------|-------------------------------|
| AR_Technology_Accessibility     | 0.67                        |                             |                                 |                      |                   |                    |                               |
| Consumer_Purchase_Behaviour     | 0.406                       | 0.724                       |                                 |                      |                   |                    |                               |
| Customer_Previous_AR_Experience | 0.375                       | 0.245                       | 0.73                            |                      |                   |                    |                               |
| Emotional_Engagement            | 0.457                       | 0.601                       | 0.443                           | 0.825                |                   |                    |                               |
| Price_Sensitivity               | 0.456                       | 0.31                        | 0.488                           | 0.54                 | 0.815             |                    |                               |
| Product_Complexity              | 0.455                       | 0.393                       | 0.334                           | 0.428                | 0.429             | 0.793              |                               |
| Product_Visualization_Quality   | 0.457                       | 0.498                       | 0.479                           | 0.617                | 0.552             | 0.478              | 0.745                         |

**Table 3 Fornell Larcker (1981) Criteria of Discriminant validity (source: Smart PLS)**

|                                 | AR_Technology_Accessibility | Consumer_Purchase_Behaviour | Customer_Previous_AR_Experience | Emotional_Engagement | Price_Sensitivity | Product_Complexity | Product_Visualization_Quality |
|---------------------------------|-----------------------------|-----------------------------|---------------------------------|----------------------|-------------------|--------------------|-------------------------------|
| AR_Technology_Accessibility     |                             |                             |                                 |                      |                   |                    |                               |
| Consumer_Purchase_Behaviour     | 0.616                       |                             |                                 |                      |                   |                    |                               |
| Customer_Previous_AR_Experience | 0.529                       | 0.347                       |                                 |                      |                   |                    |                               |
| Emotional_Engagement            | 0.595                       | 0.784                       | 0.61                            |                      |                   |                    |                               |
| Price_Sensitivity               | 0.613                       | 0.426                       | 0.654                           | 0.698                |                   |                    |                               |
| Product_Complexity              | 0.651                       | 0.574                       | 0.482                           | 0.565                | 0.593             |                    |                               |
| Product_Visualization_Quality   | 0.69                        | 0.763                       | 0.702                           | 0.89                 | 0.794             | 0.73               |                               |

**Table 4 Discriminant validity (HTMT) (source: Smart PLS Output)**

|                                 | AR_Technology_Accessibility | Consumer_Purchase_Behaviour | Customer_Previous_AR_Experience | Emotional_Engagement | Price_Sensitivity | Product_Complexity | Product_Visualization_Quality |
|---------------------------------|-----------------------------|-----------------------------|---------------------------------|----------------------|-------------------|--------------------|-------------------------------|
| AR_Technology_Accessibility     |                             |                             |                                 | 1.482                |                   |                    |                               |
| Consumer_Purchase_Behaviour     |                             |                             |                                 |                      |                   |                    |                               |
| Customer_Previous_AR_Experience |                             |                             |                                 | 1.457                |                   |                    |                               |
| Emotional_Engagement            |                             | 1                           |                                 |                      |                   |                    |                               |
| Price_Sensitivity               |                             |                             |                                 | 1.712                |                   |                    |                               |
| Product_Complexity              |                             |                             |                                 | 1.465                |                   |                    |                               |
| Product_Visualization_Quality   |                             |                             |                                 | 1.759                |                   |                    |                               |

**Table 5 Inner VIF values (source: Smart PLS Output)**

From above Table 5, it is very clear that there is no or minimal common method bias involved as all inner VIF values are less than the threshold value of 3.3.

#### 4.2 Building the Structural Equation Model (SEM)

The next stage was the construction of structural equation model. Using SMART-PLS software and PLS-Algorithm operation on the data, correlation values between Latent constructs were found, as shown in Table 6.

|                                 | AR_Technology_Accessibility | Consumer_Purchase_Behaviour | Customer_Previous_AR_Experience | Emotional_Engagement | Price_Sensitivity | Product_Complexity | Product_Visualization_Quality |
|---------------------------------|-----------------------------|-----------------------------|---------------------------------|----------------------|-------------------|--------------------|-------------------------------|
| AR_Technology_Accessibility     | 1                           |                             |                                 |                      |                   |                    |                               |
| Consumer_Purchase_Behaviour     | 0.406                       | 1                           |                                 |                      |                   |                    |                               |
| Customer_Previous_AR_Experience | 0.375                       | 0.245                       | 1                               |                      |                   |                    |                               |
| Emotional_Engagement            | 0.457                       | 0.601                       | 0.443                           | 1                    |                   |                    |                               |
| Price_Sensitivity               | 0.456                       | 0.31                        | 0.488                           | 0.54                 | 1                 |                    |                               |
| Product_Complexity              | 0.455                       | 0.393                       | 0.334                           | 0.428                | 0.429             | 1                  |                               |
| Product_Visualization_Quality   | 0.457                       | 0.498                       | 0.479                           | 0.617                | 0.552             | 0.478              | 1                             |

**Table 6 Latent Variable correlation (source: Smart PLS Output)**

Once the data is analyzed using SMART-PLS, the path coefficients and structural equation model are obtained. The coefficients between constructs are presented in Table 7. Table 7

also lists the values for beta, t-statistics, and p-statistics, while Figure 2 illustrates the structural equation model.

|                                                                   | Original<br>Sample (O) | Sample<br>Mean (M) | (STDE<br>V) | T Stat | P Val |
|-------------------------------------------------------------------|------------------------|--------------------|-------------|--------|-------|
| AR_Technology_Accessibility_ -><br>Consumer_Purchase_Behavior     | 0.077                  | 0.078              | 0.019       | 4.044  | 0.00  |
| AR_Technology_Accessibility_ -><br>Emotional_Engagement_          | 0.141                  | 0.143              | 0.032       | 4.45   | 0     |
| Customers_Previous_AR_Experience -><br>Consumer_Purchase_Behavior | 0.059                  | 0.059              | 0.024       | 2.463  | 0.014 |
| Customers_Previous_AR_Experience -><br>Emotional_Engagement_      | 0.137                  | 0.135              | 0.041       | 3.334  | 0.001 |
| Emotional_Engagement_ -><br>Consumer_Purchase_Behavior            | 0.603                  | 0.606              | 0.024       | 25.248 | 0     |
| Price_Sensitivity -><br>Consumer_Purchase_Behavior                | 0.120                  | 0.119              | 0.023       | 5.106  | 0.00  |
| Price_Sensitivity -> Emotional_Engagement_                        | 0.206                  | 0.203              | 0.037       | 5.503  | 0     |
| Product_Complexity-><br>Consumer_Purchase_Behavior                | 0.046                  | 0.047              | 0.023       | 1.998  | 0.046 |
| Product_Complexity -> Emotional_Engagement_                       | 0.099                  | 0.101              | 0.037       | 2.714  | 0.007 |
| Product_Visualization_Quality-><br>Consumer_Purchase_Behavior     | 0.219                  | 0.219              | 0.025       | 8.926  | 0.00  |
| Product_Visualization_Quality -><br>Emotional_Engagement_         | 0.311                  | 0.312              | 0.034       | 9.231  | 0.00  |

**Table 7 Path Coefficients (source: Smart PLS Output)**

The direct relationships between the independent variables and dependent variable are very weak as compared to relationship through mediation variable (Table 7) and hence they are not taken into consideration leading to 'Emotional engagement' as complete mediator variable.

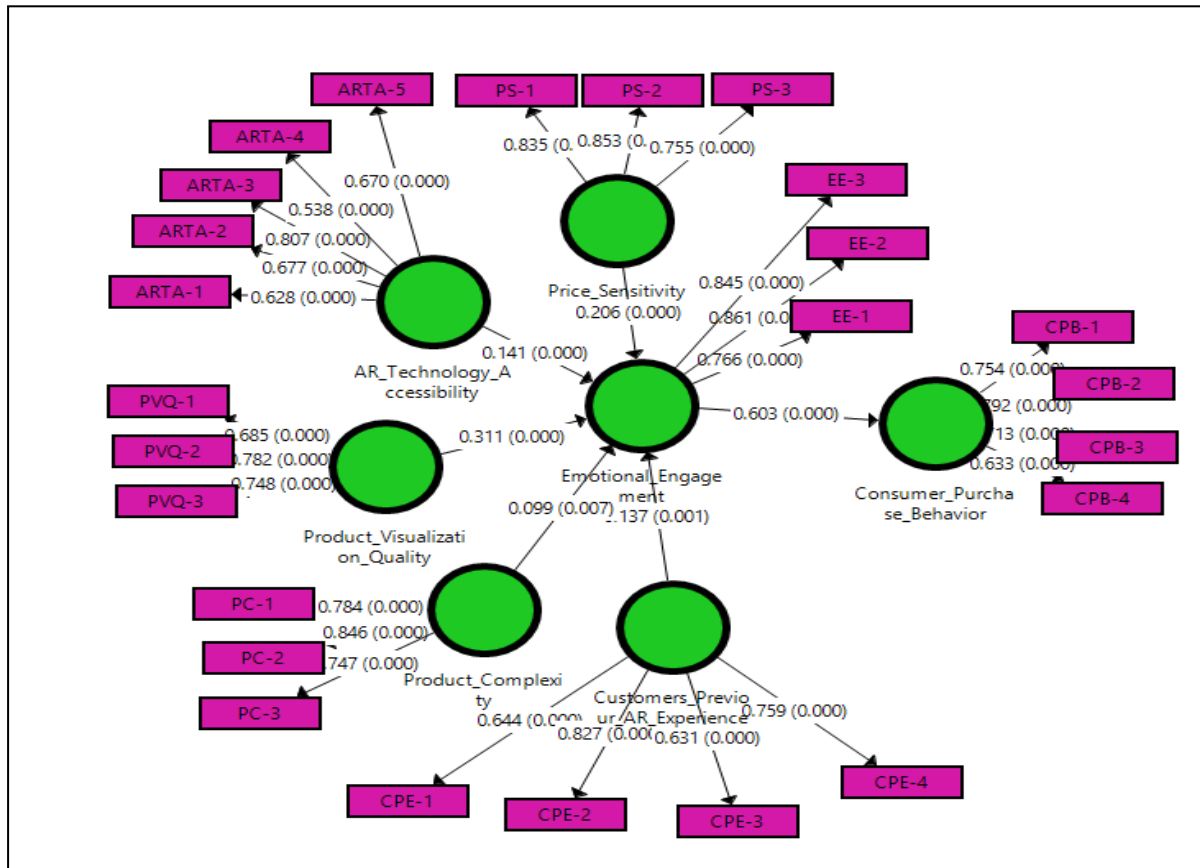


**Figure 2 The Structural Equation Model (source: Smart PLS Output)**

#### 4.3 Importance-Performance Analysis (IPMA)

According to (Wu et al., 2025), Importance Performance Map Analysis (IPMA) is an instrument to examine the model. The IPMA is a tool used to assess and rank the significance and performance of various factors in a research study. It helps researchers understand the contribution of each factor to the research model. By looking at the importance and performance of different factors, the IPMA helps researchers prioritize their efforts and allocate resources effectively. In this case, IPMA is carried out for consumer purchase behavior as shown in Figure 3.

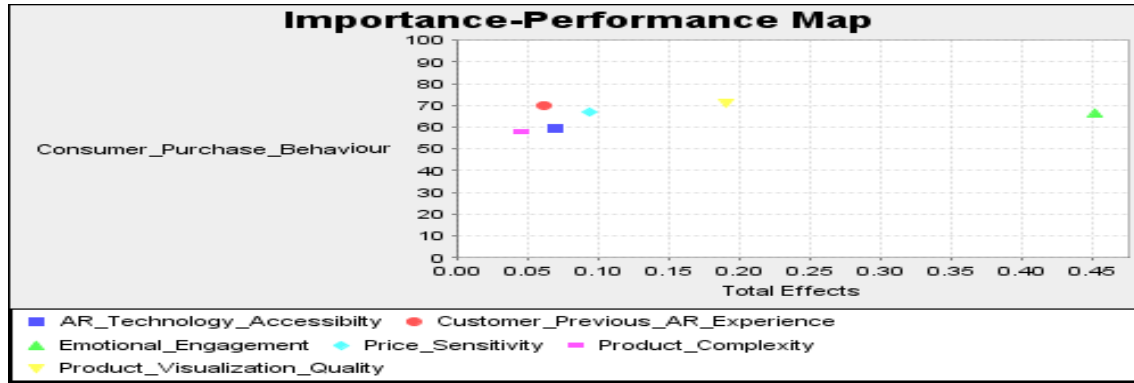


**Figure 3 Importance-Performance Map Analysis (source: Smart PLS Output)**

## 5. Conclusion

After analysing the data using SMART-PLS and bootstrapping techniques, a structural equation model was created to display the path coefficient and significance level of each latent variable, as shown in Figure 2 and Table 7. In this research on Shopping 4.0, which is supported by augmented reality as part of Industry 4.0 for consumer purchases, five key factors were identified through a literature review. These factors include AR technology accessibility, customers' previous AR experiences, price sensitivity, product complexity, and product visualization quality.

| Relation between the variables                          | Original Sample (O) | Sample Mean (M) | (STDEV) | T Stat | P Val | Hypotheses             | Supported/ Not supported |
|---------------------------------------------------------|---------------------|-----------------|---------|--------|-------|------------------------|--------------------------|
| AR_Technology_Accessibility ~ Emotional_Engagement      | 0.141               | 0.143           | 0.032   | 4.45   | 0.000 | <b>H1:</b><br>ARTA>>EE | Supported                |
| Customers_Previous_AR_Experience ~ Emotional_Engagement | 0.137               | 0.135           | 0.041   | 3.334  | 0.001 | <b>H2:</b><br>CPE>>EE  | Supported                |
| Product_Visualization_Quality ~ Emotional_Engagement    | 0.311               | 0.312           | 0.034   | 9.231  | 0.000 | <b>H3:</b><br>PVQ >>EE | Supported                |
| Price Sensitivity ~ Emotional_Engagement                | 0.206               | 0.203           | 0.037   | 5.503  | 0.000 | <b>H4:</b><br>PS>>EE   | Supported                |
| Product Complexity ~ Emotional_Engagement               | 0.099               | 0.101           | 0.037   | 2.714  | 0.007 | <b>H5:</b><br>PC>>EE   | Supported                |
| Emotional_Engagement ~ Consumer_Purchase_Behavior       | 0.603               | 0.606           | 0.024   | 25.248 | 0.000 | <b>H6:</b><br>REU>>RU  | Supported                |

**Table 8 The Total Effects Table (source: Smart PLS Output)**

The study explores their influence on Emotional Engagement (EE) and how Emotional Engagement affects consumer purchasing behaviour. Table 8, titled "Total Effects," outlines how each factor impacts Emotional Engagement and consumer purchase behaviour, which helps validate the hypotheses.

From Table 8, it is evident that product visualization quality has a significant influence on emotional engagement, with a beta value of 0.311 and a p-value of 0.000, leading to the acceptance of hypothesis H3, which is also endorsed by (Udiono, 2021), (Merle et al., 2012), (Tong et al., 2025), (Ngo et al., 2025) and (Jiang et al., 2024) . This effect is due to consumers believing that what they see is what they get. High-quality product visuals, aided by AR, create an immersive experience for the consumer, enhancing their interaction and contributing to the concept of Shopping 4.0, driven by AR technology from Industry 4.0. Consumer perception hinges on the product visualization technique applied. AR enables a digitally augmented reality view, overlaying visuals and data to aid decision-making. Enhanced visual quality increases consumer immersion and subsequent emotional engagement, which directly affects consumer buying attitudes and behavior. Similarly, the construct of price sensitivity, with a beta value of 0.206 and a p-value of 0.000, has a notable effect on emotional engagement, thus supporting hypothesis H4. Regardless of the shopping method (physical or online), price sensitivity influences the consumer's emotional response. This can be explained as, with increased use of AR technology, which makes the experience attractive and immersive for consumer, consumer is willing to pay a price premium. Better the immersive experience, higher the corresponding price for AR technology. This finding is supported by previous studies (Dhruv et al., 2017), (Meißner et al., 2020). Also, with a beta value of 0.141 and a p-value of 0.000, the accessibility of AR technology plays a crucial role in fostering emotional engagement, thereby confirming hypothesis H1. Without proper access and awareness of AR tools, the immersive experience for consumers is absent. Hence,

accessibility to AR technology is essential for building emotional engagement. This finding is supported by (Heller et al., 2021), (Žilak et al., 2022), (Akçayır et al., 2017). Regarding the customer's previous AR experience, the beta value of 0.137 and p-value of 0.001 indicate its significant impact on emotional engagement, leading to the acceptance of hypothesis H2. Thus, (Nhan et al., 2022), (Baek et al., 2018), (Suo et al., 2025), (Song et al., 2020), (McLean et al., 2019) support this finding. A consumer's first experience with AR serves as a trigger for emotional engagement, making past experience an important factor in emotional interaction. Furthermore, product complexity, with a beta value of 0.099 and a p-value of 0.007, has a relatively smaller impact on emotional engagement compared to other constructs, resulting in the acceptance of hypothesis H5 and is supported by studies (Tarafdar et al., 2019), (Riar et al., 2023), (Sun et al., 2022). This is because, unlike earlier methods where only images were shown, AR allows consumers to view complex products in 3D, aiding in better decision-making. The other explanation for lower correlation coefficient can be attributed to Cognitive Load Theory (Sweller, 2011). It posits that human working memory is limited, and complex products impose higher cognitive load on consumers. AR can reduce this extraneous cognitive load by externalizing product complexity into an interactive 3D space — yet the emotional response may still be muted if the complexity remains overwhelming, leading to lower beta value. Finally, with a beta value of 0.603 and a p-value of 0.000, emotional engagement significantly affects consumer purchase behavior, leading to acceptance of hypothesis H6 and supported by (ChicchiGiglioliet al., 2015), (Sung, 2021), (Du et al., 2022), (Huang et al., 2025), (Luo et al., 2023). The immersive experience created by AR boosts emotional engagement, which, in turn, enhances interactive consumer purchase behavior, embodying the core features of Shopping 4.0.

In the IPMA analysis, the factor 'Emotional Engagement' was identified as the most important, showing high performance as seen in Figure 3. The second most significant factor

for the dependent variable is 'Product Visualization Quality,' with a performance level that is also quite high. 'Price Sensitivity' is less important than 'Product Visualization Quality,' but its performance is quite similar. Additionally, the factors 'AR Technology Accessibility' and 'Customer's Previous AR Experience' are less important, but their performance is comparable. Therefore, to enhance 'Consumer Purchase Behaviour,' it is crucial to focus on the factors of 'Product Visualization Quality,' 'Price Sensitivity,' 'AR Technology Accessibility,' and 'Customer's Previous AR Experience,' and take appropriate actions accordingly. Product complexity is both low on importance and performance, this is because, consumers are less concerned about the complex shape and size or features of the product, because they look at the visual appeal and other features, offered by attractive AR technology. Consumer's assume that AR technology is going to be accessible in future with increasing bandwidth spectrum, and previous experience with AR technology handling , is going to be same, only product features , price sensitivity and visualisation will make a difference in emotional attachment with the products. Thus, performance wise AR technology accessibility and consumer's previous AR experience are comparable but they lack in importance. Thus, this study extends TAM beyond its traditional two-construct model (PU and PEOU) by embedding five contextual antecedents specific to AR shopping environments. This suggests that TAM, in immersive retail contexts, requires supplementary constructs capturing sensory quality, prior experiential learning, and economic sensitivity. Similarly, by positioning EE (Emotional Engagement) as the "Organism" variable and demonstrating its full mediation between AR-related stimuli and CPB-consumer purchase behaviour (the "Response"), this study empirically validates the SOR framework in a Shopping 4.0 context and extends it by identifying which specific stimuli (PVQ being strongest, PC being weakest) carry the highest organismic activation potential.

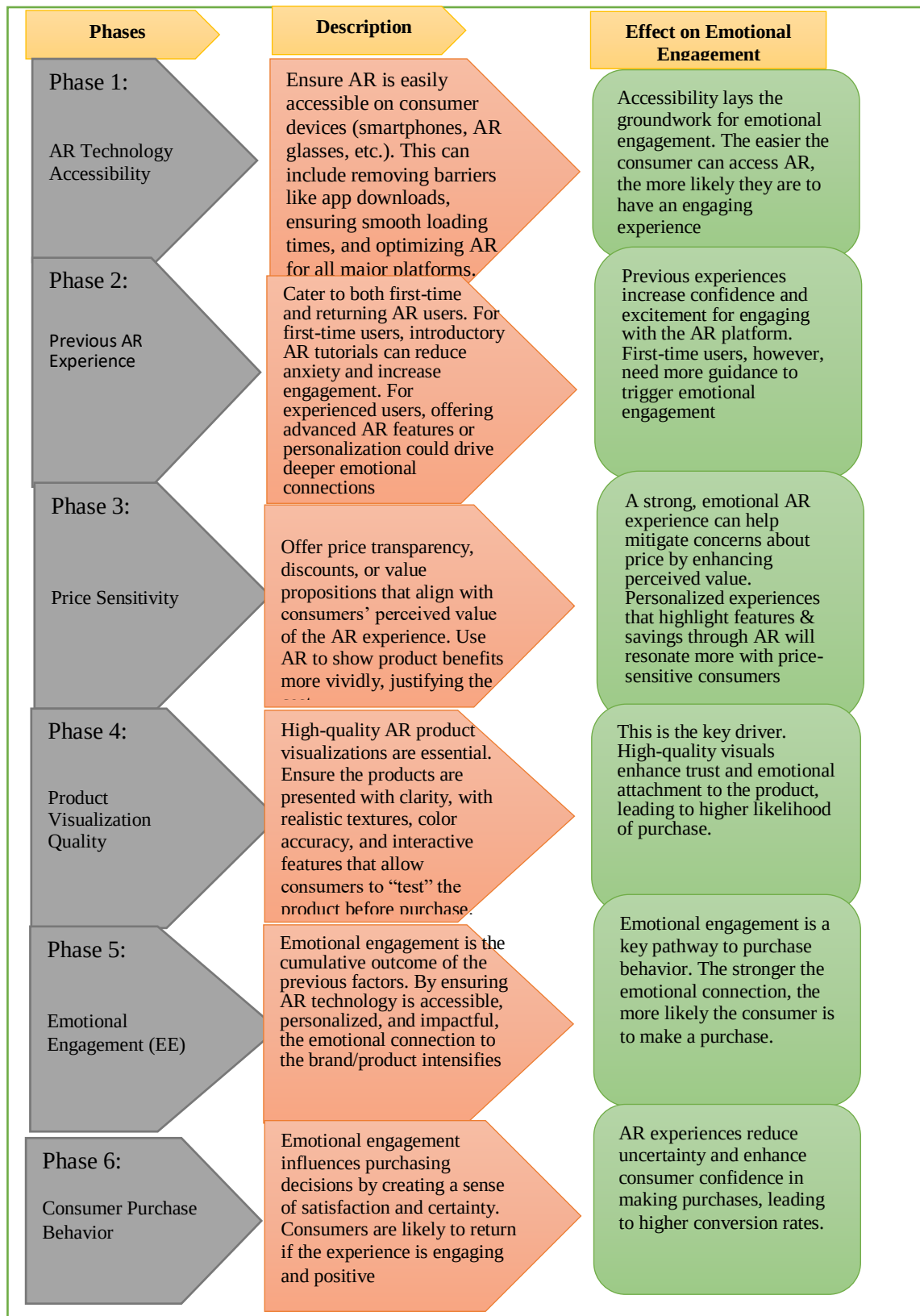


**Figure 4 Holistic Consumer Experience Model (HCEM)** (source: Author's own work)

Based on the above outcomes of the study, a Holistic Consumer Experience Model (HCEM) was proposed (Figure 4), focusing on the key constructs (AR technology accessibility, previous AR experiences, price sensitivity, product complexity, and product visualization quality), and how they collectively impact emotional engagement (EE) and consumer purchase behaviour.

The model encapsulates how each element contributes to the overall consumer journey from initial exposure to AR, emotional engagement, and eventual purchase. The easier it is for consumers to access AR, the more emotionally engaged they are likely to be. A seamless AR experience facilitates the transition into the virtual environment, which enhances emotional immersion. Past interactions with AR shape expectations and can make future interactions more engaging. Positive experiences increase consumer confidence and emotional engagement, which, in turn, influences their likelihood to purchase.

Consumers with high price sensitivity may react differently to AR experiences, particularly when it comes to perceived value. An engaging AR experience can outweigh price concerns if it boosts the perceived value of the product. AR's ability to create realistic, high-quality product visualizations directly impacts consumer emotions. The "what you see is what you get" effect fosters trust and a deeper emotional connection to the product. Complex products, when well-visualized, may benefit more from AR since it simplifies consumer understanding and enhances engagement.

## **6. Research Limitations and Future Research**

In this research, the respondents primarily include tech-savvy individuals who have some experience with AR and smartphones. However, there is another group from Rural area and uneducated people from Urban area, who buy electronics physically but are unfamiliar with AR technology. Their perspectives could significantly influence the research outcomes,

suggesting a potential area for future investigation. Secondly, AR technology is currently accessible mainly in major cities, excluding those in smaller towns that also use electronic products. Neglecting these users could skew the research findings. Thus, including them is crucial as they represent another segment of end-users for electronic products. This gap highlights the need for broader inclusivity in AR research, ensuring a more comprehensive understanding of its impact across diverse user demographics. Limitations related to cross-sectional design, self-reported measures, and potential common method variance need to be considered. In summary, while tech-savvy users familiar with AR form the primary research group, those unfamiliar but still purchasing electronics present a contrasting viewpoint. In future, longitudinal or experimental AR exposure designs can be considered for the research. Additionally, the accessibility of AR predominantly in major cities overlooks potential insights from users in smaller towns. This research has taken into consideration only simple wearable consumer products and accessories like pair of glasses, or apparel like T-shirts, and hence PVQ is a dominant factor. However, future researcher can take into account high-complexity products (e.g., consumer electronics, medical devices) where PC would exert a stronger influence on EE, as AR's ability to simplify complex products becomes the main driving factor. Even multi-group-analysis with data related to different products types (Apparel, accessories, complex products), will allow more nuanced interpretation of path coefficient differences and strengthen the practical applicability of the findings. Addressing these aspects not only enriches current research findings but also identifies new avenues for future studies in AR technology adoption and its implications on consumer behaviour.

## **7. Declarations**

### **Ethical Approval and Consent to Participate**

Informed consent was obtained from all individual participants included in the study. In addition, verbal informed consent was obtained for each participant. They were reassured that

their participation is voluntary and that they were free to withdraw at any time. Moreover, all information was gathered anonymously and handled confidentially. The study design assured adequate protection of study participants.

### **Consent to Publication**

Not applicable.

### **Funding**

This research doesn't have any funding available, and there's no personal interest conflict.

### **Clinical trial declaration**

Not applicable

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