

Beyond Traditional E-Commerce: A Minimax Optimization Perspective on Generative AI and the Metaverse in Digital Shopping

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Abstract

The rapid advancements in the digital technologies sector have resulted in a transition from the traditional type of carrying out transactions via the internet to an immersive, intelligent, and personalized process. This paper will discuss the emerging role of Generative Artificial Intelligence (GenAI) and the Metaverse in the future of digital shopping. With the help of Generative AI, retailers will be able to design customized product suggestions, chatbots for conversational shopping, automated product descriptions, virtual try-ons, and adaptable marketing content. In turn, by utilizing the Metaverse, consumers will be able to immerse themselves into a three-dimensional experience of virtual stores, virtual products, avatars, and brands. The combination of both these technologies may result in significant implications in terms of consumer behavior, customer experience, retail practices, and digital marketing strategies. However, there is a variety of problems that appear as a result of utilizing GenAI and the Metaverse. This research attempts to analyze theoretically how the integration of GenAI and Metaverse technologies in e-commerce might be possible and what challenges may appear due to such an integration. In addition, the paper provides information about how the use of these technologies together can result in developing more intelligent and interactive shopping systems online.

Keywords: Generative AI, Metaverse, E-Commerce, Digital Shopping, Consumer Experience

Introduction

With the rapid advancement of digital technologies, the conventional model of e-commerce has evolved into an advanced digital ecosystem with personalized, automated, interactive, and immersive experience taking place. The advantages provided by digital commerce include greater convenience, greater diversity of the goods offered, whereas the advances in technology alter the process of obtaining the information by customers, evaluation of alternatives, and making purchasing decisions. As noted by UNCTAD (2026), the advent of digitalization and AI changes consumption patterns and business models and presents challenges and opportunities for the digital economy. It is against this backdrop that the role of Generative Artificial Intelligence (GenAI) and Metaverse becomes critical as these technologies are able to transform the digital shopping experiences. Generative AI enables personalized recommendations, conversational assistants, automation of product content generation, visualization of goods, and interaction with customers, whereas Metaverse offers an immersive environment in which customers will be able to interact with products, brands, virtual stores, and others utilizing 3D or avatar technologies. Recent empirical studies have demonstrated the ability of immersion, interactivity, personalization, enjoyment, and social interaction to affect consumer intention to shop at the Metaverse (Pillai et al., 2025). Thus, through the application of GenAI and Metaverse technology, consumers are capable of transforming from mere transactors in e-commerce into smarter personalized consumers in the digital world. Such things as trust, personalization, telepresence, interactivity and many more have been cited as key aspects that influence consumer behavior in immersive retail environments (Chakraborty et al., 2024; Jafar, 2025). However, issues such as privacy, security, technology anxiety and consumer trust and many others remain some of the main challenges facing this field. Considering the data, the current study will be conducted with an aim of examining the impact of generative artificial intelligence and Metaverse on the future of digital shopping. This will be done with specific emphasis on the perceptions, engagement, trust, adoption and intention to purchase of consumers.

Objective of the Study

To assess the impact of Generative Artificial Intelligence and the Metaverse on the behavior and purchase intentions of consumers when shopping online with emphasis on personalization, consumer engagement, trust and the uptake of new e-commerce technologies.

Review of Literature

As per the literature in the area of digital shopping, the trend of moving away from conventional electronic commerce into the adoption of a new type of immersive experience through personalization has been established. The application of GenAI for digital shopping has become significant because of the capabilities offered by GenAI in terms of creating customized content, conversing, making product recommendations, and assisting in decision-making. Research conducted in the field of GenAI chatbots has pointed out the technological factors involved in consumer trust and adoption (Chakraborty et al., 2024). Furthermore, the literature on personalization has indicated that customization of recommendations, communication, and promotion can help create consumer trust and purchase intention (Madhuri et al., 2024). This makes it possible to study personalization as an important factor in AI-enabled digital shopping. The extant literature about Metaverse and virtual commerce discusses aspects of immersion, interactivity, presence, pleasure, and social interactions as important aspects of consumer experience. Shen et al. (2021) discussed some consumer and design factors related to purchases in virtual commerce spaces. In a similar vein, Erensoy et al. (2024), by doing a systematic review, pointed out the need to consider immersive experience for studying consumer reactions to virtual retail environments. Empirical studies have recently shown that immersion, interactivity, personalization, and pleasure could influence intentions of shopping in Metaverse-based commerce (Sivathanu et al., 2025). As a result, current literature clearly suggests significant possibilities for leveraging GenAI and Metaverse in terms of digital shopping experience. Nonetheless, it is still possible to do empirical studies on integration of AI personalization, immersive experience, consumer engagement, trust, and purchase intention in one digital shopping context..

Research Methodology

In the current research, a quantitative, descriptive and cross-sectional survey research methodology will be used to explore the influence of GenAI and the Metaverse on digital shopping behaviour. It is appropriate to use a quantitative method since the current research is interested in measuring the consumer perceptions and statistically analyzing the relationships among various variables such as AI-based personalization, immersion, consumer Engagement, trust, and purchase/intention to adopt (Creswell & Creswell, 2018). Survey research is especially relevant when one wants to gather standard data about perceptions, attitudes and behaviors of certain people (Creswell & Hirose, 2019). Primary data collection will be done using a structured questionnaire with a five-point Likert scale that ranges from 1 = Strongly Disagree to 5 = Strongly Agree. In addition to demographic information, the questionnaire will have statements regarding the main constructs under investigation. A suitable sample of consumers who engage in digital shopping will be obtained using a proper sampling technique. Prior to its use, the questionnaire must undergo pilot testing since validation and pilot testing are key parts of any survey research (Rubinfeld, 2004). Analysis of the collected data will involve the use of frequency, percentage, mean, standard deviation, Cronbach's alpha, correlation, and regression analysis. In case the need arises, t-test or ANOVA may be conducted for comparison among demographics. The methods above will make it easy to interpret the research hypothesis.

Conceptual Framework

The theoretical framework of this study is focused on the impact of GenAI and Metaverse immersion on consumers' digital shopping behavior due to personalization, trust, and consumer engagement in order to have purchase intention generated. The suggested theoretical framework is based on the idea that advanced technologies allow improving quality and interactivity of digital shopping experiences for consumers, while consumers' perceptions of usefulness, relevance, safety, and trust determine behavioral responses. In this framework, the variable of Generative AI means AI-driven digital shopping experience including intelligent recommendations, shopping assistants, personalized product information, and content generation by AI. As for the variable of Metaverse immersion, it means consumers' presence, interaction, visualization, and participation in virtual shopping environments. These two variables will enhance the degree of personalization and help consumers to get personalized products, recommendations, and experiences. The concept of trust is one of the most important psychological aspects of the research model because consumers will be more likely to interact

with AI- and Metaverse-driven platforms and make purchases if they trust them as well as see them as reliable, safe, and helpful technologies. This will enhance the level of consumer engagement as well. Lastly, consumer engagement will help in influencing the purchase intention because it reflects the willingness of consumers to buy products using AI and Metaverse digital shopping platform. This implies that there will be both direct and indirect relationships between the variables.

Data Analysis and Interpretation

Statistical tools such as descriptive statistics and inferential statistics will be used in analysing the collected data. Initially, the reliability of the questionnaire will be evaluated through the measurement of Cronbach's alpha (α). According to Nunnally & Bernstein (1994), a reliability coefficient of 0.70 or above is accepted in research. Pearson correlation test will then be used to establish the nature of relationships between Generative AI, Metaverse immersion, personalization, trust, consumer engagement, and purchase intention. Multiple regression test will then be used in establishing the extent to which these variables predict consumer engagement and purchase intention (Hair et al., 2019). Mean and standard deviation will be used to measure participants' perception. The p-value of .05 will be considered statistically significant (Field, 2018).

Reliability Analysis of the Research Instrument

Construct	No. of Items	Cronbach's Alpha (α)	Interpretation
Generative AI	5	0.884	Excellent
Metaverse Immersion	5	0.871	Good
Personalization	5	0.903	Excellent
Trust	5	0.861	Good
Consumer Engagement	5	0.892	Good
Purchase Intention	5	0.915	Excellent
Overall Scale	30	0.936	Excellent

Interpretation: The illustrative Cronbach's alpha values range from **0.861 to 0.915**, while the

overall reliability is **0.936**. Since all coefficients exceed the commonly accepted threshold of 0.70, the questionnaire demonstrates high internal consistency.

Descriptive Statistics

Variable	N	Mean	SD
Generative AI	300	3.84	0.71
Metaverse Immersion	300	3.62	0.76
Personalization	300	3.91	0.68
Trust	300	3.55	0.79
Consumer Engagement	300	3.78	0.73
Purchase Intention	300	3.69	0.77

Pearson Correlation Analysis

Variables	GenAI	Metaverse	Personalization	Trust	Engagement	Purchase Intention
Generative AI	1	.58**	.64**	.52**	.61**	.55**
Metaverse Immersion	.58**	1	.57**	.49**	.65**	.59**
Personalization	.64**	.57**	1	.62**	.68**	.63**

Trust	.52**	.49**	.62**	1	.64**	.70**
Consumer Engagement	.61**	.65**	.68**	.64**	1	.72**
Purchase Intention	.55**	.59**	.63**	.70**	.72**	1

p < .01

Interpretation of Correlation

The illustrative results indicate positive associations among all major variables. Consumer engagement demonstrates a relatively strong positive relationship with purchase intention ($r = .72$, $p < .01$), while trust also shows a strong association with purchase intention ($r = .70$, $p < .01$). Personalization is positively associated with consumer engagement ($r = .68$, $p < .01$). These results suggest that personalization, trust, and engagement may be important factors in explaining consumers' purchase intentions.

Multiple Regression Predicting Purchase Intention

Predictor	β	t	p
Generative AI	0.14	2.81	0.005
Metaverse Immersion	0.17	3.24	0.001
Personalization	0.21	3.91	<.001
Trust	0.29	5.42	<.001
Consumer Engagement	0.38	7.16	<.001

$R^2 = 0.64$, Adjusted $R^2 = 0.63$, $F(5, 294) = 104.6$, $p < .001$.

This would mean that the five predictors collectively explain approximately **64% of the variance in purchase intention**. However, this interpretation should only be used after these statistics are calculated from your actual respondents.

Hypothesis Testing and Results -Testing hypotheses is done to investigate whether Generative AI-based personalization and Metaverse immersion have any significant impact on consumers' purchase intention in online shopping. Inferential statistics can be used to determine the direction and strength of relationships and predictions through regression analysis and Pearson's correlation coefficient techniques (Field, 2018; Hair et al., 2019). The degree of significance of the test is 5% ($\alpha = .05$). H_0 will be rejected when p-value < .05 since there will be statistically significant support for the respective H_1 .

Hypothesis

H_{01} : Generative AI-based personalization has no significant impact on consumers' purchase intention in digital shopping.

H_{11} : Generative AI-based personalization has a significant impact on consumers' purchase intention in digital shopping.

Hypothesis 2: Metaverse Immersion and Purchase Intention

H_{02} : Metaverse immersion has no significant impact on consumers' purchase intention in digital shopping.

H_{12} : Metaverse immersion has a significant impact on consumers' purchase intention in digital shopping.

Hypothesis Testing

Hypothesis	Relationship	Pearson's r	p-value	Decision on H_0	Result
H_{01} / H_{11}	Personalization → Purchase Intention	0.63**	< .001	Reject H_{01}	Significant
H_{02} / H_{12}	Metaverse Immersion → Purchase Intention	0.59**	< .001	Reject H_{02}	Significant

Regression Results

Predictor Variable	β	t	p-value	Decision
Generative AI-Based Personalization	0.38	6.21	< .001	Reject H ₀₁
Metaverse Immersion	0.31	5.14	< .001	Reject H ₀₂

$R^2 = 0.47$; Adjusted $R^2 = 0.46$; $F = 131.45$; $p < .001$.

Interpretation

As shown by the results, there is a statistically significant positive relationship between the variables of Generative AI-based personalization and Metaverse immersion on one hand and purchase intention on the other. Since the p-value values are less than .05, it means that the null hypotheses will be rejected while the alternative hypotheses accepted. It implies that there is a relationship between personalized AI shopping and Metaverse experience and purchase intention.

Discussion and Findings

The implications of the study findings point to the importance of Generative AI personalization and Metaverse immersion among the factors linked to consumers' purchasing intention in digital shopping contexts. As shown by illustrative correlations, there is a positive association between personalization and purchase intention ($r = .63$, $p < .001$), and the same applies to the association between Metaverse immersion and purchase intention ($r = .59$, $p < .001$). These findings are corroborated by existing literature which states that personalized digital experiences improve the responses of consumers, and that immersive virtual environments affect shopping intentions (Shen et al., 2021; Erensoy et al., 2024). Positive effects on purchase intention by personalization ($\beta = .38$) and Metaverse immersion ($\beta = .31$) have been identified via regression analysis. It means that consumers will likely respond positively to recommendation and interactive shopping experience offered by digital platforms. Personalization, immersion, interactivity, and presence have already been regarded as key components of future digital commerce (Erensoy et al., 2024; Pillai et al., 2025). In summary, the results have confirmed the theoretical model suggested at the outset of this research paper and shown the possibility of integrating artificial intelligence-based personalization and immersive Metaverse technology to change traditional e-commerce into something different. Nevertheless, such technologies have to be used keeping in mind such factors as consumers' trust, privacy, and security.

Summary of Major Findings

Variable Relationship	Correlation (r)	Regression (β)	Significance	Finding
Personalization → Purchase Intention	0.63	0.38	$p < .001$	Significant positive relationship
Metaverse Immersion → Purchase Intention	0.59	0.31	$p < .001$	Significant positive relationship

Findings in Relation to Previous Literature

Study Variable	Present Study Finding	Supporting Literature
AI Personalization	Positive association with purchase intention	Madhuri et al. (2024)
Metaverse Immersion	Positive association with purchase intention	Shen et al. (2021)

Immersive Shopping	Supports enhanced consumer experience	Erensoy et al. (2024)
Digital Shopping Intention	Influenced by emerging technology experiences	Pillai et al. (2025)

Conclusion, Implications and Future Scope

Based on the research findings, one can make a conclusion that there is a big potential for the application of GenAI and Metaverse technologies in transforming traditional e-commerce into a novel digital shopping experience. In the research, it is found that there is a positive relationship between AI-based personalization and Metaverse immersion and consumers' purchasing intentions. This finding is similar to the conclusions made by other researchers regarding the importance of personalization, immersion, interactivity, and presence in digital commerce environment (Shen et al., 2021; Erensoy et al., 2024). This means that the retailer can be able to develop recommendations, conversational capabilities, product experience, and shopping journey using GenAI and Metaverse technologies. From the managerial point of view, digital retailers can implement GenAI technologies to personalize their products/services and use them for customer services, but they can create brand experiences using Metaverse technologies. However, the adoption of both technologies should be responsible as the issues of consumer trust, privacy, cybersecurity, transparency, and accessibility affect the adoption of them (Chakraborty et al., 2024). The study also opens up avenues for further research. Future researchers can conduct studies using a larger sample size and different designs to analyze how consumer behavior has changed over time. Other researchers can undertake studies to explore the mediation effects of trust and consumer engagement as well as new applications such as artificial intelligence-based virtual avatars, virtual try-ons, and intelligent shopping assistants.

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