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The Role of Generative Artificial Intelligence in E-Commerce: Trends, Challenges and Opportunities

Khalil Israfilzade
Kauno Kolegija Higher Education Institution

Abstract: Generative Artificial Intelligence (Generative AI) is becoming more widely recognised as a transformative technology that is reshaping the e-commerce landscape. This paper thoroughly examines Generative AI's role in e-commerce, including its historical evolution, core differentiators from traditional AI, emerging applications, implementation challenges, and future research directions. Generative AI allows for the creation of dynamic, context-relevant content, such as personalised product descriptions and targeted advertisements, as well as sophisticated visual and conversational experiences. E-commerce retailers are achieving unprecedented levels of personalisation and customer engagement using techniques such as generative adversarial networks (GANs) and multimodal transformer models. However, significant adoption barriers persist, including ethical concerns, legal complexities, consumer trust issues, resource constraints, and technological limitations. Addressing these issues necessitates transparency, strong governance, secure data practices, and scalable technology infrastructure. Finally, this paper identifies promising research directions, focussing on model explainability, reinforcement learning integration, privacy-preserving frameworks, and immersive technologies (AR, VR, metaverse). By synthesising existing scholarly literature, this review provides strategic insights for future research as well as practical implications, allowing academics and industry practitioners to effectively leverage Generative AI to foster innovation and competitive advantage in digital retail.

Keywords: Generative artificial intelligence, Digital marketing, AI in marketing, Conversational marketing, E-commerce

Introduction

In recent years, technological innovations have significantly transformed the digital retail landscape, greatly impacting consumer expectations, business operations, and competitive strategies in the field of e-commerce. Among these transformative technologies, Generative Artificial Intelligence (Generative AI) stands out as a significant catalyst for innovation. It is characterised by its ability to autonomously create new content—such as text, images, and multimedia—by learning patterns from extensive datasets, rather than simply classifying or analysing existing data (Israfilzade & Sadili, 2024). By utilising advanced techniques like deep learning, neural networks, reinforcement learning, and unsupervised learning, Generative AI empowers businesses to provide highly personalised, engaging, and contextually relevant interactions with consumers. These capabilities have become essential in the competitive landscape of today's digital markets (Israfilzade, 2023).

Historically, the incorporation of AI into e-commerce started on a small scale, employing rule-based systems in the early 2000s that mainly facilitated basic recommendation engines and offered limited customer personalisation (Bawack et al., 2022; Chung & Tseng, 2012). Nonetheless, the transformative potential of Generative AI became evident after the introduction of generative adversarial networks (GANs) by Goodfellow et al. (2014) and was further propelled by the advancement of multimodal transformer models like BERT and GPT (Xu et al., 2022). Recent advancements have enabled innovative applications such as virtual try-ons, dynamic product descriptions, contextually adaptive advertisements, and intelligent chatbots. These

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developments are transforming customer experiences and greatly improving the competitiveness of retailers (Kshetri, 2024; Wang, 2024).

While Generative AI provides significant opportunities in the context of e-commerce, it also brings forth several challenges. These include ethical dilemmas, concerns regarding data privacy, issues related to intellectual property rights, demands for resource-intensive infrastructure, and the necessity for specialised expertise (Babayev & Israfilzade, 2023; Bayer, 2024; Lasker, 2024; Garon, 2023). Furthermore, developing consumer trust and acceptance is crucial for the success of AI-driven customer interactions (Israfilzade, 2023; Nagy & Hajdú, 2021). Therefore, it is essential to understand both the strategic advantages and the inherent complexities linked to generative AI technologies for the ongoing development of digital commerce.

This paper provides a thorough exploration of Generative AI in the realm of e-commerce. It outlines the historical development of the technology, distinguishes it from conventional AI methods, identifies significant trends, and emphasises the challenges currently faced in the field. Additionally, it highlights future research directions that are crucial for bridging current gaps and fully utilising the potential of Generative AI. This review synthesises existing scholarly literature to offer valuable insights for both academic and industry stakeholders who are looking to utilise generative AI as a strategic asset in the ever-evolving realm of digital retail.

Literature Review

This literature review thoroughly examines Generative Artificial Intelligence (Generative AI) in the e-commerce domain, offering insights into its development, fundamental attributes, emerging trends, practical applications, and related challenges. The review begins by elucidating the core principles and technological underpinnings of Generative AI, distinctly differentiating it from conventional, rule-based artificial intelligence systems by highlighting its capacity to autonomously produce original and contextually pertinent content (Banh & Strobel, 2023; Israfilzade & Sadili, 2024). The historical evolution of Generative AI in e-commerce is delineated through specific phases, emphasising pivotal milestones such as the advent of Generative Adversarial Networks (GANs) and transformer-based models like GPT-3 (Goodfellow et al., 2014; Xu et al., 2022). The review subsequently examines notable industry applications—such as AI-driven content generation, personalised customer interactions, sophisticated visual merchandising, and dynamic pricing strategies—demonstrating how Generative AI significantly improves customer experience and operational efficiency (Kshetri, 2024; Wang, 2024). The study examines existing barriers and complexities, including ethical considerations, legal constraints, technical limitations, and resource demands, and concludes by delineating future research directions aimed at enhancing model transparency, integrating reinforcement learning, adopting privacy-preserving frameworks, and utilising immersive technologies such as augmented reality, virtual reality, and the metaverse.

Understanding Generative AI in E-Commerce

Generative AI is a subset of artificial intelligence that uses existing datasets to learn patterns and create new content such as text, images, audio, or video. Unlike traditional AI systems, which typically analyse and classify existing data, generative AI generates new outputs using learnt patterns and probabilistic modelling (Banh & Strobel, 2023). Deep learning, neural networks, reinforcement learning, and unsupervised learning techniques are core generative AI concepts that allow machines to perform complex creative tasks autonomously. According to Lv (2023), it is anticipated that this technology will continue to develop and will have a significant impact on a variety of industries.

Without a doubt, ecommerce is one of these industries. Generative AI has changed e-commerce by improving customer experience and increasing retailer competitiveness. Main applications include product description generation, sentiment analysis, and product categorisation (Ghaffari et al., 2024). Prominent e-commerce platforms and retailers are implementing GAI solutions for solving issues such as shopping assistance, product descriptions, and virtual try-on tools (Kshetri, 2024). As stated by Kshetri (2024), these new concepts are meant to make shopping online safer and more enjoyable overall. According to authors (Wang, 2024), generative AI improves consumer understanding and works as a comprehensive product knowledge graph. Furthermore, generative AI is expected to help create seamless omnichannel commerce experiences by utilizing extensive data-driven models and intelligence (Shaikh, 2023). Generative AI has a lot of benefits, but it also has some risks and problems that need to be dealt with in e-commerce settings.

Historical Development of Generative AI in E-Commerce

The integration of generative AI into e-commerce has evolved significantly over the last two decades, due to advances in computational power, algorithmic innovation, and shifting consumer expectations. This development represents the transition from simple rule-based systems to sophisticated generative models capable of creativity and real-time adaptation. The graphic illustrates the evolution of generative AI within the e-commerce domain through four distinct historical phases (Figure 1). In the following sections, we will examine this path closely, highlighting significant technological milestones and their transformative effects on the retail landscape.

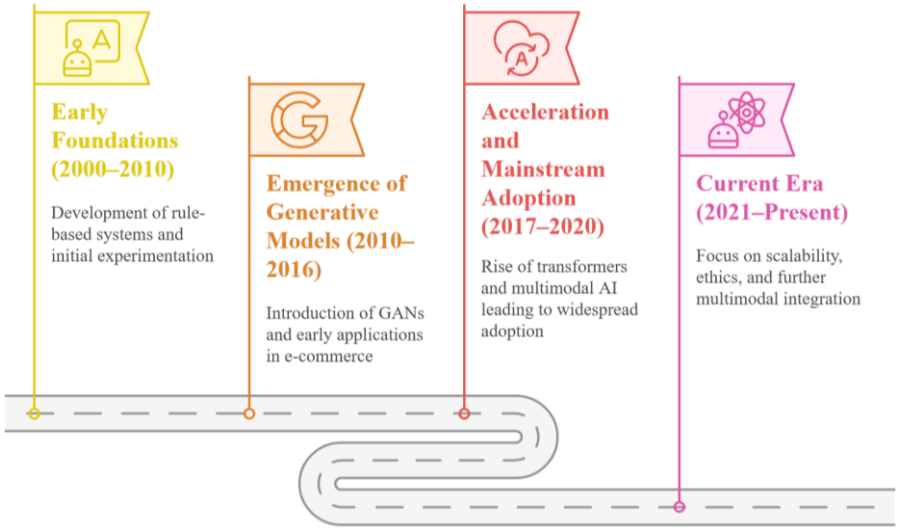

Figure 1. Evolution of generative AI in E-commerce

Early Foundations (2000–2010): Rule-Based Systems and Experimentation. In the early 2000s, we observed the rise of AI in the context of e-commerce, particularly emphasising rule-based systems and recommender algorithms (Bawack et al., 2022). The systems employed methods such as rough set theory and inductive rule learning to get insights from online product reviews, which contributed to market sentiment analysis and reputation management (Chung & Tseng, 2012). The early 2000s represented a formative period for AI in e-commerce, characterised by a dependence on structured data and established rules. Throughout this time, collaborative filtering became a fundamental aspect of recommendation systems, as demonstrated by Amazon's new application of customer purchase history to recommend related products (Linden, Smith & York, 2003). Although these systems were useful for fundamental personalisation, they faced limitations due to their inability to handle unstructured data or generate novel outputs. Initial experiments involving generative models, like Markov chains for text generation, created rather basic results, which limited their usefulness in the context of dynamic e-commerce applications. Even with these limitations, this period laid down essential principles for automation, establishing the way for future advancements.

Emergence of Generative Models (2010–2016): From GANs to Early Applications. During the mid-2010s, a major shift happened with the introduction of generative adversarial networks (GANs) by Goodfellow and colleagues in 2014, marking an important milestone in the field of generative modelling (Goodfellow et al., 2014). GAN is a specialised form of neural network that has the ability to generate completely new text, images, or music that appears to be realistic. Two different neural networks make up this structure. An instance *generator* that creates new examples, such as a new image of a human being. The *discriminator* is a piece of code that attempts to determine whether the new image is a new one or an existing image in the dataset. *For example,* Nike's mobile app, Nike Fit, utilizes augmented reality (AR) to help customers find the perfect shoe size by scanning their feet (Harazim, 2024). Sephora's Virtual Artist app enables customers to try makeup products using AR and facial recognition technology, providing a real-time and interactive experience. However, these applications remained experimental, hampered by computational costs and ethical concerns around data privacy.

Acceleration and Mainstream Adoption (2017–2020): Transformers and Multimodal AI. Transformer-based models have reshaped multimodal AI in recent years by allowing the integration of various data types such as text, images, and structured data (Xu et al., 2022). Transformers revolutionised natural language processing

(NLP), making way for models such as BERT and GPT-2. These architectures enabled context-aware text generation, which revolutionised e-commerce chatbots, search engines, and content creation pipelines. By 2020, the release of GPT-3 demonstrated generative AI's ability to create human-like marketing copy, customer service scripts, and multilingual content. *For example,* Project Muze, a collaboration between Google and the online fashion retailer Zalando, utilised a neural network-driven 'predictive design engine' that leveraged customer data to create fashion designs (Rietze, 2022). Studies show that chatbots can handle up to 70% of routine customer enquiries, freeing up human agents to focus on more complex issues and increasing overall efficiency (Uzoka et al., 2024). This period saw generative AI transition from novelty to strategic asset, with early adopters reporting significant gains in conversion rates and operational efficiency. As the field progresses, multimodal transformers are expected to play an increasingly important role in AI applications across various industries.

Current Era (2021–Present): Scalability, Ethics, and Multimodal Integration. Currently highlighted by sophisticated generative frameworks, such as diffusion models, which enable highly interactive, dynamic content generation, immersive virtual shopping experiences, and enhanced customer service via intelligent conversational agents. Generative AI is transforming the e-commerce landscape by improving personalisation, streamlining operations, and increasing sales. A notable example is Amazon's AI-powered recommendation engine, which analyses customer behaviour to recommend products and accounts for approximately 35% of the company's revenue (MarketsandMarkets, 2024). By 2024, the market for generative AI in eCommerce will be valued at USD 20.9 billion.

In the fashion industry, brands such as H&M employ AI for dynamic pricing, allowing them to adjust product costs in real-time according to demand and inventory levels (Buehler, 2025). This approach has resulted in a 15% rise in the sell-through rate for selected items, which has effectively lowered markdown expenses and enhanced revenue from seasonal products. AI-powered virtual try-on features are significantly improving customer experiences. Sephora's Virtual Artist tool enables customers to experiment with makeup virtually through augmented reality, resulting in increased engagement and satisfaction. Moreover, AI-driven chatbots are revolutionising the field of customer service. Alibaba utilises AI chatbots to manage customer enquiries, which leads to a reduction in service costs and an enhancement in response times (Buehler, 2025). These examples illustrate the ways in which generative AI is transforming e-commerce by offering personalised experiences, refining pricing strategies, and enhancing customer service, which in turn contributes to higher sales and greater customer satisfaction. While AI has numerous advantages, challenges remain, such as data quality, ethical concerns, and the need for specialised skills (Kotha et al., 2024). Future research directions include explainable AI, edge computing, and blockchain integration to improve e-commerce capabilities.

Differentiation from Traditional AI in E-Commerce

When compared to the capabilities of traditional AI systems, the introduction of generative AI has made it possible to redefine the limits of what AI is capable of accomplishing in the domain of e-commerce. Despite the fact that both approaches seek to improve efficiency and decision-making, there are significant differences between them in terms of their methodologies, outputs, and strategic implications. To begin, however, we need to make it clear what we mean by "*Traditional AI*."

Traditional AI, commonly referred to as *Narrow* or *Weak AI*, is primarily concerned with executing a particular task with intelligence (Ramírez & Ortíz, 2020). This pertains to systems that are specifically designed to react to a defined set of inputs. These systems possess the ability to learn from data and subsequently make decisions or predictions informed by that data. Imagine yourself engaging in a game of computer chess. The computer is equipped with a comprehensive understanding of the rules; it is capable of anticipating your moves and formulating its own actions according to a predetermined strategy. It does not involve creating novel methods for playing chess; rather, it entails choosing from the strategies that have been programmed into it. That represents traditional AI; it functions much like a master strategist, capable of making informed decisions within a defined framework of rules. Additional instances of traditional AIs include voice assistants such as Siri and Alexa, recommendation systems found on platforms like Netflix and Amazon, as well as Google's search algorithm (Schmidt et al., 2023). These AIs have been designed to adhere to specific guidelines, perform designated tasks, and execute them effectively; however, they do not generate anything novel.

On the other hand, *generative AI* can be considered the next generation of AI for the purpose of this article. It is a type of AI that is capable of creating something new (Banh & Strobel, 2023). The primary distinction can be found in their functionality. Therefore, traditional AI operates in a reactive approach, whereas generative AI

takes a proactive approach. Traditional AI engages with inputs by examining data and offering insights or predictions. Generative AI extends its capabilities by creating original content that reflects human creativity.

Another important distinction lies in their data requirements. Traditional AI systems demonstrate the ability to function efficiently with smaller datasets that are specifically designed for particular tasks (Rather et al., 2024). Conversely, generative AI necessitates extensive datasets to thoroughly learn patterns and produce high-quality results. The dependence on extensive datasets renders generative AI not only more resource-intensive but also enhances its versatility across various applications. From an operational standpoint, traditional AI emphasises efficiency by aiming to lower costs and enhance accuracy within established parameters. Generative AI directs attention to innovation, fostering new avenues for growth by encouraging businesses to explore unconventional ideas.

Generative AI offers enhanced personalization by dynamically adapting content to individual consumer preferences and behaviours, surpassing traditional predictive personalization methods (Israfilzade & Sadili, 2024). Unlike traditional AI-based chatbots, which typically rely on predefined scripts, generative AI supports more natural, human-like, and contextually aware customer interactions, significantly improving the quality of user engagement. Table 1 summarizes the key differences between traditional AI and generative AI in the context of e-commerce, highlighting how each approach varies in data handling, core functionality, adaptability, use cases, resource requirements, customer experience, and overall business outcomes.

Table 1. Differentiation between traditional AI and generative AI in E-commerce

Aspect	**Traditional AI in E-Commerce**	**Generative AI in E-Commerce**
Data Processing Approach	Relies on structured data (e.g., transaction records) with manual feature engineering.	Processes unstructured data (e.g., images, text) without manual feature engineering.
Core Functionality	Rule-based systems for tasks like classification or prediction (e.g., collaborative filtering)	Generates novel content (e.g., product descriptions, virtual try-ons) through models like GANs and transformers.
Adaptability and Output	Static outputs based on predefined rules; limited real-time adjustments.	Dynamic, real-time outputs (e.g., personalized pricing, adaptive recommendations).
Business Use Cases	Fraud detection, Basic recommendation systems, Inventory forecasting	Virtual try-ons (e.g., Sephora's AR tool), AI-generated marketing copy, Dynamic pricing models
Cost and Resource Implications	Lower upfront costs but higher long-term maintenance due to rigid infrastructure.	A higher initial investment in computing power but long-term ROI via automation.
Customer Experience Impact	Basic personalization (e.g., "Customers also bought...") and standardized interactions.	Hyper-personalized experiences (e.g., AI-curated outfits, voice-activated shopping assistants).
Business Outcomes	Incremental efficiency gains (e.g., optimized supply chains).	Disruptive innovation (e.g., AI-driven metaverse stores, on-demand product customization).

This comparison highlights generative AI's potential to transform e-commerce interactions and operations, providing businesses with innovative approaches to customer engagement and operational efficiency.

Key Trends in Generative AI for E-Commerce

The integration of generative AI in e-commerce has accelerated, influencing various aspects of online retailing from product presentations to personalized customer interactions. Generative AI has been altering the way businesses approach digital marketing. As we move closer to, key trends emerge that demonstrate how this technology is being more strategically integrated into the campaigns and processes that routinely occur in our everyday lives.

This section highlights key trends that demonstrate how generative AI is reshaping e-commerce, such as AI-driven content creation, enhanced personalisation, visual and multimedia innovations, improved customer support, and optimised operational processes. These emerging trends indicate a shift towards more engaging, adaptable, and efficient e-commerce experiences.

AI-Driven Content Generation

In the competitive world of e-commerce, content plays a key part in connecting brands with consumers. It influences purchasing decisions, improves search visibility, and promotes brand loyalty. Generative AI has become a significant tool in this field, improving and simplifying the creation of textual content—such as product descriptions, advertisements, and blogs—and achieving important levels of efficiency and personalisation (Israfilzade & Sadili, 2024). Through the use of advanced models, businesses are now able to generate high-quality, context-aware content on a large scale, effectively addressing both strategic and operational challenges.

E-commerce and digital marketing are two examples of industries that are increasingly adopting AI-driven solutions. These solutions are also gradually influencing the research agendas of both academic institutions and corporations.

Product Descriptions. Traditionally, product descriptions were crafted manually, resulting in static, one-size-fits-all copy that often failed to resonate with diverse audiences. Scaling this process across vast inventories proved labour-intensive and costly, particularly for global brands managing multilingual markets. Generative AI has redefined this paradigm by analyzing product specifications, customer reviews, and brand guidelines to generate tailored descriptions. These models dynamically adapt tone and style to align with brand identity—whether luxury, budget-friendly, or niche—while incorporating localized cultural nuances for regional markets.

A product description generator is a cutting-edge AI application that simplifies the process of writing interesting and persuasive product descriptions. This generator uses recent AI technology to quickly generate high-quality, engaging product descriptions that emphasise the essential characteristics and benefits of products by providing essential information (Khatri et al., 2015, Serbin, 2023). AI-generated content is actively reshaping the way ecommerce merchants approach managing their online stores, from automating product descriptions to enhancing SEO and improving customer engagement.

Major e-commerce sites, including Taobao, are gradually transitioning from mere trading platforms to content-based platforms (Zhang et al., 2019). From a user perspective, consuming content often precedes product consumption. Alibaba, for instance, has implemented extensive recommendation feeds featuring product images, short videos, and stated recommendation reasons. While these content-oriented products enrich user engagement, they also demand substantial human resources for content creation and maintenance. The strategic value lies not only in cost reduction but also in improved conversion rates, as personalized descriptions better align with individual shopper preferences.

It is an invaluable asset for e-commerce stores and marketers who are looking to create compelling content that attracts interest and drives sales, and it does all of this without the need for extensive copywriting experience or resources. However, critical evaluations of such AI-generated texts emphasize the importance of human editorial oversight (Mondal & Mondal, 2024). Editors are essential for verifying factual accuracy, preserving nuanced brand voice, and mitigating the risk of inadvertently reproducing biases present in training data.

Advertisements: Context-Aware Campaigns. The advertising industry in e-commerce has traditionally relied on static campaigns that were planned by human copywriters. This has limited the ability to respond to real-time changes in the market or to the behaviour of individual users. Generative AI, which allows for the creation of dynamic and context-aware advertisements, could disrupt this strategy. Advanced systems use demographic data, browsing tendencies, and external elements (such as seasonal trends and weather) to develop multilingual ad text for specific audience segments. Furthermore, It is no longer a matter of "if" AI can be utilised in advertising. Prominent brands such as Coca-Cola, Heinz, and Sephora have already embraced generative AI tools, and they are certainly not alone in this endeavour.

According to Madanchian (2024), these AI techniques greatly improve their ability to acquire new customers, increase conversion rates, and improve overall e-commerce success. As compared to more traditional approaches, a field experiment indicated that the use of generative AI to create personalised video advertisements resulted in an increase in user engagement of between 6 and 9 percentage points (Kumar & Kapoor). Technology makes the process of creating advertisements more streamlined, lowers expenses, and enhances targeting (Kshetri, 2024).

The findings in this field indicate that automated methods promote a data-driven approach to advertising content generation, allowing for flexible adaption to varied demographic categories. Based on feedback, AI can learn

and adapt style choices to better match consumer preferences, while experts suggest that human participation is usually required to ensure the appropriateness and creative details of the output. *For example*, AI can dynamically change ads messaging to emphasise urgency during peak shopping seasons or weather-specific demands by saying, "Last chance for holiday delivery!" or "Stay cosy with winter essentials." Real-time flexibility ensures that campaigns stay relevant in dynamic marketplaces, consequently increasing return on investment and lowering dependence on manual A/B testing.

On the other hand, the implementation of generative AI in advertising comes with issues, such as the possibility of biases, concerns over intellectual property, and threats to the authenticity of brands (Kshetri, 2024). In regard to these challenges, generative AI offers considerable potential for improving customer experiences and boosting merchant productivity within the fields of e-commerce and advertising (Ghaffari et al., 2024; Kumar & Kapoor, 2023). Despite the complicated technology underlying it, the objective is to develop Generative Response Ads that would enable non-technical individuals to simply and quickly produce advertisements. In the majority of instances, no applications are necessary.

Personalized Shopping Experiences

In today's digital landscape, personalisation has become an essential factor in fostering customer satisfaction and loyalty within the context of e-commerce. Chatbots and virtual assistants powered by generative AI are leading this transformation, allowing retailers to provide personalised interactions that resemble human understanding and adaptability. Personalized shopping experiences facilitated by AI-powered chatbots and virtual assistants have become a defining feature of contemporary digital marketing. Historically, companies disseminated promotional content through newspapers, television, radio, and early digital platforms to largely passive audiences. While this approach allowed brands to reach vast numbers of consumers, it fell short in terms of personal engagement, leaving little scope for meaningful interactions (Pilelienė, Alsharif & Alharbi, 2022, Einhorn & Löffler, 2021). With the emergence of social media and a new generation of digital platforms, marketing evolved into a more interactive process: customers are now well-informed, expect two-way communication, and desire immediate acknowledgement of their feedback and queries (Israfilzade 2021; Sotolongo & Copulsky, 2018; Babayev & Israfilzade, 2023; Israfilzade & Sadili, 2024).

In contrast to traditional strategies, conversational marketing personalizes customer experiences through AI to strengthen brand connections and improve user satisfaction (Sotolongo & Copulsky, 2018; Babayev & Israfilzade, 2023; Israfilzade & Sadili, 2024). AI chatbots and virtual assistants offer 24/7 interaction, enabling users to receive real-time help and advice with minimal wait times (Israfilzade, 2023). Because these technologies are inherently bidirectional, they facilitate rapid feedback loops, allowing firms to quickly adapt their messages or recommendations based on consumer input (Campbell et al., 2020; Ramesh & Chawla, 2022). These forms of dialogue-based marketing are increasingly critical in an era when businesses strive to differentiate themselves in saturated digital marketplaces.

Generative AI has transformed conversational marketing by allowing for personalised, scalable, and emotionally engaging interactions. Marketers can increase consumer engagement by using advanced language models, visual engines, and other AI-powered technologies to deliver context-aware, adaptable, and human-like communication. Conversational marketing offers a personalised, engaging experience, unlike traditional marketing. Conversational marketing involves feedback and real-time change (Ramesh & Chawla, 2022). Interaction attracts attention and gives marketers real consumer needs and preferences (Campbell et al., 2020). Conversational marketing helps businesses stand out in crowded digital marketplaces because consumers expect on-demand support and personalised experiences (Israfilzade, 2023).

Generative AI has numerous advantages, one of which is its ability to personalise communication-based on individual user data. This data may include browsing history, previous interactions, demographic information, and psychographic profiles (Grewal et al., 2024; Islam et al., 2024b). Using large-scale language models, these systems can generate responses that resonate with a user's emotional state or preferences, allowing for deeper engagement (Fakhimi et al., 2023). When an AI-driven conversation demonstrates warmth, empathy, or humour, customers may perceive the experience as more authentic, resulting in stronger affective bonds with both the technology and the brand.

Emotional resonance is especially important in marketing contexts where brands seek to differentiate themselves in crowded markets. By mimicking human conversational styles, such as using friendly language or acknowledging user concerns, Generative AI can foster trust, satisfaction, and loyalty (Lawson-Guidigbe et al.,

2023). Nonetheless, finding a balance is critical. Another key advantage of Generative AI is its ability to scale personalised conversations across large consumer bases while maintaining quality and responsiveness. Conversational AI, driven by generative models, addresses consumers' rising expectations of on-demand support and tailored experiences (Israfilzade, 2023; Babayev & Israfilzade, 2023). By facilitating personalized recommendation feeds, engaging marketing dialogues, and real-time customer service, chatbots and virtual assistants strengthen consumer-brand relationships and provide valuable insights into user preferences.

AI-powered chatbots and virtual assistants represent a paradigm shift in e-commerce by combining scalability and personalisation to meet changing consumer expectations. These tools improve customer experiences by providing context-aware, emotionally intelligent interactions while also increasing operational efficiency and loyalty. As generative AI advances, its role in creating seamless, personalised shopping experiences will remain critical to competitive differentiation in the digital marketplace.

AI-driven Visual and Video Generation

AI-driven tools are transforming how e-commerce brands produce and present visual content (Babayev & Israfilzade, 2023). Solutions vary from dynamic image editing, product spotlighting, and lifestyle scene generation to virtual try-on solutions for clothing and accessories and model swapping. Improvements in AI also allow for the transformation of static images and even text material into interesting video formats; template-based systems provide large libraries to accelerate professional video production. The following *Table 2* categorizes and summarizes these AI services, highlighting their core functionalities, e-commerce applications, and key benefits.

Table 2. AI-powered solutions for E-commerce visuals

Category	**Service / Feature**	**Core Functionality**	**E-Commerce Application**	**Key Benefits**
AI Virtual Try-On	Swap Fashion Model, Virtual Try-On (Apparel & Accessories)	Changes flat garment or accessory images onto diverse virtual models, adjusting for body shapes, ethnicities, poses etc	Enables customers to see how items (clothing or accessories) would appear on different model types	Increases inclusivity, lowers photoshoot costs, and accelerates content production
AI Product Imagery	Product Spotlight, Lifestyle Scene	Adds professional lighting/highlights for products (Spotlight) and places them in realistic environments (Lifestyle)	Enhances product detail visibility and contextualizes items in aspirational settings to boost engagement	Creates visually compelling presentations, drives customer interest, and saves time compared to traditional studio shoots
AI Image Editing	Image Retouch, Image Extender, Background Replacer / Remover, Colour Changer, Intelligent Artifact Removal, Image Enhancer,	Automates common editing tasks (retouching, background manipulation, colour adjustments, artefact removal, resolution boosts)	Speeds up large-scale image processing for consistent and polished product visuals across online platforms	Reduces depend on manual editing, ensures brand consistency, and quickly adapts to changing marketplace or social media requirements.
AI Video Generation	Image-to-Video, Text-to-Video	Converts static images or textual content into dynamic video clips with realistic motion, transitions, and overlay elements	Showcases product features in a more engaging format; suitable for product listings, social ads, or brand storytelling	Increases viewer engagement, uses minimal resources to produce short videos, and aligns with video-centric platform preferences.

Using these tools, retailers can customise content to different platforms and demographic categories, reduce production expenses, and improve the consumer experience. In a quickly changing digital market, where visual storytelling is essential to drive engagement and conversions, this whole ecosystem helps companies stay competitive.

AI-Driven Fashion Model Swaps. A new e-commerce solution uses advanced deep learning algorithms to smoothly fit clothing items onto virtual models, therefore maintaining the authenticity of textures, patterns, and design components (Nitasha et al., 2024, Jabade et al., 2024). The system generates realistic images comparable to conventional studio photography by means of fabric property analysis, fit characteristics, and lighting interaction, all without calling for extra photoshoots. This strategy also allows for the creation and customisation of a wide spectrum of virtual models, different in ethnicity, body size, pose, and age, so allowing online stores to show their products more inclusively and personally.

From the standpoint of e-commerce, managers can think about a fashion store introducing a new line of clothing across several areas. Rather than planning several location-specific photoshoots, the store can immediately "swap" their clothing items onto models that fit local demographics—whether it be varied body types, cultural preferences, or stylistic standards. Moreover, the capacity to rapidly localise product photos greatly lowers operational expenses, speeds up market testing, and enables companies to more efficiently maximise their merchandising plans worldwide.

AI-Driven Virtual Try-On for Apparel and Accessories. A multipurpose AI-driven approach to virtual try-on now allows e-commerce sellers to convert both apparel and accessory images into photorealistic model displays—without incurring the costs of multiple photoshoots (Islam et al., 2024a). This technology "drapes" clothing items onto chosen models by analysing garment structure, body poses, and lighting conditions, while respecting natural folds and textures. Sellers can also display accessories like eyeglasses, rings, and earrings realistically, with the system correctly positioning items based on different face shapes and hand sizes.

Practically speaking, a retailer with multiple categories—such as apparel, jewellery, and eyewear—can streamline its entire product showcase through a single platform, eliminating the need for separate photo sessions or extensive manual editing. Businesses can effectively cater to a large audience by displaying apparel on a diverse set of models and demonstrating how accessories fit on different body types (Hung et al., 2025). This inclusivity not only increases customer engagement, but it also builds trust by providing consumers with a realistic preview of how products will appear in real-world settings. Furthermore, the technology's seamless batch-processing capabilities integrate easily with existing e-commerce workflows, making it a strategic choice for brands looking to improve visual merchandising across multiple product lines.

AI-Enhanced Product Imagery. AI-driven spotlight effects combined with realistic lifestyle scene generation provide a comprehensive solution for e-commerce merchandising. The spotlight technology adds professional-grade lighting highlights to standard product photos, highlighting contours, textures, and colour details as effectively as a fully equipped studio photoshoot—but without the cost and logistical challenges (Alanadoly et al., 2024). Simultaneously, the lifestyle scene generator places products in a variety of context-rich environments, ranging from modern kitchens and luxury living rooms to outdoor adventure settings, allowing businesses to visualise how items might appear in everyday use. Whether highlighting a piece of jewellery with a refined light focus or placing a coffee maker in a stylish home setting, this cohesive approach appeals to customers on both aesthetic and emotional levels.

From an operational standpoint, brands can seamlessly integrate these AI tools into their current workflows, quickly transforming product images into visually appealing assets that communicate value and desirability (Bharati, 2023). Rather than hiring professional photographers and sourcing physical locations, retailers can use intelligent algorithms to tailor lighting parameters and background details to each product category. The end result is a low-cost, high-quality catalogue that captures customer attention, reinforces brand identity, and increases engagement. These AI-powered spotlight and lifestyle scene features represent a significant advancement in visual merchandising, making it easier for sellers to showcase items in ways that reflect brand philosophy while also fostering strong consumer connections.

AI-driven Image Editing for E-Commerce. AI-driven image editing tools have emerged to update product photography and improve its visual impact, with features like *Image Retouch, Image Extender, Background Replacer, Background Remover, Colour Changer* and *Image Enhancer* (Upadhye, 2024; Alnaser, 2024). These features aim to address common e-commerce challenges by removing distracting elements, optimising lighting and colour, and adapting product visuals to different branding requirements—all without requiring advanced

design skills or expensive photography equipment. For example, the *Background Remover* and *Background Replacer* tools enable retailers to quickly isolate products and place them in a variety of environments, ranging from plain white backgrounds for marketplaces to stylised brand-themed backdrops for social media campaigns. At the same time, *Image Retouch* ensures that product images look polished by removing flaws and unwanted objects, whereas *Colour Changer* can generate multiple colour variants of the same item, saving significant time and money versus staging multiple photoshoots.

Beyond just improving aesthetics, these AI services address the practical realities of online merchandising (Hung et al., 2025). The *Image Extender* feature, for example, allows you to adjust image dimensions and aspect ratios to meet different platform requirements—ideal for product photos that require extra space for overlays or promotional text. Meanwhile, the *Image Enhancer* increases resolution and clarity, allowing merchants to maintain consistent, high-quality visuals across all channels. These tools, when combined, form a comprehensive solution that assists businesses in maintaining a consistent look and feel, quickly adapting to new marketing opportunities, and appealing to a variety of customer tastes. Adopting these AI-powered techniques allows online retailers to create a more cohesive and engaging visual presence, increasing customer trust and conversion rates in competitive digital marketplaces.

AI-driven Image-to-Video and Text-to-Video Solutions. Improvements in AI-driven visual content generation are now enabling e-commerce companies to transform static pictures and even text material into dynamic, eye-catching videos. On the one hand, Generative AI detects key product features in standard photographs and uses subtle motion, zoom, and transitional elements to simulate professional cinematography (Bansal et al., 2024). Instead of using multiple static images or traditional slide show presentations, brands can capture consumers' attention with immersive video clips that improve product storytelling. This not only improves the perceived quality of listings, but it also aligns with modern user preferences, which shows that short-form video content is becoming more popular and influential in purchasing decisions (Yin et al., 2024).

Text-to-Video solutions also allow retailers to incorporate written content—such as product descriptions, brand narratives, or promotional copy—into cohesive multimedia experiences. Merchants can emphasise key selling points, highlight special offers, or narrate brand stories by combining text elements with AI-generated visuals and transitions, all without the cost or complexity of traditional video production (Raut, Chandel & Mittal, 2025). For example, a footwear retailer introducing a new line of running shoes may combine short bursts of informational text (e.g., material composition, durability, styling tips) with AI-generated animations that rotate or zoom in on product images. This method not only engages potential buyers more effectively than static banners, but it also provides a brief but comprehensive overview of the product's features.

From an operational standpoint, these technologies significantly reduce the barriers to creating compelling video content by automating much of the editing and compositing processes (Yu et al., 2024). E-commerce sellers can easily upload product images, promotional copy, and any other branded elements, and the system will handle scene transitions, camera-like movements, and colour consistency. This streamlined workflow is especially useful when dealing with large product catalogues, as multiple items can be processed in batches to ensure consistent style and branding across all listings. By incorporating image-to-video and text-to-video features into their merchandising strategies, online retailers can increase consumer engagement, brand loyalty, and conversions in a highly competitive digital marketplace.

Apart from automated image and text conversions, a fast-growing subfield of AI solutions focusses on speeding the video production process using extensive libraries of pre-designed templates. Optimised for various themes from product ads and brand introductions to meme-style social media posts, these templates provide drag-and-drop customisation allowing users to modify motion graphics, text overlays, and colour schemes with little technical knowledge. The aim is to simplify professional video production so that content producers, small business owners, and marketers can quickly create polished video assets even without significant budgets or specialised software knowledge.

Challenges in Adopting Generative AI in E-Commerce

The use of generative AI in e-commerce has significant potential, but it also presents a number of challenges for retailers, policymakers, and technology providers to navigate. These challenges include ethical and legal quandaries, issues of consumer trust, technical and implementation barriers, cybersecurity and fraud risks, and cost and resource constraints. Addressing these challenges systematically will be critical to maximising the positive impact of generative AI in online marketplaces.

Ethical and Legal Considerations Adopting Generative AI in E-Commerce

Generative AI presents significant ethical and legal challenges in various sectors, including e-commerce and media. One of the most pressing concerns surrounding generative AI is the ethical and legal ramifications arising from biased outputs, copyright violations, and data privacy risks (Lasker, 2024). Machine learning models trained on skewed datasets or incomplete information can inadvertently perpetuate societal biases, leading to discriminatory recommendations, pricing, or product descriptions. This problem is particularly salient in e-commerce, where biased content can negatively influence consumer behaviours and brand image. Furthermore, generative AI systems that produce new content—such as product descriptions or marketing copy—often rely on large volumes of copyrighted materials for training. Technology raises questions about authorship, liability, and responsibility for AI-generated content (Bayer, 2024). Without proper safeguards, content generation may infringe upon intellectual property rights, resulting in legal disputes and reputational harm.

Additionally, the extensive data collection that underpins AI models raises concerns about how customer information is gathered, stored, and used. E-commerce firms must comply with data protection regulations (e.g., GDPR in Europe or CCPA in California) to safeguard consumer data. Failure to do so may not only lead to financial penalties but also erode customer trust in the platform's commitment to privacy.

Global companies' fast adoption of generative AI systems makes it all the more crucial to address algorithmic bias, civil rights legislation, defamation concerns, and intellectual property laws (Garon, 2023). Among the suggested solutions are creating new categories such hybrid authorship and shared responsibility (Bayer, 2024), applying legal changes (Sharma & Sharma, 2024), and adding protections into contracts with AI companies (Garon, 2023). Maximising the promise of generative AI while reducing its potential risks depends on balancing innovation with effective regulation.

Customer Trust and Acceptance of AI-Generated Content

The effective implementation of AI-generated content in e-commerce is largely dependent on customer perception. Some customers may be sceptical or even uncomfortable when interacting with AI-powered engagement. When generative AI creates highly personalised content, consumers may question its authenticity or be concerned that their personal information has been compromised.

Recent studies have explored customer trust and acceptance of AI-generated content in e-commerce using the Technology Acceptance Model (Wang et al., 2023; Nagy & Hajdú, 2021). Research shows that the perceived usefulness and perceived ease of use have a positive impact on attitudes and intentions regarding the use of AI technology in online shopping. Trust is recognised as an important element influencing consumer attitudes towards AI (Nagy & Hajdú, 2021). In order to build trust, e-commerce companies should ensure transparency regarding their use of generative AI, display their commitment to ethical data practices, and emphasise the actual benefits of AI-driven services.

Zhou and Lu (2024) noticed that factors such as perceived intelligence, transparency, and empathy play a significant role in fostering trust in AI-generated content. However, algorithm bias has a negative impact on this relationship. The research indicates that e-commerce platforms ought to prioritise the enhancement of AI's intelligence, transparency, and empathy in order to foster user trust and promote adoption (Zhou & Lu, 2024). Furthermore, it was observed that subjective norms and the actual utilisation of AI technology significantly influence the acceptance process (Wang et al., 2023). The findings provide important insights for online retailers aiming to enhance customer acceptance of AI-generated content within the e-commerce landscape. Additionally, providing clear disclaimers or labels for AI-generated content can enhance transparency, instill confidence in users regarding the brand's integrity, and ultimately foster greater acceptance among users.

Technical Limitations and Implementation Barriers

Despite rapid advancements, generative AI still faces technical limitations that limit its practical application. Models may occasionally produce inaccurate or nonsensical outputs, known as "hallucinations," which can mislead customers and damage an e-commerce brand's reputation.

The implementation of e-commerce faces numerous challenges, particularly in developing countries. Adoption is lacking by technical limitations such as inadequate infrastructure and low IT literacy (Mohanna & Yaghoubi, 2011; Zaied, 2012). Organisational and managerial factors are also important, while social-cultural backgrounds pose significant challenges, such as a lack of trust and demand for online business (Mohanna & Yaghoubi, 2011).

Maintaining and updating AI models at scale necessitates significant computational power and specialised expertise, which can be prohibitively expensive for smaller enterprises. Integration with existing systems—such as inventory management or customer relationship management platforms—requires careful infrastructure planning and may necessitate significant changes to legacy processes. Legal and regulatory barriers add another level of complexity to the implementation process (Zaied, 2012). A study employing interpretive structural modelling and fuzzy analytical processes revealed that a lack of awareness regarding the benefits of e-commerce stands out as the most significant barrier (Valmohammadi & Dashti, 2016).

Insufficient organisational readiness, challenges related to data quality, and gaps in AI literacy among staff may represent significant obstacles that prevent the utilisation of the full potential of generative AI tasks. In light of these challenges, generative AI presents promising solutions within the context of e-commerce. Nonetheless, employing AI in these situations presents a unique array of risks and challenges (Ghaffari et al., 2024). Addressing these challenges necessitates dedicated initiatives in education, the enhancement of infrastructure, and the consideration of cultural resistance.

Cost and Resource Constraints

Implementing generative AI solutions in e-commerce frequently requires significant initial and ongoing investments, posing significant challenges for many organisations, particularly small and medium-sized enterprises (SMEs) (Vuruma et al., 2024). These costs exceed the basic costs of purchasing or licensing AI software. They typically include advanced computational infrastructure (such as high-performance servers or cloud-based GPU clusters), skilled personnel (e.g., data scientists and domain experts), and the resources needed to continuously manage and update these systems. Furthermore, because generative AI models rely heavily on large and high-quality datasets, businesses must devote significant resources to data acquisition, cleaning, storage, and curation (Choudhury, 2025).

Researchers are exploring ways to adapt generative AI for edge computing, which could democratize access to this technology in remote areas. According to Chavan and Chavan (2024), generative AI has the potential to optimise resource utilisation and automate dashboard creation in cloud-based e-commerce, which could result in cost reductions and improvements in performance.

Another major factor driving up costs is the iterative nature of AI model development. Once an initial model is in place, ongoing costs for performance monitoring, retraining, and fine-tuning arise. Changes in consumer behaviour, market dynamics, or product offerings may necessitate frequent updates to ensure generative AI outputs remain accurate and relevant. Furthermore, unexpected bugs or suboptimal model behaviours can result in additional costs, such as increased customer support or reputational damage control (Williams & Yampolskiy, 2021).

Organisations should also take into account the *opportunity costs* linked to allocating specialised staff to AI initiatives instead of other strategic projects. Recruiting or enhancing the skills of talent requires a significant investment of time and resources, and maintaining a workforce of AI specialists can prove difficult in a competitive job market (Yanamala, 2024). Smaller e-commerce firms might encounter significant challenges when competing against larger corporations or tech companies that can provide more appealing compensation packages and project opportunities.

Finally, as businesses broaden their use of generative AI applications, it is important for them to anticipate potential costs related to compliance and regulation. This may include seeking legal counsel to effectively navigate data privacy laws and ethical guidelines. Together, these factors underscore the importance of conducting a thorough *cost-benefit* analysis to guarantee that investments in generative AI are not only financially sound but also in harmony with the organization's strategic objectives.

Opportunities and Future Potential of Generative AI in E-Commerce

Generative AI offers a wealth of opportunities for e-commerce platforms seeking to enhance customer experiences, optimize operations, and gain competitive advantages. Through advanced personalization, improved conversational interfaces, data-driven pricing, and forward-looking research endeavours, the technology holds the potential to shape the future of online retail.

AI-driven Product Recommendations and Customization

AI-driven product recommendations use generative AI models to improve the way products and content are recommended to online shoppers, allowing for a shift from broad-based recommendations to highly personalised and context-specific suggestions (Sohn et al., 2024). Unlike traditional recommendation engines, which rely on collaborative filtering or predefined rules, generative models can identify subtle patterns in individual and collective user data. These patterns may include, for example, the interaction of browsing history, demographic information, situational cues (such as time of day or location), and recent trends in consumer behaviour (Figure 2).

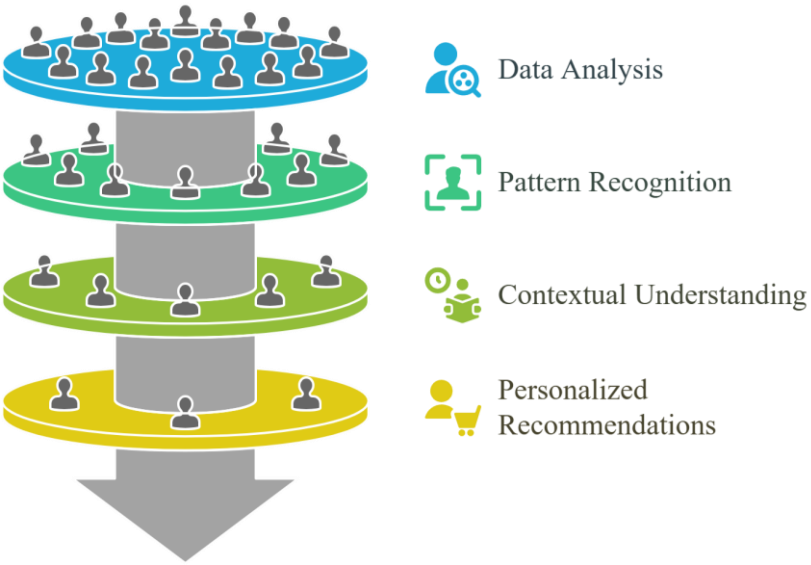

Figure 2. AI-driven product recommendations

Furthermore, generative AI is effective at creating new or "blended" types of content. For example, rather than simply drawing from an existing catalogue, the system could generate unique combinations of product features based on individual preferences (Yeon, 2024). This capability is especially useful in fashion, home décor, and electronics, where personalisation opportunities abound. By combining and matching product attributes such as style, size, colour, or function, generative models assist consumers in discovering items they would not have discovered otherwise using traditional recommendation methods.

Moreover, generative AI can automate the production of customized marketing materials, such as personalized emails, promotional banners, and chat interactions (Patil, 2024). These capabilities enhance overall user engagement and satisfaction while reducing marketing overhead for businesses. As personalization becomes an increasingly important competitive differentiator, the capacity to deliver hyper-targeted suggestions at scale will likely distinguish market leaders from followers in the e-commerce sector.

Enhanced Conversational Commerce and Multimodal AI

Conversational commerce represents the convergence of e-commerce with real-time, dialogue-based interactions—enabling consumers to browse, inquire, and transact via chat, messaging apps, or voice assistants (Israfilzade & Sadili, 2024). Generative AI fundamentally transforms this process by generating responses that are context-aware, coherent, and personalized in ways that rule-based chatbots cannot match.

In addition to conversational commerce, the idea of multimodal AI covers interactions that involve a range of input and output modes, including voice, images, video, and even augmented reality (AR) overlays (Arjunan, 2024). In a multimodal shopping context, a customer may upload a photo showcasing a preferred clothing style. In a multimodal shopping scenario, a customer might upload a photo of a desired clothing style; a generative AI system can then identify that style, recommend matching accessories, or even propose variations that suit the shopper's personal taste. This interplay between language-based understanding and visual analysis creates a seamless discovery process, bridging the gap between abstract ideas and tangible products (Lee & Ostwald, 2025).

Moreover, generative AI can enable "virtual fitting rooms" or "virtual try-on" experiences, merging image recognition, user body dimensions, and generative modelling to display how clothing or accessories might look on a particular individual (Sah et al., 2024). By reducing uncertainty about product fit and appearance, such immersive experiences can lower return rates and reinforce brand loyalty. For voice-enabled commerce, generative models can interpret spoken queries—often including background noise or imperfect audio—and craft responses that dynamically adapt to user feedback, sustaining a natural conversation flow.

In terms of customer service, generative AI-powered enhanced conversational commerce can resolve more complex enquiries without the need for human intervention. A chatbot, for example, could anticipate follow-up questions based on previous user behaviour, cross-reference relevant data (e.g., shipping status or product details), and provide answers that are human-like in both style and substance. This high level of responsiveness not only provides immediate value in customer support, but it also fosters deeper brand engagement as users develop trust in the system's ability to meet their needs. Furthermore, to maintain user trust, businesses should clearly communicate when and how generative AI enters the conversation, promoting transparency and accountability (Bozkurt & Sharma, 2024). Over time, as these systems mature and interact with emerging realities such as the metaverse or real-time AR shopping experiences, enhanced conversational commerce and multimodal AI have the potential to fundamentally change online retail interaction.

AI-Driven Dynamic Pricing Strategies

AI-powered dynamic pricing has emerged as a powerful tool for e-commerce platforms seeking to maximise revenue and remain competitive in rapidly changing markets. Unlike static or rule-based pricing approaches, generative AI models can predict demand fluctuations, analyse competitor pricing, and adjust prices in near real-time (Figure 3). These models generate more precise price adjustments that are in line with market conditions by processing massive amounts of structured and unstructured data, such as sales history, website traffic, seasonal effects, and social media sentiment.

Figure 3. AI-driven dynamic pricing process

An important benefit of generative models is their capacity to simulate "what-if" scenarios, enabling businesses to explore various pricing strategies prior to implementing them on a live platform. This predictive simulation has the potential to reduce possible losses by illuminating the risks and rewards associated with different price

points, promotions, or bundling options (Devarashetty, 2023; Ramya et al., 2024). Furthermore, AI has the capability to identify patterns in consumer behaviour with great detail, allowing for personalised or segmented pricing strategies that cater to particular customer groups. For example, it can facilitate customised discounts for price-sensitive shoppers while preserving premium pricing for those interested in higher-end products.

While there are notable advantages, the implementation of AI-driven dynamic pricing presents a number of challenges. Ensuring robust data quality is crucial, as inaccurate or incomplete data may result in less than ideal, or even counterproductive, price adjustments. Moreover, issues related to fairness and transparency emerge when consumers view dynamic pricing as exploitative (Nunan & Di Domenico, 2022). Finding the appropriate equilibrium between profitability and customer goodwill necessitates a carefully considered deployment strategy. This strategy should encompass transparent communication regarding price changes and an ethical framework guiding the determination of AI-generated prices (Inesia-Forde, 2024).

Ultimately, the organisational infrastructure required to facilitate dynamic pricing can be quite significant. E-commerce companies should prioritise the smooth integration of pricing algorithms with various operational systems, including inventory management and advertising campaigns. In the absence of sufficient system interoperability and real-time data flows, the benefits of AI-driven dynamic pricing may not be fully realized. By overcoming these challenges, organisations can gain a substantial advantage: effectively implemented AI-driven pricing strategies have the potential to enhance both sales volume and profit margins, enabling those who adopt them to succeed in highly competitive digital marketplaces.

Conclusion

This thorough literature review highlights the significant impact and vast possibilities of generative AI in the e-commerce sector. Generative AI began its journey with early rule-based systems that provided simple recommendation and classification tasks. Over the past two decades, it has undergone a remarkable evolution, leading to the development of advanced multimodal systems that can generate new, dynamic, and contextually appropriate content. Through the analysis of extensive datasets, Generative AI produces creative outputs that significantly surpass the abilities of traditional AI. This advancement is transforming the ways in which retailers engage with customers, organise product displays, and optimise operational workflows.

Generative AI's current and potential applications are notably broad and impactful. AI-driven content generation, including the automated creation of personalised product descriptions, dynamic advertisements, and tailored marketing communications, has transformed traditional marketing practices by reducing costs, enhancing scalability, and increasing content quality. The emergence of advanced visual AI applications—such as virtual try-ons, image-to-video solutions, AI-driven model swapping, and sophisticated editing technologies—further exemplifies the innovation this technology brings to visual merchandising and customer engagement. These tools provide retailers with the capability to deliver engaging, inclusive, and personalised experiences, significantly boosting customer satisfaction, brand loyalty, and market competitiveness.

Furthermore, Generative AI has transformed the concept of personalisation in e-commerce, allowing for hyper-personalised shopping experiences that dynamically adapt to individual consumer behaviours and preferences. Conversational AI tools, such as intelligent chatbots and virtual assistants, have significantly improved real-time customer support, enabling retailers to provide empathetic, context-aware, and highly responsive interactions that mimic human-like communication. This evolution not only improves the overall consumer experience, but it also provides businesses with more insight into customer needs, resulting in increased customer retention and long-term profitability.

Despite these significant advancements, implementing generative AI in e-commerce presents significant challenges. Ethical and legal issues, such as potential algorithm biases, intellectual property infringements, and complex data privacy concerns, present significant risks that must be meticulously addressed through transparent policies, rigorous oversight, and regulatory compliance. Furthermore, consumer trust and acceptance remain significant barriers; users frequently question the authenticity and reliability of AI-generated content, emphasising the importance of transparency, clear communication, and a well-defined framework for ethical AI use.

Technical limitations, such as occasional errors or "hallucinations" in AI outputs, as well as significant resource and infrastructure requirements, highlight additional barriers to widespread adoption. Organisations, particularly small and medium-sized enterprises (SMEs), frequently face significant financial and human

resource constraints, which limit their ability to implement and maintain advanced generative AI solutions. As technology advances, addressing these barriers through dedicated infrastructure investments, ongoing upskilling, robust governance frameworks, and scalable, cost-effective solutions will become critical for increasing generative AI adoption in the e-commerce sector.

The future of generative AI in e-commerce holds numerous opportunities for further research and innovation. Further research should focus on developing explainable and interpretable AI models to improve transparency, consumer trust, and compliance with emerging legal standards. Reinforcement learning, when combined with generative techniques, holds great promise for developing highly adaptable systems capable of continuous improvement and real-time response to changing market dynamics and consumer preferences. Furthermore, incorporating secure AI methodologies like federated learning and differential privacy could effectively reduce data security risks while enabling collaborative, large-scale AI deployments.

Emerging technologies, such as augmented reality (AR), virtual reality (VR), and the rapidly evolving metaverse, are poised to expand the potential of generative AI by creating immersive and interactive shopping environments that combine digital and physical consumer experiences. Leveraging generative AI in these novel contexts has the potential to fundamentally reshape consumer interactions, providing experiences that not only increase user engagement but also challenge traditional retail boundaries.

Ultimately, the integration of generative AI in e-commerce represents a strategic imperative rather than merely a technological advancement. Organisations that thoughtfully and ethically navigate the complexities of adopting generative AI are poised to achieve transformative outcomes in customer experience enhancement, operational efficiency, and market differentiation. Continued investment in research, technology infrastructure, ethical governance, and human-centric design principles will determine the success and sustainability of generative AI applications. As e-commerce continues to evolve in a data-driven, hyper-competitive digital landscape, embracing the full spectrum of opportunities presented by generative AI will be critical for businesses aiming to secure long-term competitive advantages and foster sustained innovation in online retail.

Recommendations

This literature study reveals numerous possible research directions for enhancing generative AI e-commerce. Incorporating these recommendations with current research paths would markedly improve the practical relevance, ethical integrity, and customer trust in generative AI systems in digital retail environments. Consequently, the following comprehensive recommendations have been placed forward:

1. Improve explainability and transparency. Future research should focus on explainable generative AI models to suit consumer transparency and regulatory needs. Investigating methods such as feature attribution, transparent neural networks, and interpretable hybrid models may assist in increasing customer trust and alleviate ethical concerns about AI-driven decisions like dynamic pricing and product suggestions.

2. Combine reinforcement learning and generative ai for adaptive e-commerce systems. Investigating practical applications such as dynamic pricing, inventory optimisation, customised marketing, and responsive consumer interactions could provide useful insights into system scalability, responsiveness, and efficiency.

3. Create ai solutions that prioritise security and privacy. In light of the growing concerns surrounding data privacy, it is essential for future research to concentrate on AI techniques that prioritise privacy preservation, including federated learning and differential privacy. Examining the effectiveness, scalability, and adherence to data protection regulations (such as GDPR) of these methods will assist businesses in safeguarding consumer data and enhancing user trust.

4. Utilise emerging technologies (VR, AR, Metaverse). The integration of generative AI with immersive technologies such as virtual reality (VR), augmented reality (AR), and the metaverse offers considerable opportunities. It is important for research to investigate AI-driven immersive shopping experiences, interactive product demonstrations, and virtual try-ons. This exploration should focus on consumer acceptance, user experience design, and the commercial viability of these innovations.

5. Assess the socio-economic and ethical implications. Future research ought to explore the wider socio-economic effects and ethical implications of integrating generative AI into e-commerce. This includes examining concerns related to bias, the impact on employment, intellectual property rights, and consumer

autonomy. Ethical audits, qualitative analyses, and policy-oriented studies will play a crucial role in harmonising innovation with societal responsibility.

6. Create scalable solutions for SMEs. To support wider adoption among small and medium-sized enterprises (SMEs), future studies should focus on developing accessible, cost-effective generative AI frameworks. Research into lightweight models, cloud-based AI-as-a-service platforms, and simplified integration pathways will be crucial for empowering resource-limited businesses.

In conclusion, continuous investment in these identified research areas is essential to maximise Generative AI's potential and address existing challenges. With ongoing advancements in algorithms, computational capabilities, and integration strategies, e-commerce firms that embrace these research-driven insights will secure not only competitive advantages but also help establish the standards for ethical, transparent, and consumer-centric practices in future digital retail landscapes.

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Conflict of Interest

* The author declares that he has no conflict of interest

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Author Information

Khalil Israfilzade
Kauno Kolegija Higher Education Institution
Pramones pr. 20, LT-50468, Kaunas, Lithuania
Contact e-mail: *khalil.israfilzade@go.kauko.lt*

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