Big Data-Driven Personalization in E-Commerce: Algorithms, Privacy Concerns, and Consumer Behavior Implications

Li Wei
Department of Data Science, Yunnan Agriculture University, Yunnan, China
liwei@yunanagriculture.cn

Zhang Xia
Institute of Cybersecurity, Southwest University for Nationalities, Sichuan, China
xiazhang@swnu.edu.cn

Abstract

Personalization has become a key strategy for e-commerce companies to provide tailored recommendations and deliver a differentiated shopping experience. The emergence of big data analytics enables companies to analyze large volumes of customer data to generate personalized product recommendations and targeted promotions. However, the use of big data for personalization also raises privacy concerns among consumers. This research article provides an overview of personalization algorithms, discusses privacy issues associated with the use of big data for personalization, and examines the implications for consumer behavior. The key algorithms enabling personalization in e-commerce include collaborative filtering, content-based filtering, and hybrid recommendation systems. While personalized services enhance the online shopping experience, consumers are apprehensive about extensive data collection practices. Transparency around data practices and providing consumers more control over their data can help address privacy concerns. The privacy paradox describes the mismatch between consumers' stated privacy concerns and their actual behavior of readily sharing information for personalized services. Personalized services tend to increase consumer purchase behavior, but over-personalization can lead to negative outcomes like reactance. Further research on ethical frameworks and regulations governing the use of big data for personalization is needed.

Keywords: e-commerce, personalization, big data, algorithms, privacy, consumer behavior

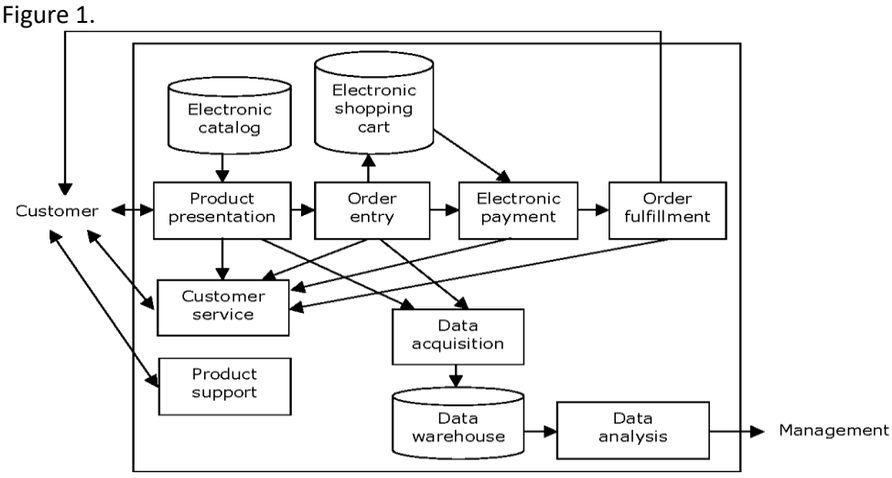
Introduction

The emergence of big data analytics has played a pivotal role in revolutionizing the operations of e-commerce companies by affording them the capability to delve into customer preferences and behavior with remarkable depth and precision. This transformation is made possible by the analysis of extensive datasets encompassing structured and unstructured data derived from various facets of customer interactions and transactions These invaluable insights empower companies to offer a heightened level of personalization to their customers, wherein product recommendations, promotional strategies, and the overall shopping experience are meticulously tailored to suit the unique preferences and requirements of each individual customer [1]. Personalization, in the context of e-commerce, revolves around the strategic utilization of customer data to customize products, services, and communication channels, thereby ensuring that they resonate most effectively with the specific preferences of individual consumers. To actualize this personalization, e-commerce enterprises deploy a range of sophisticated techniques, including recommender systems, targeted advertising, customized website layouts, personalized search results, and individually tailored email newsletters. The overarching aim of such personalization efforts is to augment customer satisfaction, enhance conversion rates, stimulate sales, and foster long-term customer loyalty. This data-driven approach represents a significant shift in the way e-commerce companies engage with their customers, underlining the importance of precision and personalization in the fiercely competitive online retail landscape [2].

Personalization in the realm of technology and e-commerce offers numerous benefits to both businesses and consumers, enhancing user experiences and increasing customer engagement. However, this practice has also raised profound concerns regarding privacy and ethical data usage. The fundamental issue revolves around the extensive data collection and analytics that underpin personalization, as it often entails a significant loss of privacy for individuals. This ongoing process has left consumers

increasingly apprehensive about the extent to which their personal information is harvested and shared by e-commerce entities, often without sufficient transparency or meaningful consent. Such apprehension stems from the very real fear that their sensitive personal data could be exploited, leaked, or subjected to hacking, thereby putting their privacy at risk.

Figure 1.



Nonetheless, the complex landscape of personalization and privacy reveals a paradoxical aspect known as the "privacy paradox." This phenomenon reflects the contradiction between people expressing significant concerns about their privacy, yet readily offering their data in exchange for the allure of personalized services. This dynamic raise profound questions about the actual extent of consumer actions to safeguard their data when convenience and tailored experiences are readily available [3]. The intricate interplay between the desire for relevant personalized services and concerns over data privacy holds significant implications for both e-commerce businesses and consumer behavior [4].

In this context, businesses must navigate the fine line between providing personalized services that cater to individual preferences and respecting the privacy rights and concerns of their customer base. Striking this balance is crucial not only to maintain consumer trust and confidence but also to adhere to evolving regulations surrounding data protection and privacy. On the other hand, consumers must remain vigilant about how their data is utilized and be informed about the measures taken by e-commerce companies to protect their information. In conclusion, the relationship between personalization, privacy, and consumer behavior is a complex and evolving landscape that warrants careful consideration, both by businesses and individuals, as technology continues to advance [5].This research article aims to provide a comprehensive overview of the algorithms, privacy issues and consumer behavior effects associated with the use of big data analytics to drive personalization in e-commerce. First, the key algorithms powering personalization are examined, including collaborative filtering, content-based filtering and hybrid systems. Next, the privacy implications of collecting and analyzing large amounts of customer data for personalized commerce are discussed. Finally, the impact of personalized services on consumer purchase behavior is analyzed, along with the potential for over-personalization backlash. The article concludes by proposing areas for further research around developing ethical frameworks and regulations to govern big data usage in e-commerce personalization [6].

Algorithms Enabling Personalization

Several categories of algorithms allow e-commerce companies to use big data to deliver personalized recommendations and shopping experiences. These include collaborative filtering, content-based filtering and hybrid recommendation systems.

Collaborative Filtering: Collaborative filtering is a widely adopted and effective approach for personalization in various domains, particularly in the context of recommendation systems. This method relies on the analysis of historical transactions and activities of a large group of users to identify connections and similarities among them. By examining the products that similar customers have purchased or shown interest in, collaborative filtering can recommend relevant items to individual users. For example, e-commerce giant Amazon employs collaborative filtering techniques in its

product recommendations, such as "Frequently Bought Together" and "Customers who bought this item also bought." These recommendations are generated by analyzing aggregated purchase data, and the fundamental assumption is that users who have shown agreement in their past product choices are likely to do so again in the future. It's worth noting that collaborative filtering primarily relies on usage data and doesn't require external information about the products themselves [7].

One of the key strengths of collaborative filtering is its effectiveness when dealing with extensive user and item databases. The more extensive the dataset, the better the collaborative filtering algorithm can identify patterns and make accurate recommendations. This approach is particularly well-suited for applications with a substantial user base and a wide variety of products, such as e-commerce platforms, streaming services, and content recommendation systems. The scalability of collaborative filtering allows it to provide valuable recommendations in situations where other methods might struggle.

Implicit usage feedback plays a crucial role in the success of collaborative filtering. Implicit feedback encompasses actions and behaviors of users, such as clicks, views, and purchase history, rather than explicit ratings or reviews [8]. By considering implicit feedback, collaborative filtering can work effectively in situations where explicit feedback is limited or unavailable. This is especially relevant in scenarios where users may not actively provide ratings or reviews, but their actions and interactions with products still hold valuable information.

However, collaborative filtering is not without its challenges. One of the prominent issues is the "cold start problem." This problem arises when there is insufficient user transaction history available for new users or newly introduced products. Without enough historical data to draw meaningful connections and similarities, collaborative filtering struggles to provide personalized recommendations in such cases. To address the cold start problem, hybrid recommendation systems, which combine collaborative filtering with other techniques like content-based filtering, are often employed to provide better recommendations for new users and products [9],[10]. These hybrid systems leverage both user behavior and product attributes to overcome the limitations of collaborative filtering in these situations [11].

Content-based Filtering: Content-based filtering analyzes data about the attributes of products to recommend items similar to what the user previously viewed or purchased The algorithms match product metadata such as text descriptions, keywords or categories to user preferences inferred from past transactions. For example, if a user buys several mystery novels by a certain author on Amazon, the system can deduce the user's preferences and recommend more books in that genre. Content-based systems do not require data about other customers. A limitation is that only similar recommendations are provided, reducing opportunities for serendipitous discoveries by the user [12].

Hybrid Recommendation Systems: Many e-commerce companies blend collaborative and content-based filtering to develop hybrid recommendation systems The algorithms integrate ratings or usage patterns across customers with product attribute data to suggest relevant items to each user. For example, the book seller BookLamp combined user purchase history with book content analysis to make personalized reading recommendations Hybrid approaches aim to enhance relevance by capitalizing on the strengths of both collaborative and content-based methods. Advanced algorithms also incorporate contextual factors like time, location and usage mode to make situational recommendations tuned to the user's current context [13], [14].

Table 1. Comparison of personalization algorithms used in e-commerce

Algorithm	Key Data Inputs	Advantages	Limitations
Collaborative Filtering	User transactions and ratings	Effective with large user data, no need for external data	Cold start problem with new users or items
Content-based	Product attributes and descriptors	Able to recommend based on product metadata alone	Limited to similar recommendations

Hybrid	User data plus product attributes, Contextual factors	Enhances relevance by combining approaches	Complex to develop and maintain

Privacy Concerns with Big Data Personalization

Personalized customer experiences in the realm of e-commerce offer the potential for enhanced customer satisfaction and engagement. Nonetheless, the realization of these tailored experiences hinges upon the extensive collection and analysis of vast amounts of data, a practice that inherently raises serious privacy concerns and necessitates ethical scrutiny. In the context of e-commerce, when consumers engage with online platforms, a plethora of data is systematically captured, encompassing various facets of their online activities, such as identity, demographics, browsing patterns, shopping behavior, and even geolocation information [15]–[17]. The aggregation of these expansive data sets, sourced from multiple touchpoints, empowers businesses to gain deeper insights into each individual customer, enabling them to fine-tune their marketing efforts and offer more personalized services.

The growing concern, however, revolves around the transparency and ethics associated with the usage of this personal data by companies. While companies may collect and process vast amounts of personal information, there is often a lack of clarity and transparency regarding how this data is used, who it is shared with, and the measures in place to secure it. Privacy policies, although mandated by various regulations, frequently present complex and lengthy legal texts that are often overlooked or not fully comprehended by consumers. This lack of understanding and awareness creates a significant gap in the communication between companies and their customers, further exacerbating the ethical concerns surrounding data collection and utilization [18].

The fundamental ethical question that emerges is whether consumers are genuinely aware of the extent to which their personal data is being utilized, and whether they have willingly consented to this data usage. Informed consent is a foundational principle of ethical data collection and usage, yet the reality often falls short of this ideal. Consumers may unknowingly provide consent by simply using an e-commerce platform without fully grasping the implications of their actions. It is imperative to bridge the gap between what is stated in lengthy privacy policies and what the average consumer comprehends. This gap in understanding highlights the need for more transparent and comprehensible communication regarding data practices to ensure that consumers can make informed decisions about their online interactions. Moreover, as data breaches and cyber threats continue to rise, the security of personal data remains a paramount ethical concern. Customers expect their information to be handled with the utmost care and safeguarded against unauthorized access. However, the security measures in place are often not disclosed in a transparent manner, leaving consumers in the dark about the safety of their personal data. This lack of transparency not only erodes trust but also jeopardizes the ethical responsibility of companies to protect their customers' data [19].

To address these ethical concerns and promote transparency, companies must take proactive measures. Firstly, they should prioritize simplifying and clarifying their privacy policies to ensure that consumers can readily understand the data practices involved. Additionally, companies must actively engage in educating their customers about data collection and usage, empowering them to make informed choices. Furthermore, transparent communication regarding data security measures is essential to bolster trust and reassure customers about the safety of their information.

Customers are often unaware of how much of their personal information is routinely gathered and analyzed to enable personalized commerce experiences. Many perceive the extensive data extraction as intrusive and an invasion of privacy. There are concerns that intimate details about people’s lives, preferences and behaviors are being monitored, tracked and exploited for profit by companies through personalization systems [20]–[22]. While big data enables customization that is useful and relevant, it also represents a loss of privacy and control for individuals over their personal information. Consumers are apprehensive about potential discrimination, manipulation or loss of autonomy Personal data could be misused to restrict choices, target vulnerable groups or encourage addictive behaviors. There are also fears around data security, with the possibility that sensitive personal or financial information could be leaked or hacked [23].

Transparency around data practices and providing consumers more control over their information sharing preferences can help mitigate privacy concerns with personalization. Companies should clearly communicate how customer data is collected, used and shared, rather than obscuring it in dense legalese. Giving users access to their data profiles along with options to correct, limit or delete the data can help restore a sense of control. Allowing customers to explicitly opt-in or consent to specific personalization services provides choice. Designing personalized offerings that enhance consumers' shopping experiences without crossing ethical boundaries will also encourage ongoing usage. Building trust is key to alleviating privacy concerns around the use of big data for personalization [24].

Impact of Personalization on Consumer Behavior

Personalized e-commerce experiences enabled by big data analytics influence customer engagement and purchase behavior in both positive and negative ways. When implemented appropriately, personalized recommendations can provide convenience, enhance satisfaction and increase sales. However, concerns arise around over-personalization limiting choice and diversity. Companies will need to strike the right balance between relevance and user autonomy.

Positive Effects on Purchase Behavior: Customized recommendations play a pivotal role in the realm of e-commerce, as they have the potential to significantly impact consumer behavior and preferences. In this era of data-driven decision-making, businesses are increasingly leveraging advanced technologies and big data analytics to provide personalized product suggestions to their customers. This strategy is not only beneficial for the consumers but also proves to be a valuable asset for businesses seeking to boost their sales and foster customer loyalty. One of the most compelling reasons for offering tailored recommendations is their ability to increase the quantity of purchases made by consumers. When users are exposed to products that align with their individual tastes and preferences, they are more likely to make purchases they might not have discovered otherwise. This level of personalization enhances the overall shopping experience by saving time and effort, as customers are presented with options that are highly relevant to their needs [25], [26].

Furthermore, personalized promotions based on user traits and transaction history have been shown to be more effective than generic, untargeted offers. When customers receive promotions that resonate with their previous buying behavior and interests, they are more inclined to make a purchase. By analyzing a customer's past purchases and preferences, businesses can create promotions that are tailored to the individual, increasing the chances of converting a lead into a sale.

The connection between personalized content and consumer satisfaction is a critical one. When customers feel that the content and recommendations they receive match their needs and interests, they experience a higher level of satisfaction with the e-commerce platform. This heightened satisfaction, in turn, often leads to continued usage and loyalty. Users of personalized services tend to develop a sense of connection with the company, as they feel recognized and cared for as individuals, not just as faceless consumers. A noteworthy tool for achieving these personalized recommendations is the utilization of big data analytics. Companies can harness the power of vast datasets to gain deep insights into customer behavior, preferences, and purchase history. With this information, e-commerce platforms can fine-tune their recommendation algorithms to provide customers with product suggestions that align with their tastes and past choices. This, in turn, enhances user engagement with the platform, which is critical for retaining and attracting customers in the highly competitive e-commerce landscape. Additionally, personalization not only drives engagement but also significantly impacts conversion rates. When customers are presented with products that align with their preferences, they are more likely to add items to their carts and complete their purchases [27]–[29]. This leads to an increase in conversion rates, resulting in higher sales for e-commerce businesses. In essence, personalization is a powerful driver of revenue and profitability. Furthermore, the impact of personalized recommendations extends beyond individual purchases. It fosters repeat purchases as satisfied customers are more likely to return to the platform for their future shopping needs. This not only increases the customer's lifetime value but also reduces customer acquisition costs. By maintaining a loyal customer base, businesses can secure a more stable and predictable revenue stream.

Potential for Over-Personalization Backlash: However, over-personalization where all choice is pre-filtered based on past user behavior can limit serendipitous discoveries and reduce diversity Consumers may react negatively when they perceive

personalization as too intrusive and limiting. Reactance arises when users feel their freedom to choose is threatened, triggering intentions to assert autonomy by rejecting personalized recommendations For example, a customer predominantly shown romance book recommendations on Amazon may feel pigeonholed and purposely seek out other genres. Over-personalization could also lead to a “filter bubble” where users only see options similar to past choices, restricting exposure to different viewpoints.

To avoid negative backlash, e-commerce personalization needs to strike the right balance between relevance and diversity. Designing adaptable systems where consumers can easily adjust their personalization settings allows more control. Recommender systems should suggest useful items but also allow some randomness and variety to provide novelty. Transparency around how the algorithms personalize content is important to build user trust and acceptance. If customers understand how recommendations are generated from big data analysis, they will likely perceive the customization as useful rather than intrusive. Allowing users to indicate varied interests can prevent over-focusing personalization on limited past transactions. Overall, while judicious data-driven personalization provides benefits, companies should beware not to cross the line into over-personalization that annoys customers and curtails choice.

Conclusion

The application of big data analytics in the context of personalized e-commerce is a dynamic and evolving field that demands sustained research efforts, the establishment of design frameworks, ethical guidelines, and regulatory measures. Collaboration among academia, industry, and policymakers is essential to propel the responsible use of data-driven personalization in e-commerce. This multifaceted endeavor raises several critical research directions that hold the potential to shape the future landscape of personalized e-commerce. One significant avenue for future research involves conducting surveys and experiments aimed at gaining a deeper understanding of consumer perceptions, concerns, and acceptance of big data personalization in e-commerce. By deciphering user attitudes and expectations, we can develop personalized services that prioritize transparency, user control, and privacy protection. Such insights will be invaluable in striking a balance between providing tailored experiences and safeguarding user privacy, aligning services with user preferences and values [30], [31].

Another essential research direction pertains to the development of models, metrics, and best practices to assist e-commerce companies in assessing the appropriate "personalization intensity" for their target user base. This approach can mitigate the risks associated with over-personalization, which may alienate users and lead to privacy concerns. By strategically measuring and controlling the level of customization, businesses can fine-tune their personalization efforts to align with the specific requirements and preferences of their audience.

Advancements in recommendation algorithms are also pivotal for the future of personalized e-commerce. Research in this domain should focus on creating algorithms that deliver seamless hybrid recommendations, striking a delicate balance between diversity, novelty, and relevance without excessively filtering content [32]. Comparative user studies can be conducted to evaluate these algorithms against traditional collaborative and content-based filtering methods, thereby enhancing the quality of recommendations and user satisfaction.

Furthermore, the exploration of emerging technologies like artificial intelligence (AI) and blockchain offers new opportunities to enhance transparency and ethical considerations in big data utilization for e-commerce personalization [33], [34]. Research into responsible data management models that leverage these technologies can contribute to a more ethical and transparent data environment. Developing and implementing these models can foster trust among users and reinforce the ethical foundations of personalized e-commerce.

The formulation of industry self-regulations and updates to data privacy laws is paramount to ensure the ethical handling of personal data by e-commerce firms when enabling personalized services. Legal frameworks that protect consumers while simultaneously supporting innovation must be established through multi-stakeholder discourse [35]. The collaboration of industry experts, legal scholars, and policymakers is vital in shaping a regulatory framework that encourages responsible data practices,

safeguards user rights, and promotes ethical standards within the personalized e-commerce landscape [36].

References

[1] K. K. H. Kunasekaran and Association of Scientists, Developers and Faculties (ASDF), United Kingdom, "Research on E-commerce customer loyalty under big data," *Int. J. Adv. Res. Big Data Manag. Syst.*, vol. 4, no. 1, pp. 1–16, May 2020.

[2] S. Guan, "Smart E-commerce logistics construction model based on big data analytics," *J. Intell. Fuzzy Syst.*, pp. 1–9, Sep. 2020.

[3] S. Haitao, "Big data analysis of e-commerce loan risk of college students in the context of network finance," *Inf. Syst. E-bus. Manag.*, vol. 18, no. 3, pp. 439–454, Sep. 2020.

[4] M. Muniswamaiah, T. Agerwala, and C. C. Tappert, "Context-aware query performance optimization for big data analytics in healthcare," in *2019 IEEE High Performance Extreme Computing Conference (HPEC-2019)*, 2019, pp. 1–7.

[5] C.-L. Goi, "The use of big data in marketing analytics," in *Handbook of Research on Innovation and Development of E-Commerce and E-Business in ASEAN*, IGI Global, 2020, pp. 62–78.

[6] Y. Fu, "Evaluation method of big data reliability in electronic government," in *2020 International Conference on E-Commerce and Internet Technology (ECIT)*, Zhangjiajie, China, 2020.

[7] Y. Wang, B. Wang, and Y. Huang, "Comprehensive analysis and mining big data on smart E-commerce user behavior," *J. Phys. Conf. Ser.*, vol. 1616, no. 1, p. 012016, Aug. 2020.

[8] J.-H. Liang, "Application of big data technology in product selection on cross-border E-commerce platforms," *J. Phys. Conf. Ser.*, vol. 1601, no. 3, p. 032012, Jul. 2020.

[9] Vijayan* *et al.*, "Calculating Effective Product Marketing on E-Commerce Applications based on Customer Rating using big data," *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, no. 12, pp. 5130–5136, Oct. 2019.

[10] M. D. Alberic, L. YeZheng, D. N. S. Rodrigue, and V. Vellem, "Research on innovation of cross-border e-commerce business model based on big data," in *Proceedings of the 3rd International Conference on Business and Information Management*, Paris France, 2019.

[11] M. Muniswamaiah, T. Agerwala, and C. C. Tappert, "Federated query processing for big data in data science," in *2019 IEEE International Conference on Big Data (Big Data)*, 2019, pp. 6145–6147.

[12] P. Feng, "Big data analysis of E-commerce based on the internet of things," in *2019 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*, Changsha, China, 2019.

[13] Y. Xiao and F. Ling, "On E-commerce precision marketing strategy based on big data," *Big Data Cloud Innov.*, vol. 3, no. 1, Jun. 2019.

[14] Y.-W. Zhang, "Research on cross-border E-commerce platform supplier credit evaluation based on big data interconnection," *J. Phys. Conf. Ser.*, vol. 1601, no. 3, p. 032037, Jul. 2020.

[15] A. Maalla and Q. Jia, "Research on key technologies of E-commerce big data analysis platform," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 242, p. 052038, Mar. 2019.

[16] W. Mu, "A big data-based prediction model for purchase decisions of consumers on cross-border E-commerce platforms," *J. Eur. Syst. Autom.*, vol. 52, no. 4, pp. 363–368, Oct. 2019.

[17] S. Karthik, K. Srihari, and Moorthi, "Improving Business Process by Predicting Customer needs based on Seasonal Analysis: the role of Big Data in E-Commerce," *Int. J. Bus. Excel.*, vol. 1, no. 1, p. 1, 2019.

[18] J. Zhang, T. Wu, and Z. Fan, "Research on precision marketing model of tourism industry based on user's mobile behavior trajectory," *Mob. Inf. Syst.*, vol. 2019, pp. 1–14, Feb. 2019.

[19] X. Zhao, "A study on e-commerce recommender system based on big data," *conference on cloud computing and big data analysis ...*, 2019.

[20] P. A. Hurtado, C. Dorneles, and E. Frazzon, "Big Data application for E-commerce's Logistics: A research assessment and conceptual model," *IFAC-PapersOnLine*, vol. 52, no. 13, pp. 838–843, 2019.
[21] M. Tao, P. Huang, X. Li, and K. Ding, "Big data based E-commerce search advertising recommendation," in *Cyberspace Safety and Security*, Cham: Springer International Publishing, 2019, pp. 457–466.
[22] I. Khan, A. Mandal, and P. S. Kumar, "Contextual price features for e-commerce search ranking," in *2019 IEEE International Conference on Big Data (Big Data)*, Los Angeles, CA, USA, 2019.
[23] M. Muniswamaiah, T. Agerwala, and C. C. Tappert, "Approximate query processing for big data in heterogeneous databases," in *2020 IEEE International Conference on Big Data (Big Data)*, 2020, pp. 5765–5767.
[24] X. Zhao, "A study on the application of big data mining in e-commerce," in *2018 IEEE 4th International Conference on Computer and Communications (ICCC)*, Chengdu, China, 2018.
[25] Q. Zu and J. Wu, "Big data analysis of reviews on E-commerce based on Hadoop," in *Human Centered Computing*, Cham: Springer International Publishing, 2018, pp. 492–502.
[26] G. Pal, G. Li, and K. Atkinson, "Big data real-time clickstream data ingestion paradigm for E-commerce analytics," in *2018 4th International Conference for Convergence in Technology (I2CT)*, Mangalore, India, 2018.
[27] Y.-C. Lin, A. Datta, and G. D. Fabbrizio, "E-commerce product query classification using implicit user's feedback from clicks," in *2018 IEEE International Conference on Big Data (Big Data)*, Seattle, WA, USA, 2018.
[28] L. Marasa, JNTUA University, and K. Kunchum, "Big data application performance monitoring in retail E-commerce using spark," *Int. J. Eng. Trends Technol.*, vol. 50, no. 2, pp. 63–66, Aug. 2017.
[29] G. Fan, H. Xu, and K. Li, "Construction of E-commerce credit system based on big data analysis," in *Proceedings of the 2017 7th International Conference on Mechatronics, Computer and Education Informationization (MCEI 2017)*, Shenyang, China, 2017.
[30] J. Lichy and M. Kachour, "Big data perception & usage," in *Proceedings of the 2019 3rd International Conference on E-commerce, E-Business and E-Government - ICEEG 2019*, Lyon, France, 2019.
[31] M. Muniswamaiah, T. Agerwala, and C. Tappert, "Data virtualization for analytics and business intelligence in big data," in *CS & IT Conference Proceedings*, 2019, vol. 9.
[32] D. Malhotra, N. Verma, O. P. Rishi, and J. Singh, "Intelligent big data analytics," in *Mobile Commerce*, IGI Global, 2018, pp. 259–276.
[33] B. Galhotra, "Evolution of E-commerce in India: A review and its future scope," in *2019 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COMITCon)*, Faridabad, India, 2019.
[34] G. Walsh, C. Koot, R. Schmidt, and M. Möhring, "Big Data — neue Möglichkeiten im E-Commerce," *Wirtsch. Manag.*, vol. 5, no. 2, pp. 48–56, Feb. 2013.
[35] G. Ilieva, T. Yankova, and S. Klisarova, "Big data based system model of electronic commerce," *Trakia Journal of Science*, vol. 13, no. Suppl.1, pp. 407–413, 2015.
[36] M. Muniswamaiah, T. Agerwala, and C. Tappert, "Big data in cloud computing review and opportunities," *arXiv preprint arXiv:1912.10821*, 2019.