

Big Data Analytics in E-Commerce – Key Applications, Life Cycle and Challenges

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Abstract

Big data is essential for e-commerce, serving as a rich source of insights that drive business growth and competitiveness. Through advanced analytics of web server logs, abandoned carts, and transaction records, e-commerce businesses gain valuable understanding. The true power of this data lies not just in its collection, but in its effective analysis and application. This study is based on secondary data. This paper focuses on the big data in e-commerce, the key applications of big data in e-commerce, the big data life cycle in e-commerce, the challenges of using big data in e-commerce and the future of big data in e-commerce. The paper concludes that the big data had revolutionized the ecommerce sector and offers right goods at right time to the consumers.

Keywords – Big data, e-commerce, Analytics

1. Introduction

According to Wikipedia: Big data is a field that treats ways to analyse, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many fields (columns) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate¹.

Big data and its capabilities are becoming more prevalent across various sectors and market segments. It gives businesses and entrepreneurs access to previously unheard-of potential for process optimization, service quality improvements, and conversion rate growth. Big data was once a cutting-edge technology for extremely complicated work environments, but nowadays, it's getting increasingly popular in commercial sectors. Big data is large, varied information sets that are expanding exponentially. Ecommerce may use it to make better business decisions and improve performance, goods, and operational procedures. Additionally, it facilitates finding valuable insights and assists in studying client behaviour².

2. Review of Literature

(Bilgiç & Duan, 2019) This paper surveys recent studies on e-commerce and Business Analytics, highlighting the business value created through analytics. The authors had concluded that e-commerce data can provide valuable support for decision making. Business Analytics and Big Data Analytics can uncover valuable insights from e-commerce data³.

(Akter & Wamba, 2016) The paper focuses on synthesizing concepts, challenges, and opportunities related to Big Data Analysis in the e-commerce landscape without listing individual studies. From the study it can be concluded that Big Data Analysis provides value to e-commerce firms for decision making and problem-solving. Leading e-commerce firms have embraced BDA and experienced growth⁴.

(Cobos Gutiérrez, 2024) This paper focuses on strategies and best practices for optimizing e-commerce performance through big data and business intelligence approaches. The paper concludes that integrating big data with business intelligence is crucial for enhancing e-commerce performance. It emphasizes the significance of effective decision-making processes driven by big data analytics. The authors identify that customer satisfaction can be significantly improved through the application of big data strategies. The findings suggest that leveraging big data can enhance competitiveness in the e-commerce market. The review highlights best practices and effective techniques for utilizing big data in e-commerce platforms⁵.

(Chenwei Zhang 2025) The research focuses on how e-commerce businesses utilize consumer data from online transactions, social networks, and web activities to optimize marketing processes and enhance customer engagement. the paper underscores that big data is crucial for modern e-commerce precision marketing, enabling personalized experiences, strategic decision-making, and improved customer engagement. It also points to the need for continued research to address technological bottlenecks and explore new integrations for more effective and ethical marketing practices⁶.

(Pertwi & Puspita, 2025) This paper focuses on the application, benefits, impacts, and challenges of Big Data Analytics in business decision-making within the e-commerce sector. The application of Big Data Analytics significantly enhances the speed and accuracy of business decision-making in the e-commerce sector. The implementation of Big Data Analytics strengthens the competitive edge of e-commerce companies in a rapidly evolving market. Key challenges identified include managing massive data volumes, data integration complexity, data quality and security issues, and a shortage of skilled analytical personnel⁷.

3. Objectives of the study

The objectives of the study are

- 1.to study about the big data in e -commerce
- 2.to know about the key applications of big data in e -commerce
- 3.to study the big data life cycle in e-commerce
- 4.to assess the challenges of using big data in e-commerce
- 5.to know about the future of big data in e-commerce

4. Methodology

This study adopts a descriptive research design based on secondary data. Data were collected from published sources such as online journals and websites. Sources were selected based on relevance, credibility, and recency. Ethical standards were maintained by properly citing all sources.

I Big Data in e-commerce

The ecommerce industry generates data at an unprecedented scale. From search queries and clicks to purchase histories and product reviews, ecommerce businesses have such vast and diverse datasets on their hands that it can be rightfully called big data.

The scale of big data demands more than basic analytics; it calls for a dedicated ecosystem of technologies, including scalable data storage, advanced processing frameworks, and powerful AI-driven tools to make sense of it all. Effectively handling big data means investing in purpose-built infrastructure and adopting new ways of thinking about data architecture, quality, and integration. But when data management and analytics are done right, the payoff is significant, as insights from big data can enable personalized customer experiences, more accurate demand forecasting, smarter pricing strategies, and optimized supply chains.

E-Commerce big data is the massive and rapidly growing volumes of information generated across digital touchpoints and business systems. It includes customer interactions, such as clicks on ecommerce websites, purchase history, and reviews, as well as operational, product, inventory, and financial data.

Big data in ecommerce falls into three categories:

Structured data

Structured data, such as customer profiles, order histories, and product catalogues, comes in standardized formats (CSV, SQL tables) with fixed fields or schemas, can be easily stored and indexed in relational databases, and is ready for instant querying and analysis.

Semi-structured data

Semi-structured data, like emails, customer support tickets, or product specifications. While this data doesn't conform to the rigid structure of a traditional relational database, it still contains organizational markers like tags and metadata.

Unstructured data

Unstructured data, like images, videos, or free-form text from customer reviews or social media posts, doesn't follow a predefined data model or schema, which makes it more complex to store, process, and analyse, but holds deep, untapped business value.

Understanding these distinctions helps ecommerce companies strategically invest in the right infrastructure and talent to harness the full potential of big data. For example, analysing unstructured product reviews can demand machine learning tools, while structured data can be analysed using business intelligence (BI) tools⁸.

By analysing big data, e-commerce platforms can refine their marketing strategies, enhance customer service, and optimize supply chain management and operational efficiency. For example, insights derived

from customer purchase patterns can help tailor personalized marketing campaigns that increase conversion rates and encourage repeat business⁹.

Data analytics for E-commerce covers a broad spectrum: from understanding customer preferences and predicting demand to optimizing pricing, reducing cart abandonment, and personalizing every touchpoint at scale¹⁰.

Big Data is usually characterized by the volume of data, the velocity at which it is generated and gathered, and the variety or depth of the data points being considered (the three Vs of big data).

- **Volume** refers to the original size and volume of data collected. It ought to be significant enough for the data to qualify as big. It is a relative measurement, though, and depends on processing speed. Big data ranges from a few megabytes to hundreds of petabytes.
- **Velocity** is the speed at which data is produced and transferred. A business that uses big data will have a sizable and continuous flow of data from networks, cell phones, social media, Internet of Things (IoT) devices, and other sources. This information needs to be processed, transferred, and analysed quickly.
- **Variety** refers to the categories the data belong to, from structured, quantitative data to unstructured text documents, emails, movies, and audio. Big data encompasses all conceivable business activities and includes structured and unstructured information. Information that the business has previously managed in databases and spreadsheets is referred to as structured data and is typically quantitative. Unorganized information that can't fit into a preset model is referred to as unstructured data. It usually contains information from social media, which aids organizations in learning more about the customers' needs¹¹.

II Key Applications of Big data in e-commerce

Big data analytics is increasingly used in the ecommerce industry to enhance customer experiences, increase operational efficiency, and improve decision-making. Here are key ecommerce use cases where big data is making a significant impact.

Personalization & customer experience improvement

Ecommerce teams use big data analytics to extract granular customer behaviour insights from massive and diverse datasets, including browsing patterns, sales data, demographic profiles, and engagement history, to deliver more personalized shopping experiences. These insights can then fuel product recommendation algorithms that drive highly targeted upselling and cross-selling, significantly improving conversion rates and customer satisfaction.

Drawing on insights from customer-related big data, businesses can also fine-tune website content, banner placement, and page layouts to match the preferences of different audience segments, improving the relevance of on-site experiences and engagement throughout the buyer journey. Finally, large volumes of customer data are often used to train AI-powered chatbots, enabling them to provide context-aware support and personalized product guidance.

Pricing analytics & targeted price customization

Ecommerce teams use big data tools to make sense of disparate real-time data sets to refine their pricing strategies for maximum profitability and market responsiveness. Algorithms that continuously process big data assess variables, such as product demand, inventory availability, customer demand patterns, and competitor pricing, can help ecommerce specialists determine the best-suited pricing for products at the given moment. Besides, by analysing detailed information on customer shopping habits, behaviour, and incentives, businesses can offer targeted discounts or loyalty-based pricing for high-LTV, frequent, or price-sensitive customers.

Inventory & supply chain management

Insights derived from historical sales data, real-time customer demand information, seasonal trends, promotional calendars, and external factors such as weather can help businesses develop effective inventory management strategies to avoid stockouts and prevent unnecessary overstocking. For example, analysing temperature trends, regional sales data, and campaign performance can help predict where seasonal products will be in high demand, enabling smarter inventory allocation across warehouses in advance of demand spikes.

When it comes to order fulfilment, big data plays a key role in delivery optimization. By integrating real-time traffic data, weather conditions, and customer location information, logistics managers can dynamically reroute delivery trucks, reducing transit time, cutting fuel costs, and improving on-time delivery rates.

Fraud detection & payment security

Ecommerce businesses use big data analytics to level up fraud detection and improve identity verification. By analysing massive, diverse datasets, including transaction history, device and browser data, and location information, they can uncover subtle fraud patterns that can go undetected by conventional tools. This multidimensional analysis allows for the detection of more sophisticated, cross-channel fraud attempts, such as coordinated bot attacks or high-value purchases from mismatched device and IP combinations.

Using behavioural data analytics helps define what “normal” looks like for each customer. When deviations occur, such as a spike in order frequency, sudden international transactions, or abnormal checkout behaviour, the fraud detection system powered by big data analytics flags them for further validation.

In addition, advanced identity verification systems, driven by big data, draw on behavioural biometrics, geolocation, device data, and historical patterns to evaluate security risks more accurately. Adaptive authentication engines analyse ecommerce big data to dynamically escalate security measures, such as two-factor or biometric verification, when the system detects potential anomalies, like a “buy now, pay later” order placed from a new device at an unusual time.

Marketing & advertising optimization

With the help of big data analytics, ecommerce businesses can create highly targeted marketing campaigns. For instance, marketing teams can apply it for advanced customer segmentation, grouping

customers based on nuanced behavioural data, such as device usage patterns, website scroll depth, video watch time, and the time of day when people interact with the company.

Analytics platforms that process big data can also track multi-session, multi-device customer journeys to support both targeting and retargeting of ads, content, and offers. Moreover, by evaluating campaign performance across different cohorts and platforms, ecommerce teams can shift budget from underperforming channels to those yielding higher ROI, proactively design campaigns in response to emerging market trends, and tailor communication strategies at a granular level based on individual customer preferences and behaviours.

Predictive analytics

Predictive analytics tools can be applied to process ecommerce big data and inform proactive decision-making. These tools analyse a wide range of historical and real-time data, from internal company information to broader economic signals, to detect patterns that indicate what's likely to happen next.

By feeding big data into predictive models, e-commerce companies can anticipate product demand, flag at-risk customers before they are lost, adjust marketing efforts to align with emerging trends, and plan inventory levels or marketing strategies more accurately. Additionally, ecommerce teams can determine optimal timing for promotions and launch them when customers are most likely to respond, thereby maximizing revenue¹².

III The Big Data Life cycle in e-commerce

To effectively use big data in ecommerce, businesses need an established framework to handle its sheer volume, variety, and velocity. This big data lifecycle is continuous and resource-intensive and should be designed to support real-time insights, high scalability, and data diversity. Here's how this process typically unfolds:

Data collection

Ecommerce big data is gathered continuously from numerous sources, including website clickstream logs, mobile apps, point-of-sale (POS) systems, social media, CRM platforms, and connected customer-facing devices like kiosks or smart checkout stations. To ensure an ongoing flow of data, companies need scalable pipelines that can handle both structured and unstructured formats.

Data storage

After collection, the data is stored in a way that supports further processing and analysis. For this purpose, there are three main types of storage systems for ecommerce big data that can be implemented independently or as a combination:

Data lakes that store raw data in its original form

Data warehouses that store curated, structured data optimized for analysis

Data lake houses that combine the scalability of lakes with the structure and governance mechanisms of warehouses

Data preparation

Raw data needs to be prepared to fit analytical models by specialized tools that perform tasks like data cleansing, deduplication, schema validation, and transformation. Given the scale and inconsistency of big data, this step is necessary for ensuring reliable outputs.

Data analysis

The cleaned, structured data is analysed using advanced analytics techniques such as data mining, clustering, and deep learning.

Data visualization

Finally, findings are presented in the form of dashboards and schemes, making insights accessible to business users across the enterprise.

To support each stage of this lifecycle, ecommerce businesses often turn to ecommerce development to modernize their digital infrastructure, which includes building data-ready architectures and integrating platforms that enable data capture, scalable storage, and analytics¹³.

IV Challenges of Using Big Data in e-commerce

While there are many advantages of using big data in e-commerce, leveraging big data is not without its challenges.

Data Collection

Collecting a lot of irrelevant data can hinder processing speeds, waste storage space, and overload systems, making data collection a challenge for many e-commerce stores looking to gain a competitive edge from big data.

Data Storage and Security

Given that e-commerce businesses collect sensitive customer information such as names, addresses, payments, and other PII, securing this data from hackers and ensuring data management practices comply with data protection laws and regulations can be a significant challenge.

Inaccurate and Inconsistent Data

With the amount of data collected from multiple sources, it's likely that conflicting or incorrect information is mixed in, which can stunt the reliability of the insights gathered.

Data Compliance Regulations

E-commerce businesses must navigate complex data compliance regulations to ensure the lawful and ethical use of customer data, adding another layer of complexity to big data management.

Real-Time Data Analysis

Lastly, there is the challenge of processing, analysing, and using data in a timely and meaningful way. Since there is a lack of tools that can be used to store, and protect data while extracting valuable insights from it,

many online businesses must use sophisticated analytics tools that require skilled professionals like privacy engineers or cryptographers.

Despite these challenges, many e-commerce businesses may not realize the value of the data they are collecting¹⁴.

V The Future of Big Data in e-commerce

The intersection of big data and E-commerce will continue to deepen through 2026 and beyond, driven by several converging trends:

- 1. Generative AI for product discovery** — LLMs and generative AI are beginning to reshape how customers search for and discover products, creating new data streams and new analytical requirements.
- 2. Real-time personalization at scale** — Advances in streaming data processing are making it possible to personalize every interaction in real time, rather than relying on batch-processed segments.
- 3. First-party data strategy** — With the continued deprecation of third-party cookies, retailers are doubling down on first-party data collection — making owned analytics infrastructure more valuable than ever.
- 4. Predictive commerce** — AI-powered demand forecasting, automated replenishment, and dynamic pricing are converging into what analysts are calling “predictive commerce” — where Big data in sales decisions happens autonomously and continuously.
- 5. Privacy-preserving analytics** — As data regulations tighten globally, privacy-first analytics techniques — including federated learning and differential privacy — are becoming part of the standard E-commerce data toolkit¹⁵.

5. Conclusion

Big data has completely revolutionized the e-commerce sector. Customers gain from the individualized, real-time experience, while Big Data aids eCommerce businesses in increasing profits. Customers may easily explore and purchase the goods they are interested in, while business owners generate more money. Big data seeks to put the customers in front of the relevant goods at the right moment.

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