Impact of Big Data Analytics on E-Commerce for Business Application: A Review and Analysis of Its Essence in a Competitive World

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Abstract: Big data analytics has had a transformative effect on e-commerce. An estimated annual growth rate of 22 to 24 percent has been observed for the production of digital data, and it has resulted in the generation of zettabytes of data. It is anticipated that this trend will continue in the future years, with projections indicating a significant increase in the global data-sphere. The exponential growth of data has compelled businesses to adopt a data-driven approach to rethink their decision-making strategies and embrace new insights derived from vast troves of information, recognizing that the more they know about their data, the greater their chances of success, as this mindset contributes to higher productivity, rapid expansion, and creative innovations, resulting in distinctive competitive benefits. In this research, we attempt to present genuine proof on how big data analytics might benefit e-commerce platforms to predict, monitor and analyze sales, and build a better model, through a small illustration. Through this paper, we aim to validate the positive impressions and potential of big data analytics on e-commerce.

1 INTRODUCTION

Shopping, and trading goods have been an integral part of society even before medieval times. The emergence of E-commerce is not a surprise considering this actuality, but the development in this field is what is to be regarded as remarkable as advancements in programming, machine-learning, big data, etc. and digitization have brought significant changes that are flourishing in E-commerce and Business (Garg et al., 2021). The most significant of them all is the involvement of Big data analytics(BDA). In this big data and technological era, e-commerce has flourished with a great deal of anxiety about the product/consumer market, competition and development, driving e-commerce enterprises to substantially invest in BDA (Gaikwad & Patil, 2022). It uses advanced statistical and machine-learning algorithms to analyze complex datasets for informed decision-making, and is becoming increasingly important as the volume, velocity, and variety of data continue to grow exponentially in e-commerce (Al-Alwan et al., 2022).

Many companies and businesses are rising with the help of E-commerce platforms, where products meet customers. E-commerce transactions provide access to nearly every possible commodity and service, including books, music, aircraft tickets, and financial services such as stock investing and online banking. BDA has emerged and revolutionized the way businesses collect, process, and assess massive amounts of data. With the help of powerful tools like Hadoop, Tableau, Cassandra, Open Refine, Hive, MongoDB etc. (Painuly et al., 2021), and models/algorithms, organizations can now gain precious revelations from their data to drive better decision-making and enhance shopping experience,

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gross-margin and sales (Alrumiah & Hadwan, 2021; Sazu, 2022). BDA has a significant impact in E-commerce, enabling companies to extract actionable insights from their data to improve performance/sales, increase efficiency, and drive innovation (Farras et al., 2022). E-commerce has developed throughout the past 40 years and paved its way from electronic data interchanges and teleshopping to modern cutting-edge online electronic stores. It has become a contemporary, widespread business model (Wong, 2022) and been the subject of much research.

Understanding how consumers make purchasing decisions online is one field of e-commerce study that looks at things like website design, product information, and usability. According to studies, people tend to be more inclined to make purchases from websites they feel comfortable with and believe to be trustworthy and user-friendly (Guan et al., 2021). Social media's influence in affecting consumer perceptions of products and companies (Peter et al., 2023). In e-commerce research, security and privacy also pose major problems. With an upsurge in online fraud and identity theft, academics have looked into security measures such as authentication and data encryption procedures (Alkis & Kose, 2022). Given the growing importance of timely delivery and efficient inventory administration in e-commerce, another area of research focuses on logistics and supply chain management (Lee & Mangalraj, 2022; Kalkha et al., 2023).

Researchers have investigated strategies to optimize these processes through the use of technology like RFID, GPS, and automated warehousing systems (Kalkha et al., 2022). Some also examined the influence of e-commerce on established supply chain models and the prospect for new business models to come into being and the role of other technologies like Artificial Intelligence (AI) and Cloud Computing in e-commerce (Zhuang et al., 2021). The studies also looked at how e-commerce has affected sociocultural norms, such as the emergence of online communities and the changing nature of both professional and recreational activities (Onete et al., 2022; Chava et al., 2024). Other areas of research related to e-commerce include the adoption of e-commerce in emerging economies (Almajali et al., 2021), the dark side of e-commerce (Ho, 2022), and e-commerce return regulation (Zennaro et al., 2022).

Gopal et al.(2022), essentially identify data science, neural networks, enterprise resource planning, cloud computing, machine learning, data mining, RFID, Blockchain and IoT, and business intelligence as the most recognized practices for big data. The involvement of BDA in E-commerce was a substantial growth required to impress a massive amount of clients. E-commerce faces challenges with big data, including managing volume, selecting tools, shortage of skilled professionals, inadequate security measures, and integrating data from multiple sources (Painuly et al., 2021). With the latest advancements in big data, data management technologies (Li & Zhang, 2021) and machine-learning models, E-commerce is striving to reach goals that were once considered impractical. BDA has become an integral part of modern-day e-commerce, playing a crucial role in driving strategic decision-making for organizations.

The importance of BDA in e-commerce cannot be overstated. Firstly, it enables organizations to gain deeper clarity into customer behaviour, market trends, and other critical aspects of their operations (Sulova, 2023). With the help of advanced analytics tools, businesses can analyze massive volumes of data generated from multiple sources to identify patterns and trends aiding in making better decisions (Kumar et al., 2022), strengthen strategic steps (Gao, 2021; Ranjan & Foropon, 2022) and gain competitive advantage. Understanding customer demographics assists business development teams in visualising product sales pathways, customer happiness, churn rate, and forecasting future sales. Secondly, e-commerce systems that combine with big data analytics can provide decision-makers with real-time information to make informed decisions quickly. By utilizing the power of predictive analytics, organizations can make proactive decisions that improve performance (Kumar et al., 2022; Bogdan & Borza, 2019), reduce costs, and increase revenue. This is especially important in a rapidly changing business environment where timely decision-making can mean the difference between success and failure. In today's highly competitive marketplace (Guan et al., 2021), businesses that use advanced analytics tools can extract valuable disclosures to identify new growth opportunities, optimize operational efficiency, and create more effective marketing campaigns.

As organizations grow and generate greater quantities of data, their e-commerce systems must be able to scale to meet their needs. BDA provides

scalability by allowing businesses to store and analyze huge amounts of structured (like Name, Age, and Gender) and unstructured data (like clicks, links, voices, and likes) (Wong, 2022), which provides a more comprehensive view of their operations, essential for organizations that want to keep up with rapid growth and take advantage of emerging opportunities. Lastly, implementing BDA can lead to significant cost savings in various areas such as supply chain management and marketing campaigns (Lee & Mangalraj, 2022). Consecutively, it helps businesses achieve sustainable growth and profitability.

Big data analytics ideals helps reveal information such as hidden patterns, correlations, market trends, and customer preferences that can assist organizations in making educated business decisions. It provides businesses with advanced tools and techniques to process, examine, and exploit data to make better decisions and reconstruct strategies (Zineb et al., 2021), enabling businesses to gain more accurate perceptions into customer behavior, market trends, and operational efficiencies, leading to improved products, service quality, and customer satisfaction. Consequently, it has revolutionized the field of business intelligence, giving companies a competitive edge in today's data-driven economy (Tong-On et al., 2021). The utilization of BDA has become indispensable (Rehman & Mehmood, 2022) for E-commerce businesses in order to effectively operate within their expansive market segment (Farras et al., 2022). The techniques used to analyze big data in general are: text analytics, audio analytics, social media analytics and predictive analytics (Rawat & Yadav, 2021), using renown algorithms such as Neural Networks, Decision Trees, K-Means (Zineb et al., 2021), SVM and Linear Regression (Shahrel et al., 2021). Big data can be valuable in a variety of customer places, such as boosting innovation through purchase behavior, issue recognition, and usage. Big data has altered the capabilities that businesses require to function efficiently. Trabucci & Buganza (2019), state that organizations capable of processing fresh data are more likely to be succeed. It is important to also note that companies that can exploit big data in their business processes, particularly, may have a significantly higher chance of enhancing their efficiency and revenue growth than their competitors (Wang et al., 2022).

As a result, big data represents a novel sort of capital for increasing business innovation efficiency. The most prominent benefits that BDA provides are improved decision making by identifying patterns, trends and using information systems like DSS (Decision Support Systems) which provide vital information on customer behavior, market trends, and operational performance (Phillips et al., 2021; Eom, 2020); enhanced operational efficiency by identifying inefficiencies, bottlenecks, and areas for improvement thereby optimizing operations, cutting costs, boosting productivity and promoting organizational agility (Hammouri et al., 2022); quick and accurate customer understanding through analyzing demographic information, purchasing behavior, and preferences (Mikalef et al., 2020), aiding in the development of focused advertising, customer segmentation, churn prediction and sentiment analysis (Zineb et al., 2021), personalized product recommendations, and enhanced customer experiences (Varma & Ray, 2023; Farras et al., 2022) which contribute to customer satisfaction and loyalty (Rehman & Mehmood, 2022); improved product and service innovation enabling organizations to develop innovative products and services by analyzing customer feedback and social media interactions (Dwivedi et al., 2023).

2 CASE STUDY

In this study, we try to investigate the influence BDA has on E-commerce platforms with the help of a mini case study of Superstore dataset from Kaggle (containing sample sales data for the period January 2015 to January 2019, url: https://www.kaggle.com/datasets/rohitsahoo/sales-forecasting) and analytics/visualization tool- Tableau. The schema for the dataset is as shown in Table 1.

Table 1. Schema of the dataset

Field Name	Field Type	Description
Row ID	String	Specifies the ID of the sales data
Order ID	String	Specifies the order ID of the product
Order Date	Date	Specifies the order date
Ship Date	Date	Specifies the shipment date
Ship Mode	String	Specifies the shipment mode
Customer ID	String	Specifies the Customer ID
Customer name	String	Specifies the Name of the Customer
Segment	String	Specifies the segment of the product sold
Country	String	Specifies the country of the shipment
City	String	Specifies the city of the shipment
State	String	Specifies the state of the shipment
Postal Code	String	Specifies the postal code of the shipment
Region	String	Specifies the region of the shipment
Product ID	String	Specifies the ID of the product sold in sample dataset
Category	String	Specifies the category of the product sold
Sub Category	String	Specifies the sub category of the product sold
Product Name	String	Specifies the name of the product sold in the sample dataset
Sales	Decimal	Specifies the sales quantity

3 RESEARCH OBJECTIVE

To assess the indispensability of Big Data Analytics for the success of an E-commerce platform.

Understanding the data : The data was reviewed to remove any duplicates and null values, and missing values were replaced with aggregate values. Data validation was done to ensure that every row followed the data schema and ensured there weren't any mismatches. Some basic analysis in Tableau were performed, to gain a deeper understanding of the data. Figure 1 depicts the sales by state, color grouped by regions (Central, East, West, South) in the US. It is observed that the maximum sales took place in California, with a total sum of 446,306; the lowest sales data in North Dakota with total sales of 920. Figure 2 depicts the distribution of sales across 3 product categories: Furniture, Office Supplies, Technology, and their respective sub-categories. “Technology” has the most sales under the “Phones” sub-category.

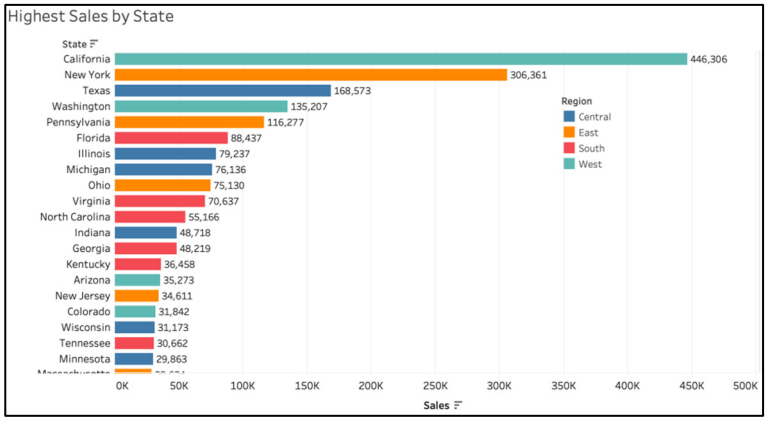

Figure 1: Highest Sales by State.

Sales by Category and Sub Category

Category	Sub-Category	Sales
Furniture	Bookcases	113,813
	Chairs	322,823
	Furnishings	89,212
	Tables	202,811
Office Supplies	Appliances	104,618
	Art	26,705
	Binders	200,029
	Envelopes	16,128
	Fasteners	3,002
	Labels	12,348
	Paper	76,828
	Storage	219,343
	Supplies	46,420
Technology	Accessories	164,187
	Copiers	146,248
	Machines	189,239
	Phones	327,782

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Figure 2: Sales by Category and Sub Category.

4 DATA ANALYSIS AND FORECASTING

Effective data analysis is of prime importance, and plays a pivotal role in helping sellers identify and address areas where their sales are falling short. In this section, we focus on obtaining fruitful and actionable inferences that can benefit an E-Commerce merchant.

On classifying the sales in different provinces for different categories we observe the following. The lowest sales for Furniture, Office Supplies, and Technology were observed to be in Montana, the District of Colombia and South Dakota, respectively and the highest sales for all the categories were in

California (As seen in Figures 3, 4, and 5). To effectively address low sales in a province (say, Montana), sellers from the particular province(s) could consider tailoring marketing efforts to better resonate with the local customer base, capture the attention of potential customers through promotional offerings and campaigns, or even adopt strategies from a competitor.

Figure 6 illustrates the company's sales performance, that showcases a mix of highs and lows throughout each year. Notably, the year 2018 stands out as a remarkable milestone with the highest sales ever recorded, totaling around 104,691 units. On the contrary, in 2015, the company experienced its lowest point, selling only 5,407 items. This pattern suggests a progressive trend overall, despite the existence of fluctuations.

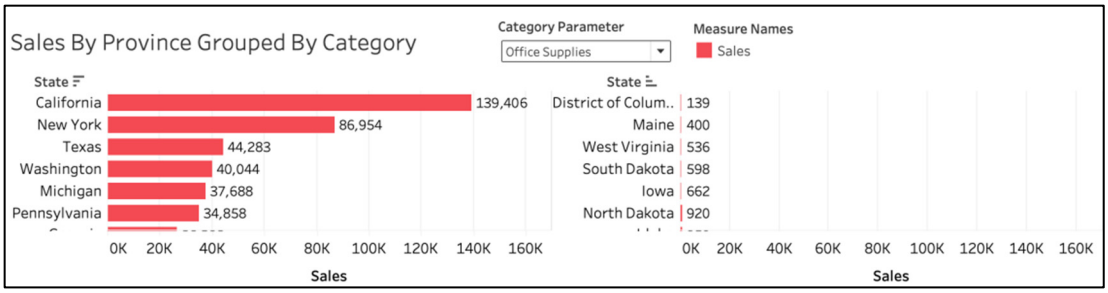

Figure 3: Sales by Province for the Furniture Category.

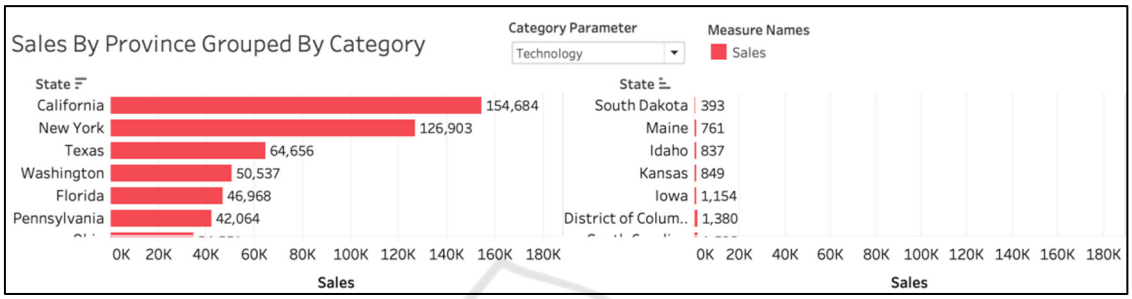

Figure 4: Sales by Province for the Office Supplies Category.

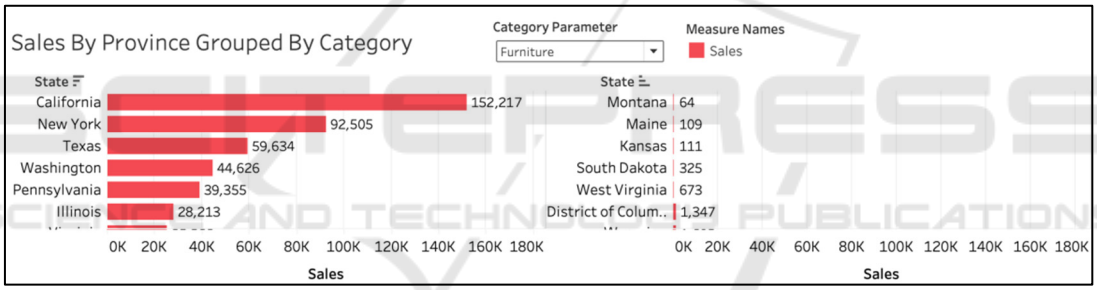

Figure 5: Sales by Province for the Technology Category.

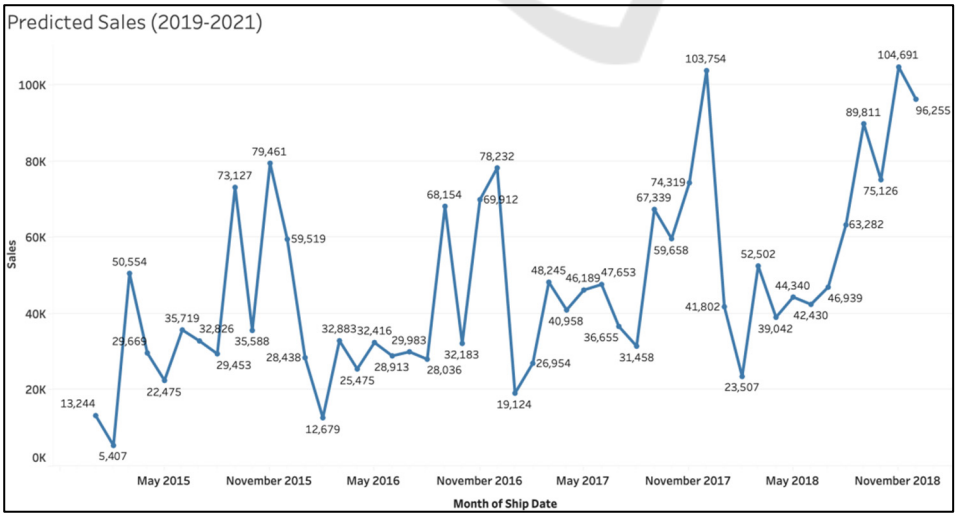

Figure 6: Actual sales during 2015 to 2019.

Powerful tools like Tableau, offer predictive analysis and forecasting capabilities, Figure 7 depicts the prediction of sales in the years 2019-2021, based on the previously acquired data, which aids companies to make informed decisions and develop effective plans that align with anticipated market conditions, so as to gain advantage over competition and maximize business outcome. For instance, one of the estimations is that there could potentially be a significant decline in sales during February 2019, which can eventually impact the company at that particular period of time in various ways, providing an opportunity for the company to take proactive measures to mitigate any adverse effects and help minimize any negative implications. The expected sales by region is depicted in Figure 8, allowing one to deduce the differential sales success across different regions. It is clear that certain locations have larger sales figures than others, which could aid in understanding regional sales patterns and enable organizations to deploy resources effectively, optimize inventory management, and streamline supply chain operations to match the requirements of high-performing regions. Figure 9 offers a comprehensive overview of the distribution of sales within each region, showcasing the performance of various product categories in each of these regions. Analyzing such data enables businesses to understand the sales composition and identify the sub-categories that contribute significantly to overall sales in each region and assist in product assortment and resource allocation.

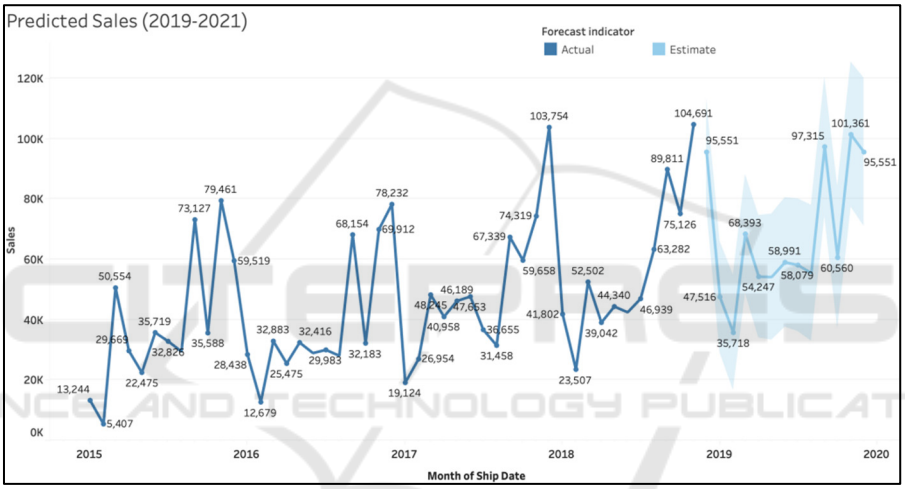

Figure 7: Predicted Sales for the period 2019 to 2021

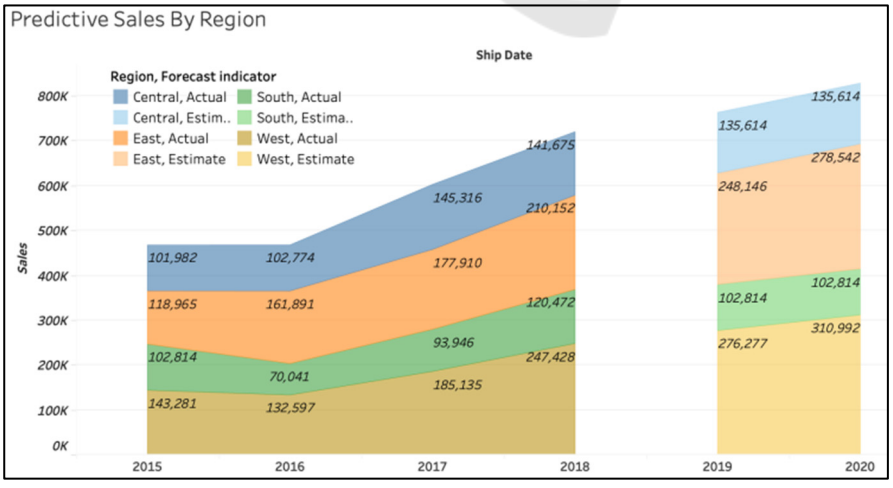

Figure 8: Predicted Sales by Region

		Region			
Category	Sub-Category	Central	East	South	West
Furniture	Bookcases	23,774	43,819	10,899	35,321
	Chairs	82,373	95,688	44,739	100,023
	Furnishings	15,016	28,145	17,063	28,988
	Tables	39,155	38,809	43,830	81,016
Office Supplies	Appliances	21,177	34,119	19,525	29,797
	Art	5,746	7,431	4,510	9,018
	Binders	56,865	51,256	36,734	55,174
	Envelopes	4,537	4,138	3,346	4,107
	Fasteners	770	820	503	909
	Labels	2,436	2,555	2,344	5,013
	Paper	17,185	19,538	13,892	26,214
	Storage	45,407	69,429	35,251	69,256
	Supplies	9,467	10,655	8,319	17,979
Technology	Accessories	32,742	43,906	26,906	60,632
	Copiers	37,260	53,219	9,300	46,469
	Machines	26,797	66,106	53,891	42,444
	Phones	71,940	99,885	58,098	97,859

Figure 9: Sales for Categories in each Region

5 CONCLUSION

On the basis of our exploration, we find that in the current digital environment, where competition is fierce and consumer standards exceed expectations, businesses must harness data to obtain an edge over rivals. With the rise of Industry 4.0, everyone shall embrace digitization for establishing more efficient, error-free, and open systems. As data volumes continue to swell, new obstacles arise that must be resolved expeditiously to ensure the development of trustworthy systems. E-commerce platforms capitalize on the power of data using BDA to comprehend the way customers behave, adjust promotional efforts, optimize processes, and drive revenue expansion, providing valuable inferences into consumer preferences, market trends, and productivity, facilitating intelligent choices in analyzing and creating predictive models based on purchase history, browsing behavior, demographics, and social media interactions. Embracing the power of BDA is a strategic move that empowers businesses to navigate the complexities of the digital age and remain at the forefront of the rapidly evolving e-commerce landscape, which can help attain critical discernment, make informed decisions, gain a competitive advantage, improve scalability, and achieve significant cost savings. Through the investigative analysis of the Superstore sales data, we were able to assess and categorize the data using data analysis on different aspects such as customer groups and regionality and answer how exactly one can scrutinize the knowledge from different charts to achieve intelligent business decisions with the ambition to stay ahead of the curve through constant improvisations in their workflow. Organizations that seek to thrive in today's fast-paced business environment shall thereby prioritize the incorporation of Big Data Analytics into their decision-making processes, for its high offerings and value in a business framework.

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