| RESEARCH ARTICLE

AI-Driven Next-Gen U.S. Retail: An Empirical Study on Optimizing Supply Chains by leveraging Artificial Intelligence, Business Intelligence, and Machine Learning.

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| ABSTRACT

Business Intelligence (BI), Artificial Intelligence (AI), and Machine Learnings (ML) have been playing an important role for optimizing Supply Chain Management (SCM) in the U.S. retail industry. The integration of these innovative and cutting-edge technologies into SCM has transformed the efficiency, agility, and profitability of retail businesses across the nation. It's important to know how these advanced technologies transformed the supply chain process for optimizing inventory level to avoid any bottleneck, overstocking or stockout situation. This research examines how the integration of these modern technologies transformed the supply chain process and enabled retailers in optimizing their supply chain management. In this research work, we have used extensive knowledgebase on Business Intelligence, Artificial Intelligence, Machine Learning, the U.S. retail industry, and the Supply Chain Management, and later we applied this knowledgebase in the U.S retail domain to see how retailers integrate these technologies into their supply chain management process. We also used secondary information available online from reliable sources to make it more realistic. The U.S retail sales revenue was reported at US$7.6 trillion in Y2024 with an expected growth of CAGR of 3.2% over the last five years (Y2019-Y2024). We see a steady growth in the retail sector after the COVID-19 pandemic. Therefore, there is a growing demand for integrating these technologies into the retailers' SCM so that they can predict consumer demand more accurately and maximize their sales revenue. These technologies serve retailers with greater benefits like forecasting product demand, optimizing inventory level, data-driven decision making, cost reductions by avoiding overstocking, increasing efficiency etc. Though these modern technologies enable retailers with supply chain optimization, there are still some downsides, which include high initial payouts, data silos, resistance to adoption of new technology, consistent and quality dataflow, data integration from various sources etc.

| KEYWORDS

Business Intelligence (BI), Artificial Intelligence (AI), Machine Learning (ML), Blockchain, Robotics & Automation, Optimization, Supply Chain Management (SCM), US retail domain, Predictive Analytics

| ARTICLE INFORMATION

I. Introduction

The U.S. retail industry has been growing steadily over the last five years, especially post-COVID-19 pandemic period. In line with the increasing trend in sales revenue, there is an increasing demand for modern, cutting-edge technologies in managing and optimizing retailers' supply chain management. The U.S. retail industry faces some challenges like demand fluctuations, change in consumer behavior, disruptions in supply chain due to socio-political (like TARIFF) factors, market competition, cost optimization and so on. Therefore, it's important for the retailers to understand the importance of these latest technologies and how they can integrate these BI, AI, and ML applications into SCM to optimize profitability and minimize operational costs.

The integrations and applications of BI, AI and ML technologies may empower retailers with advanced capabilities in forecasting accurate demand, predicting consumer behavior following their preferences, optimizing supply chain and minimizing inventory management costs, taking data-driven strategic decisions to be competitive in the market. In this research work, we focus on these cutting-edge technologies, their features, and the importance of integration of these technologies into the SCM in the U.S. retail industry.

2. Literature review

2.1 Business Intelligence (BI)

Business Intelligence technologies and their applications are becoming eminent part of today's business world which enrich the business firms with sufficient information for taking data-driven strategic business decisions, since BI applications provide "useful insight, support decision making, and drive organizational performance" (Ramakrishnan et al. 2012, p. 486). BI tools are used to collect structured and/or unstructured data from internal and external sources, analyze them and interpret relevant information to get valuable insight into the business and take informed decisions. We see a good range of BI tools with distinct features available in different industries. Companies adopt and integrate BI tools as per their business requirements. Most popular BI tools include Microsoft Power BI, Tableau, QlikSense, Dundas BI, Sisense, and Microsoft Copilot etc.

2.2 Artificial intelligence (AI)

Artificial intelligence refers to intelligence exhibited by computer systems. It is a field of research that study and develop methods enabling machines to learn from historical data, patterns and develop intelligence based on algorithms that maximize the chances of achieving defined goals (Russell & Norvig 2021, pp. 1–4). Most popular AI applications include web search engines (google search engines), recommendation systems (use by Amazon, YouTube), virtual assistance (google assistance, Siri), and generative and creative tools (ChatGPT, AI art).

2.3 Machine Learning (ML)

ML in data science involves analyzing big datasets for identifying patterns and trends by using statistical learning. ML algorithms are a subset of AI algorithms. The more common ML algorithms include linear regression, neural network, logistic regression, decision trees, random forest. ML are of several types including supervised learning, unsupervised learning, semi-supervised learning, reinforcement learning.

2.4 Supply Chain Management (SCM)

Managing the supply chain is very important for a business entity. A company must maintain sufficient stock to prepare goods and/or services and deliver the final products to its end users on time. Besides, it must estimate demands and plan following the consumer's demand. SCM involves coordinating and monitoring various functions from product's source to the end customer. There are five general functions of SCM like planning, sourcing materials, organizing manufactures, delivery of products/services, and managing return services. Efficient management of a company's supply chain can benefit in various ways like minimizing inventory costs, optimizing stock levels, and increasing customer satisfaction by delivering products on time.

3. Methodology

In this research, we have used extensive knowledgebase on Business Intelligence, Artificial Intelligence, Machine Learning, the U.S. retail industry, and the Supply Chain Management, and later we applied this knowledgebase in the U.S retail industry to see how the major retailers integrate these technologies in optimizing their supply chain management system. For our research purposes, we used quantitative analysis based on secondary data from reliable sources.

4. Research Outcomes

4.1 The U.S. Retail Industry (NAICS 44-45)

The U.S. retail domain is one of the largest and dynamic sectors of U.S. economy, which contributes significant portion of consumer spending, generates employment opportunity, and integrates technological advancements.

4.2 Market Segmentation:

The U.S. retail industry landscape includes Brick-and-Morter Retailers, E-commerce and Online Retailers, Grocery & Supermarkets, Discount & Dollar Stores, and Specialty retailers. Brick-and-Morter Retailers segment includes traditional physical outlets such as

grocery stores, departmental stores, any special retailer in the U.S. market. Walmart has become one of the largest retailers in this market for general merchandise items, fresh produce, groceries etc. Target, a mass-market retailer, has been operating its outlets with an upscale image. Costco is known as a warehouse club offering members bulk products. Home Depot and Lowe's offer a good range of home appliance products, home improvement materials, and home decoration products.

Another important and popular segment in the U.S. retail market is E-commerce and Online retailers. Amazone has become the largest e-commerce platform in the U.S. virtual market followed by Walmart, e-Bay.com, Etsy etc. Grocery and Supermarket segment offers daily necessary groceries which includes large chains, discount stores, specialty food shops. In this segment, major player may include Kroger, the largest supermarket chain in the U.S., followed by Publix, Whole Foods Market (Amazone), ALDI and LIDL (cost-driven, Low-cost discount grocery retailers). Other segments include Discount and Dollar stores like Dollar General, Dollar Tree/Family, Big Lots and Specialty Retailers segment includes Apple store, Best Buy, Nike & Adidas.

4.3 Market Size

As per the United States Census Bureau (January 29, 2024), the U.S. retail sales revenue was reported at US$7.04 trillion in Y2022 with an increase of 8.0% from US$6.52 trillion in Y2021. As per the report, Men's clothing stores had significant contribution in retail sales revenue (US$10.8 billion with an increase of 27.9% in Y2022) followed by Gasoline Stations (28.5% increase), Motor Vehicle & Parts Dealers (2.9% increase), Grocery stores (8.2% increase), Electronic Shopping and Mail-Order-Houses (9.5% increase).

The U.S. Retail sales revenue has been improving significantly after COVID-19 pandemic period. The post-pandemic consumer trends, shifting consumer behavior, online shopping popularity, process automation and diversification of products & services offering consumers more value propositions that led to these improvements in sales revenue. A good range of value propositions may have a positive impact on consumers behavior and increase sales revenue. (Rahman, et al., 2025)

As per the IBIS World report, The U.S. retail sales revenue was reported at US$7.6 trillion in Y2024 with an expected growth of CAGR of 3.2% over the last five years (Y2019-Y2024). The projected growth in this sector for the next five years Y2025-Y2030 would be at a moderate rate, aligned with the U.S. GDP and the consumers preference and trends. The total number of businesses operating in the retail industry stood at 3 million across the nation, and the total number of employees working within this sector is 20 million.

Graph-01shows an increasing trend in monthly sales revenue from retail and food services (January to December 2024). The monthly sales revenue was reported at $637.0 billion in January 2024 and the projected revenue was expected to be $800.0 billion (p) in December 2024.
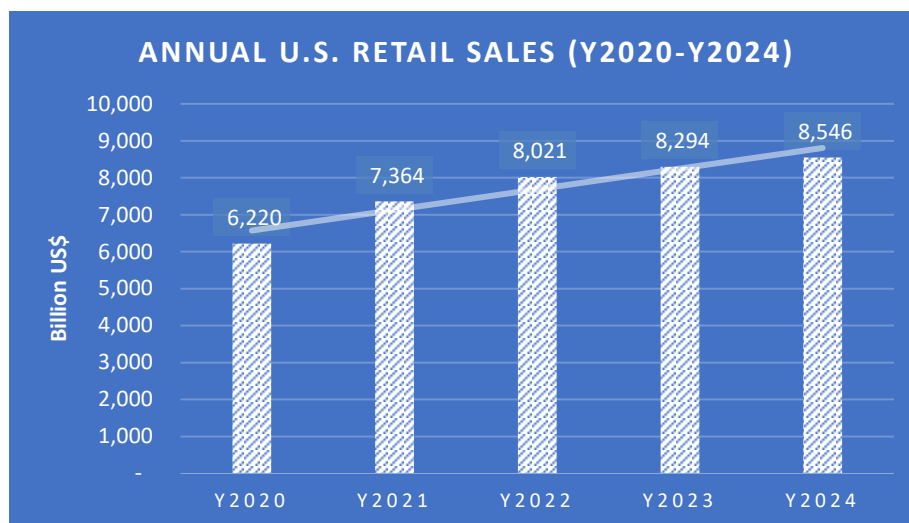
Graph_01: Monthly U.S. Retail Sales (January – December 2024)
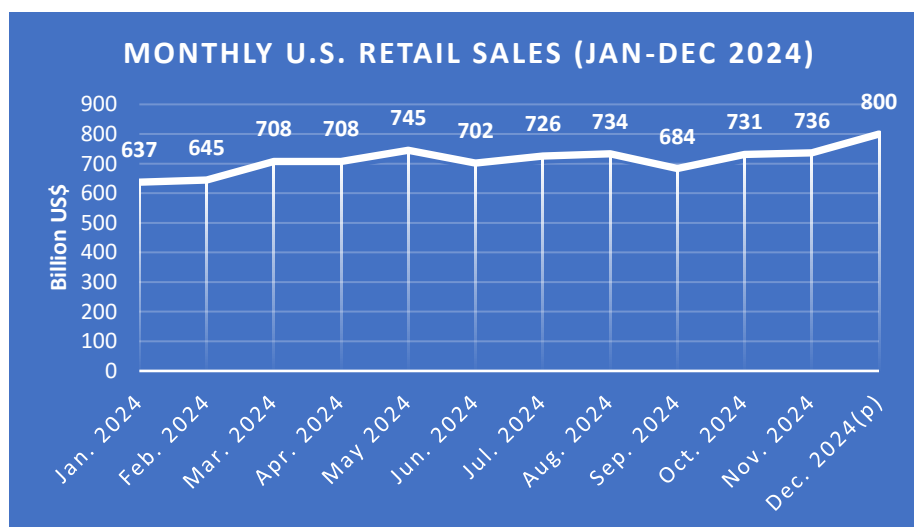
Raw Data source: The U.S. Census Bureau

Graph-02 shows a gradual improvement in retail sales in the United States from post-Covid-19 period Y2020 to the year Y2024.

Graph:02 Annual U.S. Retail Sales (Y2020 – Y2024)

ANNUAL U.S. RETAIL SALES (Y2020-Y2024)

Raw data source: The U.S. Census Bureau

Therefore, based on this **descriptive analysis**, we can do **predictive analysis** for forecasting future trends, demands of the U.S. retail products and services by applying BI, AI, ML algorithms and develop **prescriptive analysis** for retailers to prepare themselves in optimizing their supply chain management so that they can maximize their sales revenue by satisfying consumers' growing demands.

4.4 BI, AI, ML in SCM in the US retail industry

Today's business world is more likely to rely on business intelligence, artificial intelligence, machine learning tools & technologies for increasing their business performance, efficiency, and attracting more customers by retaining existing customers. The US retail market is not an exception. Companies in the US retail market use various technologies in transforming their Supply Chain Management (SCM) process to stay competitive by improving operational efficiency and enhancing customer experience.

4.4.1 Business Intelligence in SCM in the US retail industry

Business Intelligence (BI) tools provide actionable insights to retail business entities to make strategic decisions by leveraging relevant, sufficient and appropriate historical data. Retail business managers apply business intelligence applications for managing their supply chain. BI tools are used to identify business trends, forecast future demand, create dashboards, charts, graphs for swift business decision, avoid overstocking or understocking by optimizing inventory level, help measuring reorder level, EOQ (Economic Order Quantity) level and so on.

Business Intelligence tools help retailers to do descriptive analysis based on historical data and forecast future demand more accurately by analyzing consumer behavior, patterns, and trends. Retailers use BI tools to leverage business sales data over the periods to ensure the inventory level is maintained in line with demand to avoid any over or understocking, which helps retailers minimize inventory cost. BI tools also enable retailers to operate their business with high operational efficiency, accuracy in managing its supply chain, and streamline sufficient logistics, identify inefficiencies. In the US retail market, Walmart uses Microsoft Power BI tool to analyze its transactional data from in-store sales and online platform for forecasting demand, optimizing its inventory level and managing its supply chain process effectively and efficiently.

7.4.2 Artificial Intelligence in SCM in the US retail industry

Artificial Intelligence (AI) has been improving Supply Chain Management (SCM) significantly over the years by automating processes, performing predictive analysis and enabling retailers to make real-time business decisions. Retailers in the US retail market rely heavily on AI tools to improve their operational efficiency so that they can satisfy growing consumer demand and choice and increase customer satisfaction index to attract more and more customers.

Retail companies use Artificial Intelligence algorithms to perform predictive analysis for forecasting their products' demand, planning for inventory management, prioritizing activities on supply chain management more accurately to increase customer

satisfaction. In addition, AI technology enables retailers to personalize consumer's experience and recommend suitable products based on consumer's behavior, choice and buying history.

For managing warehouses and fulfilment centers retailers use AI-powered autonomous vehicles, and robots for picking products, packaging, and then delivering to various customers across the country. AI-powered cutting-edge technology help retailers to manage the whole supply chain process.   In the US retail market, Amazone uses AI algorithms to perform predictive analysis and forecast product demands, optimize inventory level, and streamline logistic supply. Besides, Amazone uses AI for cashier-less checkout at their Amazone Go stores, revolutionizing shopping experience.

4.4.3 Machine Learning in SCM in the US retail industry

Machine Learning (ML) refers to a subset of Artificial Intelligence that focuses on developing algorithms over time for predicting trends, optimizing supply chain, and helps retailers by automating data-driven decision-making processes. ML learns automatically from historical data and improves algorithms over the periods.

ML benefits retailers in forecasting demand by performing predictive analysis on historical data, considering seasonal effects, fluctuations in demand. Companies can adjust their inventory levels based on these predictions to avoid any over or understocking situation. Overstocking may increase inventory cost, holding costs, maintenance costs, and understocking may decrease sales revenue.

ML helps retailers minimize delivery costs, shipping costs and improve optimizing SCM by suggesting the best solutions to avoid bottleneck situations. It can also be used to detect any potential risk in SCM including product shortages, or any potential delay in goods-in-transit. Once the potential risks are identified, retailers can mitigate these sorts of risk immediately to avoid any shortfall. In addition, ML can also help retailers to monitor product quality by detecting defective products which are useful for minimizing waste and helping maintain product quality. In the US retail market, ML helps Target (a retailer) in predicting products demand and auto adjusting the supply chain so that they can meet customer demand.

4.5 Technologies enabling BI, AI, and ML in SCM

There are several technologies available by which the integration of BI, AI, and ML in supply chain management made possible. US retailers prefer technologies as per their nature of business, and requirements. These key technologies include below:

4.5.1 Cloud computing:

Cloud computing provides various cloud-based computing services like data storage facility, processing power, software applications over the internet rather than local server or personal devices. It allows retailers to integrate AI and ML algorithms in their supply chain management without a significant upfront investment.

Retailers can consider cloud-based services because they're cost efficient, scalable, easily accessible from anywhere anytime, safeguard against any disaster, more secured; despite some of the limitations like privacy concern, limited control etc. Popular cloud-based service providers include Microsoft Azure, Amazon Web Services (AWS), and Google Cloud Platform (GCP).

4.5.2 IoT (Internet of Things):

IoT refers to a network of physical devices, sensors, and software which are connected to the internet via Wi-Fi, Bluetooth, 5G, or other networks for collecting and exchanging data. It provides real-time data on retailers' inventory management process to monitor inventory position, track real-time shipment, and be aware of environmental condition of warehouse to avoid any incidence. IoT may also help retailers with providing security cameras, smart thermostats, and lighting systems in the warehouse to make it more secure.

4.5.3 Blockchain:

Blockchain is a decentralized, digital ledger technology that securely records transactions across multiple computers. Each transaction is stored in a "block," which is linked to the previous one, forming a "chain." Once recorded, data cannot be altered without network consensus, making blockchain highly secure and reliable. Blockchain can help retailers by providing transparency, traceability, security, and efficiency in retail operations. Walmart uses blockchain for maintaining food safety and tracking fresh produce from farmers to their local stores. Home Depot uses blockchain to avoid any dispute from supplier, and track product deliveries in real-time. Amazone & IBM use blockchain for counterfeit prevention and tracking their logistics.

4.5.4 Robotics & Automation:

Robotics and process automations are playing the key role to transform the U.S. retail industry aiming to reduce inventory cost, increase operational efficiency, improve accuracy, and optimize logistic supports from manufacturing to the end user. In the U.S. retail industry, Amazon uses warehouse robots (Kiva Systems), and drone-aided deliveries. Walmart uses AMRs (Autonomous Mobile Robots) using sensors, AI, and ML to navigate warehouses and move inventory autonomously which reduces manual labor costs and increase efficiency at work. Kroger created AI-powered micro-fulfilment centers for automating the process of handing fresh produce. FedEx & UPS perform their business operations using the process of robotic sortation, self-driving trucks, and drone deliveries.

5. Challenges & Opportunities:

Though there are opportunities for retailers to optimize their supply chain by integrating various BI and AI tools in the supply chain process, retailers may face some challenges to integrate and apply these applications. They may face difficulty in feeding quality, accurate and consistent data flows which are required for predicting product demands by using AI and Machines Learning models. Integrating data flows from various sources may be a challenge for the retailers. Our next research focus would be on how to integrate uninterrupted data flows from various sources and ensuring quality and sufficient data for predictive and prescriptive analysis based on descriptive analysis.

Since the innovations and applications of BI, AI, and ML have been increasing exponentially in response to satisfy consumers' demand, there is a growing need for trained, tech-savvy, skilled professionals for developing and integrating these advanced technologies in managing retailers' supply chain processes. We would also cover this issue/challenge in our next research work.

6. Conclusion

The research findings suggest that the integration of sophisticated BI, AI, and ML tools and applications lead to substantial improvements in optimizing supply chain management within the U.S. retail industry. The modern technologies become integral part of the SCM in the retail industry. Retailers who already integrated and leveraged these technologies benefited themselves by optimizing operational efficiency, minimizing costs, experiencing better consumers satisfaction by predicting consumer behavior, and forecasting product demand. We see the major retailers like Walmart, Amazon, and Target gains optimizations in their SCM process and become the market leader in their respective segment.

We see a steady growth in the retail sales revenue during the post-COVID period from Y2020 to Y2024. In response of this increasing trend, retailers are more likely integrating their SCM with cutting-edge technologies and coming up with new value propositions to attract potentials consumers. Future research should explore more emerging technologies such as blockchain and IoT in conjunction with AI-driven SCM optimization. Though these technologies benefit retailers in many ways, there are still some flipsides of these technologies which include high initial payouts, data silos, resistance to adoption of new technology, consistent and quality dataflow, data integration from various sources etc.

References

[1] *Ramakrishnan, T., Jones, M.C., and Sidorova, A. 2012. "Factors Influencing Business Intelligence (BI) Data Collection Strategies: An Empirical Investigation," Decision Support Systems (52), pp. 486-496.*

[2] *Russell, Stuart J.; Norvig, Peter (2021). Artificial Intelligence: A Modern Approach (4th ed.). Hoboken: Pearson. ISBN 978-0-1346-1099 3. LCCN 20190474.*

[3] *Rahman, K. O., Rezvi, R. I., Nasrullah, F., Islam, M. S., Hasan, M., Khanam, A., & Akash, A. H. (2025). Business Model Canvas: Business Analytics on Gas stations with C-stores in United States (Vol. 7). London: Journal of Business and Management Studies. doi:https://doi.org/10.32996/jbms.2025.7.1.13*

[4] *Coursera (global platform for online learning) https://www.coursera.org/articles/bi-tools*

[5] *LEAFIO (partner for retailers) https://www.leafio.ai/blog/retail-business-intelligence-complete-guide/*

[6] *UC Berkeley School of Information https://ischoolonline.berkeley.edu/blog/what-is-machine-learning/*

[7] *IBMhttps://www.ibm.com/think/topics/machine-learning#:~:text=Machine%20learning%20(ML)%20is%20a,and%20exposure%20to%20more%20data.*

[8] *Coursera (global platform for online learning) https://www.coursera.org/articles/supply-chain-management*

[9]   *Retalon (provider of advanced retail predictive analytics & AI solutions for supply chain)* https://retalon.com/blog/machine-learning-in-supply-chain

[10]   *United States Census Bureau https://www.census.gov/newsroom/press-releases/2024/annual-retail-trade-survey.html*

[11]   *IBIS World: https://www.ibisworld.com/united-states/industry/retail-trade/1000/?utm_source=chatgpt.com*