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ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT FOR AUTOMOBILE INDUSTRY

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Abstract: This study investigates how artificial intelligence (AI) affects supply chain management (SCM) in the automobile industry, with a focus on how AI may change business practices and solve environmental issues. The study evaluates the effect of AI on supply chain management (SCM) in the automotive sector using a mixed methods approach, demonstrating advancements in a number of areas. It looks at AI-related technologies including robotics, IoT, and machine learning and presents real-world applications and advantages like increased supply chain resilience and productivity. The article stresses the ethical and environmental aspects of adopting AI while acknowledging the obstacles that still need to be overcome. It also looks ahead to future developments in demand forecasting, blockchain, predictive maintenance, autonomous cars, and human-machine collaboration. In general, the study advances knowledge on how artificial intelligence is transforming the automotive supply chain.

Keywords: Artificial Intelligence (AI), Supply Chain Management (SCM), Automobile Industry, Automotive Sector.

I. INTRODUCTION

Before the advent of significant technological progress, we would imagine the concepts like artificial intelligence, machine learning, automation, self-driving cars, data reading and self-analysing, etc. In the 21st century the automobile industry has adopted to progressive technologies to overcome the surging demand of the global markets. Artificial intelligence has integrated into various aspects of the industry, considering supply-chain as a particular field in the industry, it has become a driving force that has full potential to change the ways of operations in automobile industry and mainly their supply chain management.

In the automobile sector, there are interconnected networks of vendors, manufactures and distributors, although they are focusing on bringing in: increased efficiency, low cost of production, on time delivery, improve overall supply chain management; furthermore, there is also a need to a movement to oversee or diminish impacts on environment. In this context, Artificial Intelligence technology holds the potential to lead enhancement of supply chain by delivering indispensable, optimal solutions while predicting the future outcomes tied to Supply Chain system.

A. AI with Supply Chain

Within the realm of Artificial Intelligence (AI), supply chain management represents a significant domain of research and innovation. With the integration of artificial intelligence including automation, predicting analytical technology and machine learning, it promises to transform overall supply chain management operations. These advancements give smarter and efficient ways to plan supply, best routing planning, demand and supply analysis forecasting, and also tracking of real time inventory. Research in artificial intelligence has a twofold objective: addressing the present challenges and enhancing the efficiency of logistics management in the future. As businesses continue to adapt AI driven solutions, they are also actively shaping the dynamic landscape, with a primary focus on SCM.

II. LITERATURE REVIEW

[1] Reza Toorajipour, Vahid Sohrabpour, Ali Nazarpour, Pejvak Oghazi, Maria Fischi, conducted a study on Artificial Intelligence in supply chain management. Their paper aims on finding out if AI techniques being used are helpful in making SCM work better. The paper points out areas like: AI techniques commonly used in SCM, AI techniques that can be used in the future, how AI is making a difference in various parts of SCM and which parts of SCM most benefit from AI. They followed a specific set of rules to decide which earlier conducted researches were relevant and which weren't, to provide a systematic insight by analyzing and synthesizing the information.

[2] In this research "Impact of Artificial Intelligence on Supply Chain Management Performance", conducted by Baha M. Mohsen has stated that AI can analyze data and predict demand, optimize transportation routes and find the inefficiencies in supply chain to improve faster responses to change in demand and cost reductions. This paper explores the applications of AI on SCM performance, potential for AI in supply chain and its effect in terms of agility and lean principles. They have used the Sccopus database to study active regions, subjects, and document types related to impact of AI on SCM performance.

[3] Shuchita Gupta, Ben Amaba, Mike McMohan, Kunal Gupta's paper titled "The Evolution of Artificial Intelligence in the Automotive Industry", presents the infusion on AI in the entire life cycle of a vehicle, spanning from its innovation through manufacturing, distribution, and reaching customers is absolutely important. AI serves as the crucial factor for shaping the next-gen vehicles and establishing a new brand presence in the market. It also suggests that every company must undergo a process of reimagining and adopting new technologies in order to keep up with the new market trends.

[4] Christine Kinsey in her paper "Artificial Intelligence and the Future of Supply Chain Management", focused on how AI is integrated in supply chain management, particularly in automotive sector. This research helped address the hurdles that are faced by the companies while adopting to AI, and also offers a case study that involves a well-known automotive manufacturer and contemplates the future prospective impact of AI in supply chain industry.

III. RESEARCH METHODOLOGY

A mixed methods research strategy was used in this study to thoroughly examine the effects of AI on supply chain management in the automotive industry. It uses both quantitative and qualitative approaches, the necessity to explore the complex viewpoints of stakeholders and industry experts in addition to measuring the quantifiable effects of using AI led to the selection of this approach.

A. ***Quantitative Approach:*** A statistical approach was used in earlier studies on AI's impact on SCM for automotive industry. A stratified sample strategy was used to ensure diverse representation in a previously conducted survey that was directed towards over 200 experts in the industry. The digital surveys were used to gather quantitative data on efficiency measures, cost savings, and performance enhancements brought about by the integration of Ai. Applying statistical analysis, gave significant insights into how AI affects many parts of supply chain operations quantitatively.

B. ***Qualitative Approach:*** Previous research on AI in SCM in the automotive sector used qualitative approaches, conducting in-depth interviews with 15 major stakeholders. Decision-makers, supply chain managers, and developers of AI systems were included in this sample. These people discussed their experiences, difficulties, and possibilities related to the use of AI in supply chain operations; after that, recurrent themes and patterns were found using thematic analysis, which provided deep insights into qualitative aspects of AI application in the industry's supply chain.

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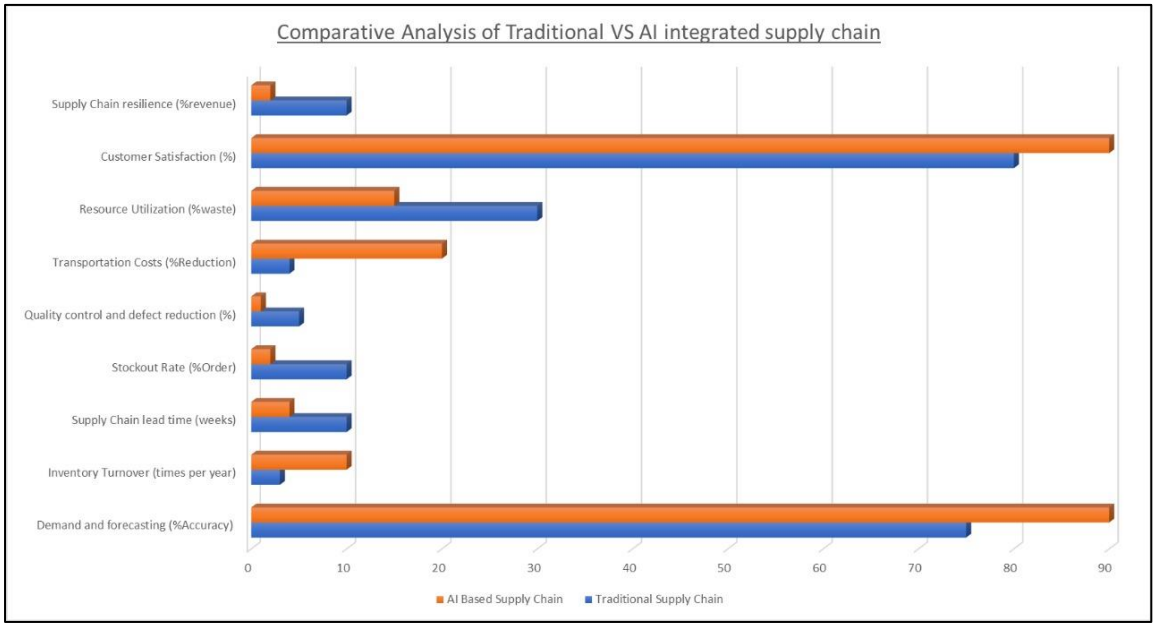
IV. COMPARATIVE ANALYSIS

	TRADITIONAL SUPPLY CHAIN	AI SUPPLY CHAIN
Demand Forecasting Accuracy	In automobile industry, typical forecasting accuracy might range from 75% to 80%	It can achieve accuracy rates of about 85-90% or even higher, which lowers the risk of under or over production
Inventory Management and Turnover	By traditional method inventory turnover rate may lead to 3-6 times per year.	AI SCM can increase turnover by almost 6-10 times per year which reduces cost of carrying and capital expenses related to inventory management.
Lead Time Reduction	Generally, by traditional method, on average it might take up to 6-10 weeks for automotive parts and components.	The overall period for automotive parts and components can be reduced to 4-8 weeks, which improves responsiveness of supply chain.
Stockout Rate	Stockouts can occur in 5-10% of automotive parts orders which might also lead to delay in production process.	AI driven inventory management can reduce stockout rates up to 2-5% or even lower which minimizes problem related to disruption in production process.
Quality Control and Defect Reduction	By traditional process quality and defectiveness in the product can have defect rate of 2-5%	Quality control with the help of computer supervision and ML we can reduce defect rate to 0.5-1% by improving the overall product quality and reducing the cost for rework.
Transportation Costs	In automobile industry by traditional method, transportation costs may account to 4-8% of total supply chain costs.	By optimization with the help of AI in transportation, we can reduce overall cost by 10-20%
Resource Utilization	Resource inefficiencies can result in 20-30% waste.	Optimum usage of resources due to AI in automotive production can help reduce wastage by up to 15-20%, which will lead to cost saving and sustainability.



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V. AI TECHNOLOGIES IN SCM

A. *Machine Learning (ML)*

1) *Demand Forecasting:* Machine Learning algorithms forecasts future demand for automobile components or vehicles by utilizing historical data, such as sales figures and market patterns. With less chance of overstocking, this data helps optimize production and inventory, saving money and increasing customer happiness.

2) Quality Control: By examining photos of parts or finished goods, machine learning algorithms along with computer vision, detects manufacturing flaws. This automation guarantees improved product quality, lower fault rates, and strengthens the brand's dependability.

3) Predictive Maintenance: ML forecasts the real-time maintenance requirements of vehicles and machinery using a combination of sensors from the IoT. By preventing costly breakdowns, extending equipment lifespan, and reducing downtime, this proactive approach offers more cost-effective maintenance than reactive approaches.

B. *Internet of Things (IoT)*

1) Asset Tracking: Throughout the supply chain IoT sensors can be affixed to cars, components, and other assets. Real-time data regarding these sensors' location, state, and use is transmitted by them. The supply chain visibility provided by this information is crucial. To make sure they always know where their assets are, automakers can follow the flow of cars and parts from the assembly line to the final customer.

2) *Telematics:* IoT-enabled devices mounted in cars gather information on engine performance, driving habits, and other important parameters. Vehicle maintenance, fuel efficiency, and route optimization can all benefit from this data. Telematics can also be used to promote safe driving habits and lessen vehicle wear and tear by tracking driving behavior.

C. *Robotics*

1) Automated Warehousing: Tasks like picking can be carried out by robots in automated warehouses. They are able to precisely and quickly remove particular products from storage shelves and get them ready for shipping. Order fulfilment can be much faster and more accurate because of automation, which also lessens the demand for human labor for monotonous jobs and decreases order processing errors.

2) *Autonomous Vehicles:* Autonomous vehicles, including autonomous forklifts or automated guided vehicles (AGV's), move goods around in warehouses and distribution centers with the least amount of human interference. By moving goods or parts inside a building, these vehicles can maximize material flow and lessen the need for human labor. This guarantees continuous and dependable transportation while increasing operational efficiency and lowering labor expenses.

VI. ANALYSIS

A. Inventory Management

In the automotive sector, AI holds immense potential for improving various aspects of inventory management. It can boost efficiency, decision making, and overall control of inventory.

1) Inventory Optimization: By utilizing a variety of parameters, AI continuously optimizes inventory to guarantee that proper number of components is available when needed, all the while lowering expenses and cutting down waste. It achieves all this by managing demand fluctuations, synchronizing production schedules, accounting all costs and aiming at reducing junk.

2) Cost Reduction: By optimizing inventory levels in real-time and ensuring that companies carry just what is required, AI in inventory management lowers carrying costs. It also helps reduce waste by preventing overstocking *and understocking through data analysis and demand trends, resulting in more economical and efficient inventory practices.

B. Demand and Supply Analysis

1) Demand Analysis

- *Market Segmentation:* AI systems examine large-scale databases that include consumer preferences, purchase patters, and demographic information. More accurate inventory management is made possible by this in-depth knowledge of customer demand, guaranteeing that proper cars and options are available when and where they are needed.
- *Predictive Analysis:* Businesses may forecast customer demand for particular car models, features, and choices by using Artificial Intelligence's predictive capabilities. This enables proactive modifications to production schedules and inventory levels, optimizing the supply chain to effectively meet consumer expectations.
- *Sentiment Analysis:* AI is able to analyze customer sentiments from social media and reviews, giving important information about customer trends and preferences. Product development and marketing tactics are informed by this data, which helps companies match customer sentiment with their offers.
- *Competitive Analysis:* AI gathers information about the goods, promotions, and prices of rival companies. Businesses can make wise decisions to maintain their competitiveness by utilizing analysis. In order to be flexible and competitive in the supply chain, they might modify their price, marketing, and inventory strategies in response to changes in market and the activities of their competitors.

2) Supply Analysis

- *Supply Chain Optimization:* AI leverages historical data and real-time information to optimize the supply chain. It ensures that the right parts and materials are available when needed, reducing process disruptions and minimizing lead times for delivery.
- *Predictive Maintenance:* AI-powered predictive systems keep an eye on the state of manufacturing machinery, seeing possible problems before they result in production errors. This proactive strategy reduces downtime and improves equipment reliability.

3) Market Equilibrium

By offering real-time insights on production capabilities, market circumstances, and inventory levels, artificial intelligence (AI) helps manufacturers and vendors to keep a healthy balance between supply and demand. This makes decision-making easier and helps avoid problems like overstocking, understocking, and overproduction.

- *Data Integration:* AI is capable of analyzing information from a variety of sources, such as market reports, social media, and sales data. With this thorough data analysis, organizations may gain a comprehensive understanding of the dynamics of supply and demand in the automotive industry, enabling them to make well-informed decisions.
- *Scenario Planning:* Advanced AI can evaluate various supply and demand scenarios by running simulations and scenario analyses. This capability assists businesses in making critical decisions by exploring different potential outcomes, ensuring a proactive and adaptive approach to supply chain management.

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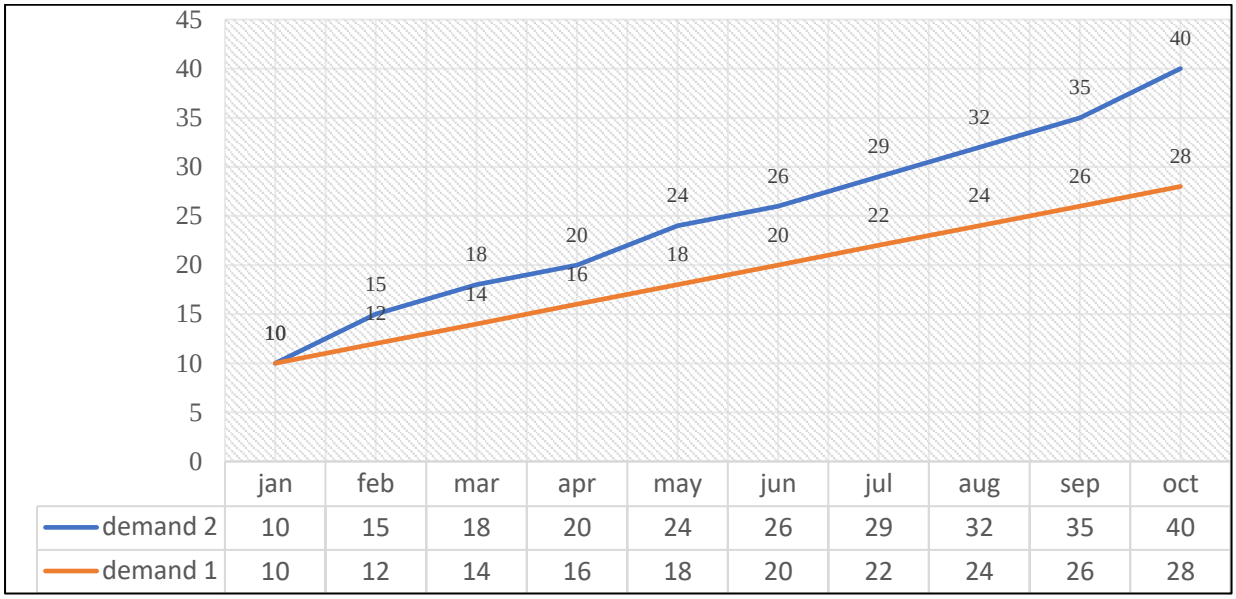

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct
demand 2	10	15	18	20	24	26	29	32	35	40
demand 1	10	12	14	16	18	20	22	24	26	28

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VII. USE CASES

USE CASE	DESCRIPTION	BENEFITS	EXAMPLES
1) Demand Forecasting	Guessing future demand for components and vehicles based on antique sales data, market trends, and economic indicators.	Reduces inventory costs, improves production planning, and optimizes resource allocation.	Toyota's AI-powered demand forecasting system accurately predicts demand for up to 6 months in advance, reducing the risk of stockouts or overstocking.
2) Inventory Optimization	Analysing real-time inventory levels, sales trends, and production schedules to determine the optimal inventory levels for each component and vehicle.	Reduces storage costs, prevents stockouts, and ensures timely delivery of parts and vehicles.	BMW's AI-powered inventory optimization system helps the company maintain optimal inventory levels for over 10,000 parts, reducing costs by 10%.
3) Production Planning and Scheduling	Optimizing production schedules to maximize efficiency and minimize disruptions.	Reduces production delays, improves plant utilization, and enhances customer satisfaction.	General Motors uses AI-powered production planning and scheduling tools to optimize its assembly lines, reducing production times by up to 20%.
4) Route Optimization	Optimizing delivery routes for trucks and vehicles to minimize travel time, fuel consumption, and traffic congestion.	Improves delivery efficiency and reduces transportation costs.	Daimler Trucks uses AI-powered route optimization to plan its delivery routes, reducing fuel consumption by up to 10%.
5) Predictive Maintenance	Predicting equipment failures before they occur, enabling proactive maintenance and preventing downtime.	Reduces equipment downtime, improves asset utilization, and enhances safety.	Tesla uses AI-powered predictive maintenance to monitor its manufacturing equipment, identifying potential issues and scheduling maintenance before they cause disruptions.
6) Quality Control	Automating quality inspection processes to ensure consistent quality and identify defects early on.	Reduces defects, improves product quality, and enhances customer satisfaction.	Ford uses AI-powered quality control systems to inspect vehicle components for defects, reducing the number of recalls by up to 20%.
7) Risk Management	Identifying and mitigating potential risks in the supply chain, such as natural disasters, labour strikes,	Improves supply chain resilience, reduces disruptions, and protects revenue.	Volkswagen uses AI-powered risk management tools to assess potential disruptions and develop

	and supply chain disruptions.		contingency plans, ensuring the continuity of its supply chain.

VIII. BENEFITS

[1] ***Better Productivity:***

- The automobile industry's productivity is greatly increased by supply chain management powered by AI. It is capable of automating data processing, regular chores, and decision-making procedures. Employees are free to concentrate on more important duties as a result of eliminating human error and the need for physical labor.
- By optimizing resource allocation and production schedules, AI-based demand forecasting reduces the likelihood of overproduction or underproduction. Predictive maintenance driven by AI guarantees that equipment runs well, reducing downtime. Higher overall productivity is the outcome in both production and logistics.

[2] ***Prognostic Conservation:***

- For the purpose of prognostic conservation, AI forecasts equipment breakdowns and maintenance requirements ahead of time. This method reduces the requirement for spare parts inventories and avoids expensive reactive maintenance, both of which waste resources.
- Predictive maintenance enabled by AI can keep an eye on the condition of vehicles and equipment. It guarantees resource efficiency and prevents needless expenditures on premature maintenance or part replacement by forecasting when particular parts need to be replaced or maintained.

[3] ***Shorter Delivery times and Improved Transportation:***

- AI algorithms consider real-time variables including traffic, weather, and delivery dates while optimizing transit routes. As a result, just-in-time delivery techniques are made possible by reduced delivery times and increased transportation efficiency.
- Automotive companies can cut down on vehicle and component delivery times by utilizing AI for route optimization. In addition to cutting down on transportation expenses, this minimizes the amount of time that inventory must be held in stock and guarantees that goods get at their destinations on time.

[4] ***Supply Chain Resilience:***

- By detecting and reducing risks, AI helps to strengthen supply chains. It helps businesses to keep things running smoothly, bounce back from unforeseen events more quickly, and adjust swiftly to disturbances.
- Ai is able to keep an eye on outside variables that could have an impact on the supply chain, such as the state of the weather, changes in politics, or economic indicators. AI can assist businesses in fast adapting to disruptions, locating substitute suppliers, and modifying logistics routes to keep parts and cars moving.

[5] ***Reduced Risks:***

- Supply chain risks can be decreased by AI-driven risk analysis and mitigation. AI can spot hiccups or weaknesses, giving businesses the opportunity to put plans in place to lessen the risks and improve supply chain dependability as a whole.
- AI can forecast possible supply chain interruptions caused by events like natural disasters or changes in the economy by analyzing past data and external factors. Subsequently, businesses can create backup plans and risk-reduction techniques to lessen the effects of unforeseen circumstances on their supply chain.

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IX. CHALLENGES

1) *Data Quality:*

- AI systems in Automobile supply chain rely heavily on accurate, consistent, and up-to-date data to make predictions, optimize processes and make informed decisions. Supply Chain's entire performance and competitiveness are strongly correlated with quality of its data since it makes better decisions, lowers the cost and gives high customer satisfaction
- *Maintaining the data may sometimes become challenging when-*

- The Automobile industry frequently works with large number of suppliers, each of whom has own standards, quality control procedures, and data formats, which may lead to mistakes and inconsistencies in data.
- Data gathering may be done from different regions, each with own legal framework, dialects, and techniques of gathering; which sometimes makes the process of integrating and standardizing data extremely difficult.
- It may be difficult to compile and analyze data because it can be in both structured and unstructured formats.
- Traditional data management systems may become overwhelmed by massive amount of data produced by contemporary supply chains, which could result in mistakes and inaccuracies.

2) *High Implementation Costs:*

- When it comes to creating and integrating AI solutions into current supply chain systems, high implementation costs are a major obstacle, especially in the automobile sector.
- *Cost of Infrastructure:* Supply Chain management AI implementation frequently requires installing new hardware and updating software infrastructure which includes specialized AI gear, cloud computing resources, GPUs, and high-performance servers.
- *Training and Skill development costs:* Workers must receive Ai technology training in order for them to use AI tools efficiently and comprehend how AI functions. The time that employees spend apart from their ongoing responsibilities is an additional expenditure associated with training programs and seminars.
- *Maintenance costs:* For AI systems to continue being secure and successful, they need to be constantly updated, maintained, and monitored. This continuous process that involves upgrading models, resolving software issues, and adjusting to shifting business requirements. It also comes with extra expenses for infrastructure and labor.

3) *Change Management:*

- A crucial component of implementing AI in SCM in the automotive sector is change management. It entails taking a calculated risk while switching from manual to AI driven systems.
- *Shift in Mindset and Organizational Culture:* An organization's thinking and culture must drastically shift in order to implement AI. Employee resistance to change may arise from the deeply ingrained nature of traditional manual procedures. This opposition may make it more difficult to successfully integrate AI.
- *Establishing Change Champions:* Finding organizational change advocates individuals who are passionate about implementing AI can aid in advancing the cultural transformation. During the shift, these champions can support and motivate their peers.
- *Continuous Learning and Feedback:* An adaptive change management strategy incorporates ongoing feedback and learning. Frequent evaluations and feedback loops can aid in problem identification, process improvement, and requirement adaption.

4) *Data Privacy and Security:*

- Considerations like as data security and privacy are crucial when using AI to SCM in the Automobile sector.
- *SCM Data Sensitivity:* Sensitive data of many kinds, such as supplier and customer information, manufacturing schedules, and transportation specifics, are gathered and handled in SCM.

Because this data may be proprietary and secret, hackers and security breaches may find it to be a lucrative target.

- *Data Breach Consequences:* Significant financial, legal, and reputational repercussions may result from data breaches, which includes the price of looking into the breach, alerting the parties that were impacted, filing lawsuits, and suffering a loss of revenue.
- *Protection of Intellectual Property:* Intellectual property, including design blueprints and exclusive technology, is a key asset in the automotive business. Unauthorized access to this data may result in theft and abuse of intellectual property.

X. ETHICAL AND ENVIRONMENTAL FACTORS

A. *Environmental Factors:*

- *Transparency and Accountability:* Ensuring that the operations of AI systems are transparent and that there's clear accountability for their decisions is paramount.
- *Human Oversight and Intervention:* While AI can automate many tasks, maintaining a mechanism for human oversight and intervention is essential for responsible decision-making.
- *Environmental Impact:* Considering the environmental implications of AI technologies, including energy consumption and resource usage, is a key aspect of ethical AI adoption.
- *Long-term Sustainability:* Evaluating the long-term impact of AI adoption on the industry, including factors like job displacement and economic disparities, is essential.
- *Ethical Procurement and Vendor Selection:* Carefully assessing the ethics of AI vendors and suppliers and ensuring they uphold responsible AI practices is a vital consideration.

B. *Ethical Factors:*

- *Energy Efficiency:* It is crucial to assess and enhance the energy efficiency of AI-powered systems utilized in the supply chain. Prioritize algorithms and hardware setups designed for optimal energy conservation.
- *Resource Conservation*: Mindful handling of resources, including the conscientious sourcing and judicious use of raw materials and critical components in AI hardware, contributes significantly to environmental sustainability.
- *Life Cycle Assessment:* Conduct a comprehensive evaluation of the complete life cycle of AI systems, encompassing production, operation, and decommissioning. This includes considerations such as transportation, maintenance, and environmentally responsible end-of-life practices.
- *Sustainable Data Centre Practices:* If applicable, opt for data centres and hosting providers that demonstrate a commitment to energy-efficient practices and reliance on renewable energy sources.
- *Green Computing Practices:* Employ techniques like server virtualization, cloud computing, and power management to optimize energy consumption during AI operations.
- *Regulatory Compliance*: Stay informed about environmental regulations and standards relevant to electronic waste management and energy efficiency. Ensure adherence at all stages of AI integration.

XI. FUTURE OUTLOOK

1. *Demand Forecasting:*

- To increase the accuracy of demand forecasting, AI systems can examine past data, current market conditions, and outside variables. Better inventory control is made possible by this, and the possibility of stockouts or overstock scenarios is decreased
- As an example, a automobile company uses AI algorithms to examine worldwide market trends, consumer preferences, and economic statistics. A spike in demand for electric cars is anticipated by the system due to new environmental rules. To accommodate the expected demand, the organization modifies supply chain logistics and production schedules.

2. *Predictive Maintenance:*

- AI-driven predictive maintenance can reduce downtime and increase overall equipment effectiveness (OEE) by helping to forsee equipment breakdowns in the manufacturing process. This is especially crucial in the automobile sector, where accuracy and dependability are essential.
- AI powered sensors are used in an automotive assemly line to track the health of robotic arms and other equipment. By analysing data in real-time and spotting patterns that could indicate future malfunctions, the AI system plans maintenance in advance. This guarantees that machinery runs as efficiently as possible, reducing interruptions to the production process.

3. Blockchain for Transparency:

- Supply chain transparency and traceability can be improved by combining blockchain technology and AI. This is especially helpful for confirming part authenticity and guaranteeing adherence to industry requirements.
- An example of a blockchain-based supply chain system with AI integration being used by an automobile manufacturing. The AI follows every component from suppliers to the assembly line by continuously analysing data on the blockchain. The system automatically initiates notifications in the event that any deviation from quality criteria is found, allowing for prompt remidial action.

4. Autonomous Vehicles in Logistics:

- Drones and AI-powered autonomous cars have the potential to completely transform automotive logistics. They can improve overall transportation efficiency, shorten delivery times, and optimise delivery routes.
- An automobile manufacturer uses self-driving delivery trucks with AI navigation systems. These vehicles move parts autonomously from suppliers to manufacturing facilities by using real-time traffic data, weather reports, and optimal route algorithms. This decreases operating costs, shortens delivery times, and lessens the possibility of transportation-related human mistake.

5. Human-Machine Collaboration:

- To increase productivity and safety on the manufacturing floor, human-AI machine cooperation will develop. AI systems will get more versatile, supporting people in difficult jobs and guaranteeing a smooth communication between humans and machines
- Robotic arms driven by AI are used by employees in an automotive manufacturing facility to collaborate. AI technologies monitor human motion and modify the robotic arms' movements accordingly. AI continuously learns and adjusts to changes in manufacturing requirements, ensuring accuracy and safety. The outcome is a production process that is more adaptable and efficiently.

XII. CONCLUSION

The use of Artificial Intelligence (AI) into supply chain management in the automotive sector represents a paradigm change characterized by notable progress and an expanding corpus of literature. A thorough grasp of AI's influence on the automotive supply chain is provided by the mixed methods research technique, while the literature analysis concentrates on important studies that illustrate AI's significance in this regard. Comparative analysis shows how AI has significantly improved a number of measures, highlighting its potential to completely transform sustainability and efficiency.

AI technologies, such as robotics, IoT, and machine learning, have a wide range of applications in supply chain management, from quality control to demand forecasting. AI's adaptability in risk management, inventory optimization, and demand forecasting is demonstrated by real-world use cases. Adoption of AI will raise supply chain resilience, productivity, and transportation efficiency, all of which will improve operational effectiveness and environmental sustainability.

Notwithstanding these benefits, there are still issues that need to be resolved, including data security and privacy, implementation costs, and change management. Responsible AI adoption is emphasized by ethical and environmental factors, which place a strong emphasis on openness, responsibility, human oversight, energy efficiency, and resource conservation.

Demand forecasting, predictive maintenance, blockchain-AI integration for transparency, autonomous cars in logistics, and improved human-machine collaboration are all expected to continue to progress in the years to come. The incorporation of AI in the automotive supply chain is a paradigm-shifting move, but it also comes with problems that must be overcome and sustainable, ethical norms must be upheld.

XIII.REFERENCES

[1] https://www.supplychainconnect.com/supply-chain-technology/article/21266750/future-market-insights-the-role-of-ai-in-the-automotive-market
[2] https://www.supplychainbrain.com/blogs/1-think-tank/post/34419-ai-the-future-of-automotive-manufacturing
[3] https://www.bairesdev.com/blog/ai-in-supply-chain/
[4] https://peak.ai/hub/blog/solving-automotive-supply-chain-challenges-with-ai/
[5] Abid Haleem a , Mohd Javaid b,*,1 , Mohd Asim Qadri c , Ravi Pratap Singh d , Rajiv Sumane. Artificial intelligence (AI) applications for marketing: A literature-based study. International Journal of Intelligent Networks. Received 25 July 2022, Revised 21 August 2022, Accepted 23 August 2022, Available online 5 September 2022, Version of Record 7 September 2022.
[6] Xi, Yingrui, "Values of artificial intelligence in marketing" (2020). Masters Theses. 8010.
[7] Dr. Shivani Kapoor1 ,Dr.Ruchika Rastogi2, Dr. Alok Kumar3, The Role of Artificial Intelligence in Managing Supply Chain Risks occurred due to Covid-19 pandemic in Automobile industry. Eur. Chem. Bull. 2023,12(Special Issue 4), 1518-1536
[8] Reza Toorajipour a , Vahid Sohrabpour b,c , Ali Nazarpour d , Pejvak Oghazi e,* , Maria Fisch. Artificial intelligence in supply chain management: A systematic literature review. Journal of Business Research Available online 25 September 2020 0148-2963/© 2020 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY license.
[9] Christine Kinsey. Artificial Intelligence and the Future of Supply Chain Management. Spring 5-2-2019 Honors Projects. 473.
[10] Baha M. Mohsen. Impact of Artificial Intelligence on Supply Chain Management Performance. Journal of Service Science and Management, 2023, 16, 44-58
[11] Abedinnia, H., Glock, C. H., Grosse, E. H., & Schneider, M. (2017). Machine Scheduling Problems in Production: A Tertiary Study. Computers & Industrial Engineering, 111, 403-416. https://doi.org/10.1016/j.cie.2017.06.026
[12] Awuzie, B., & McDermott, P. (2017). An Abductive Approach to Qualitative Built Environment Research. Qualitative Research Journal, 17, 356-372. https://doi.org/10.1108/QRJ-08-2016-0048
[13] Barták, R., Salido, M. A., & Rossi, F. (2010). Constraint Satisfaction Techniques in Planning and Scheduling. Journal of Intelligent Manufacturing, 21, 5-15.
[14] Pomerleau, D.A., 1993. Neural network perception for mobile robot guidance. Dordrecht, The Netherlands: Kluwer. Potvin, J., Dube, D., and Robillard, C., 1996. A hybrid approach to vehicle routing using neural networks and genetic algorithms. Applied Intelligence, 6, 241–252. Rao, R.V., 2007.
[15] Vendor selection in a supply chain using analytic hierarchy process and genetic algorithm methods. International Journal of Services and Operations Management, 3 (3), 355–369. Ratner, B., 2000.
[16] A comparison of two popular machine learning methods. DM STAT-1 – Online Newsletter about Quantitative Methods in Direct Marketing, 4. Reis, B.Y., 1999.
[17] A multi-agent system for on-line modeling, parsing and prediction of discrete time series data. In: M. Mohammadian, ed. Computational intelligence for modeling, control and automation. Amsterdam, The Netherlands: IOS Press. Rohde, J., 2004.

[18] Hierarchical supply chain planning using artificial neural networks to anticipate base-level outcomes. OR Spectrum, 26, 471–492. Russell, S. and Norvig, P., 1995.
[19] Artificial intelligence: a modern approach. Upper Saddle River, NJ: Prentice-Hall. Sadeh, N.M., et al., 2001. MASCOT: an agent-based architecture for dynamic supply chain creation and coordination in the Internet economy. Production Planning and Control, 12 (3), 212–223. Samuel, A.L., 1995. Some studies in machine learning using the game of checkers. In: G. F. Luger, ed. Computation and intelligence: collected readings. Menlo Park, CA: AAAI Press/The MIT Press
[20] The Seven Functions of Marketing with Examples. (n.d.). Retrieved from https://jgdb.com/business/marketing/marketing-function/the-seven-functions-ofmarketing-with-examples. 50. Tjepkema, L. (2019, July 2). What Is Artificial Intelligence Marketing? Retrieved from https://www.emarsys.com/resources/blog/artificial-intelligence-marketingsolutions/. 51.
[21] Turban E., Outland J., King D., Lee J.K., Liang TP., Turban D.C. (2018) Intelligent (Smart) E-Commerce. Electronic Commerce 2018. Springer Texts in Business and Economics. Springer, Cham 52. Vieira, A., &
[22] Sehgal, A. (2017). How Banks Can Better Serve Their Customers Through Artificial Techniques. Digital Marketplaces Unleashed, 311–326.The number of selective AI implementations (at multiple sites in an organization, but not at enterprise scale) has not moved significantly, standing at 24% today (January 2019) versus 2017’s 27%. CAPGEMINI