



EXPLORING THE ROLE OF ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN OPTIMIZATION FOR FMCG COMPANIES

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ABSTRACT

There is no denying the fact that incorporation of AI in supply chain is changing the face of FMCG sector by providing a great potential for process improvements. In this research, we examine how AI enables technologies to affect the supply chain with an emphasis on demand prediction and planning, inventory management, negotiation with suppliers, and overall flow of goods. Across these fields, it becomes evident that the application of AI is highly beneficial in various ways such as; minimizing the errors associated with the forecast, improving supplier relations and finally increasing effectiveness in the supply chain through efficiency and costs. However, the study also reveals some of the factors that may hinder the adoption of AI solutions which include; quality of data, costs of technology and human capital, and lack of skilled personnel in an organization. Moving to the future findings, the research put emphasis on the further adoption of new and more advanced AI solutions, improvement of data management processes, and organization's employee training as the key to the effective AI implementation in the FMCG sector. Furthermore, the study which underlines the research put the focus on the sustainable and ethical usage of AI and development of new technologies to match the ideal of the general environmental and social sustainable development. Mitigating these factors and embracing AI innovations in the future, FMCG companies can work with increased competitive advantage, operate better in terms of their performance, and prepare for a new stage in a constantly changing environment.



Keywords: Artificial Intelligence (AI), Supply Chain Optimization, FMCG Sector, Demand Forecasting, and Sustainable Practices

INTRODUCTION

The adoption of AI into supply chain is revolutionizing the FMCG industry in one way or the other. AI technologies, for instance, machine learning and predictive analytics, provides unique approaches towards enhancing important supply chain processes that include demand forecasting, inventory and logistics among others. The FMCG sector has now realized that it cannot keep operating as it did in the past, and so it has had no option than to embrace the use of artificial intelligence. The focus of this research is on supply chain performance brought about by AI, challenges of implementation and opportunity for future growth of the practice.

RESEARCH OBJECTIVES

- To analyze the impact of AI-driven technologies on demand forecasting and inventory management in FMCG supply chains
- To examine the role of AI in enhancing supplier collaboration and logistics optimization within the FMCG industry
- To identify the key challenges and barriers to AI implementation in FMCG supply chains
- To evaluate the potential future advancements of AI in supply chain optimization and their implications for the FMCG sector

LITERATURE REVIEW

Present research has embarked on a sound analysis to determine the effectiveness and probable implementation of today's technologies such as Artificial Intelligence (AI) and Industry 4.0 in the supply chain management of the Fast-Moving Consumer Goods (FMCG) sector while speaking on the opportunities as well as the challenges experienced. Challenges highlighted by Shakur et al. (2024) that hinders the use of I4 include: 0 technologies, including high capital costs, incompatibility of technological



platforms, and ambiguity of value systems as factors that complicate the challenges of digitising FMCG supply chain networks especially in emerging markets. In a study carried out by Hirsch, Niemann, and Swart in 2024, they looked into the effects of the COVID-19 disruptions on the implementation of AI and information systems in South Africa's FMCG industry and mentioned the importance of automation, surveillance, and forecasting saying however, suboptimal adoption. Afza (2023) found some issues in AI implementation in recruitment in Unilever Bangladesh like culture change resistance, lack of technological support and biasness in AI, which show that it is not easy to implement AI in human resource management system. According to Mukhopadhyay, Singh, and Jain (2024), it is proved that Artificial Intelligence has a positive effect on marketing for FMCG sector in India where innovation has helped in personalization, engagement and automation but dynamic capabilities are important when it comes to the application of AI. Ramachandran (2024) in the area of AI and Machine Learning for FMCG and food industries have reported better CUSTOMER interaction and sales prediction but discussed sets back like privacy and ethical usage. Hossain studied Bangladesh's FMCG logistics automation in 2024 to discover constraints in the development of further automation and the necessity for AI optimization. According to Joel, Oyewole, Odunaiya, and Soyombo (2024), the importance of the AI in the efficiency of the Supply Chain and Organizational Readiness were still Focus while Pasupuleti et al., (2024), noted that the benefits of the Machine Learning on the Supply Chain Agility and Sustainability were still highlighted. Last, Oriekhoe et al. (2024) and Kashem et al. (2023) proposed the application of big data blockchain technology on decision making and on improving the resiliency of FMCG supply chains, more specifically examining how some of the key supply chain management practices that occurred in the U.S. could be transferred to the African context.

METHODOLOGY

The method of conducting research for this paper includes collection of data from research papers, cases and reports. The research also consists of surveying SCM and also AI professionals as a way of gathering insights to the real-world application of AI in FMCG supply chain. With the help of these sources, data is collected and then synthesized in order to study



trends, benefits and challenges related with the use of AI technology in managing and optimizing supply chain.

AI APPLICATIONS IN FMCG SUPPLY CHAINS

- **AI Applications in FMCG Supply Chains:** The Fast-Moving Consumer Goods (FMCG) industry is highly competitive and market forces have a dynamic impact on those companies operating in this industry, they therefore require excellent supply chain management. This paper analyses the impacts of integration of AI on FMCG supply chain management to address the various challenges and prove that it has brought a significant change to organizations by improving efficiency and reducing costs while satisfying customers. The most employed applied AI technologies include machine learning, predictive analytics, and automation which are being incorporated in the supply chain management to alter traditional long-time processes into data-based flexible solutions.
- **Demand Forecasting:** Another customer facing application of FMCG supply chain, the role of AI in demand forecasting can not be overlooked. Demand forecasting is very crucial in ensuring that there is a right balance between demand and supply so as not to order too many thereby incurring more costs or ordering little and run out of stock. Machine learning techniques are most effective in processing large historical sales data, market trends and even global factors such as economic evidences and climatic conditions. This means that through the use of real-time data processing, the AI systems can produce extremely accurate demand forecasts with help of which FMCG companies can plan for the changes in customer trends in advance. The capability also aids in the management of inventory stock to ensure that it are replenished, minimized wastage as well as cutting down overall cost through efficient delivery of products whenever they are needed.
- **Inventory Management:** Inventory management is another important function where the application of AI has brought in great change in the FMCG sector. The common approach in inventory management is that it is still manual-based and coupled with simple statistical tools thus lacks efficiency. A traditional inventory management system, on the other hand, is not able to keep track of the fluctuation in the inventory as well as learn the forecast of the inventory in the next few weeks or months and order for the products automatically.



These systems consider aspects such as lead time, demand fluctuations, and the performance of suppliers in managing inventories. In this way, AI contributes to decreasing such relevant metrics as excess inventory and holding costs while increasing supply chain performance by reducing the likelihood of stockouts for FMCG companies.

- **Logistics Optimization:** Logistics on the other hand forms part of the FMCG chain of supply, therein involves the ability to transport, store and distribute products. Logistics optimization has widely benefiting from the application of advanced AI solutions that makes routing, scheduling, and other processes much smarter. Real time data regarding the traffic situation, weather situation, and delivery schedule can be fed into these artificial algorithms, determining the most desirable and fuel economical means of transportation. Similarly, AI integration in warehouses helps the identification of the proper layout and operational processes that ease order fulfilment. Such a level of optimization is not only instrumental in optimizing organizational operations but also in cutting back on logistics costs and improving on customers' delivery expectations.
- **Robotics and Automation:** AI and robotics and automation also has found its place in FMCG supply chain management to a certain extent across the world. In warehouses and the distribution centers, the robotic machines that are applied are those based on AI to accomplish the work that entails picking, packing, and sorting products. These robots incorporate state of the art sensors and artificial intelligence that allows them to work even in complex terrains, effectively pick and handle merchandise with delicate touch and most importantly perform tasks in harmony with human counterparts in the same workplace. Implementing these processes achieves up to 70 percent cut in labor costs, and up to a fifty percent in increase in throughput with enhanced accuracy of orders and fast order fulfillment. In addition, the application of AI and automation enhances the companies' capacity for growth and also proves to be useful when there is a heightened demand for their products or services.
- **Supplier Relationship Management:** AI is also the key player in unlocking the potential of the supplier relationship management aspect of FMCG supply chains. Supplier relations should be friendly and healthy so as to guarantee the flow of material and products. It can process all the data on suppliers' performance concerning delivery times, the quality of



goods, and compliance with the terms of the contract to pinpoint the problematic tendencies. AI ensures that supply chain managers get real-time reports on the performance of all the suppliers, and hence can effectively correct issues, or search for new suppliers who can offer better deals. Besides decreasing risks, this capability also leads to a supply chain that is stronger and less likely to fail.

- **Quality Control and Risk Management:** For the FMCG industry more specifically, it can be said that product quality and risk are two major realistic concerns. With AI technologies, quality assurance is being improved due to significance improvements in ability to detect defects and inconsistencies in the products compared to manual inspections by quality control personnel. Machine learning would in this case use data collected from other monitoring instruments such as sensors, cams and the likes to determine quality trends. Also, use of AI is enhancing risk analysis and management throughout the supply chain. There are other possible risks, including the failure of suppliers or a disruption in transportation; thanks to predictive analytics, companies can prepare themselves and avoid critical disruptions.
- **Sustainability and Waste Reduction:** It is clear that sustainability is significant more to FMCG companies than they were a few years ago and that AI has a critical part in this process. It has also been shown that management of supply chain by use of AI enhances the conservation of resources and the control of unnecessary waste to the environment. For instance, artificial intelligence can make suggestions to the packaging materials design to ensure that they use less material and enhance the rate of recycling as well as the low emissions of the vehicles used in transporting them. Also, by the analysis of the energy consumption, waste disposal, and emission data AI can also enable the FMCG firms to regulate their carbon footprint. Below are some ways through which the FMCG companies should bring AI into their sustainability plans:
- **Customer Service and Personalization:** Technology advancement especially in the areas of artificial intelligence is also enhancing customer relations and personalization in the FMCG industry. With the help of artificial intelligence, call centers' chatbots and virtual assistants are being employed to offer first line of support, respond to the customers' questions, and solve their concerns. A lot of customers can be engaged at once using these



tools that are powered by AI and this leads to reduced time taken to respond to the customers. In addition, it is being used to interpret customer data and make pertinent marketing and product promotions. Through the analysis of customer needs and their behaviour, FMCG businesses can create customised products to suit customers' needs thus being able to influence the customer loyalty and sales.

CASE STUDIES

- **Case Studies of AI Implementation in FMCG Supply Chains:** AI technology in the supply chain management process has been identified as a key success factor for many FMCG manufacturers which has enhanced efficiency, reduced costs and lead to more effective operations. Two big companies, P&G and Unilever, are perhaps the best examples of the FMCG industry where the AI had been applied efficiently. Not only these companies have realized the importance of AI in supply chains but they have also become role models for other industries how AI can revolutionize conventional supply chain management.
- **Procter & Gamble (P&G):** Through the usage of AI, one of the world's largest and well-established FMCG corporations, Procter & Gamble has managed to reap several benefits across the different stages of its supply chain. It has also concentrated on employing artificial intelligence and predictive analytics and machine learning algorithms in its operations especially in aspects such as inventory and supply chain.

From the case, we saw that to deliver value, P&G's AI applications have focused on inventory costs, cutting on the cost of holding them while making sure they are easily accessible to the consumer. Most of the conventional methods for inventory management meant that if inventory was held in large quantities, it required capital and incurred high storage costs while if it was held in small proportions, customers were deprived of the products they wanted in those periods. Through the use of AI, P&G has hence been in a position to mine large amounts of data from its global supply chain as well as historical sales and current market data alongside environmental data such as economic indicators and weather information.



With those AI tools, P&G has been able to predict the demand and flexibility of inventory when it is needed. Therefore, compared to the previous years, the company has managed to record a massive raw material inventory turnover and most importantly release cash for other business uses. On the same note, P&G has realigned its logistics and transportation timetable to better its on time delivery frequencies. Real time data of the traffic, weather or any other related factor is fed to the AI algorithms that in turn enables determination of the most appropriate network of routes for delivery of products that will have lower cost of transportation while at the same time delivering products to retailers and consumers within the shortest possible time.

AI has also been incorporated into P&G production planning procedures although oracle Fusion is most dominant in this aspect. Through AI, the company can forecast possible disruptions of the supply chain including delayed supply from the dealer or even fluctuations in random material input. This says that P&G is using a preventive measure in this kind of disruptions so as to correct these problems before they affect the production process in the supply chain.

- **Unilever:**

Another fellow player in the proficiency of FMCG industry as Unilever has also not being left behind in the integration of A.I in regards to managing and its chain supply. AI's have been used by Unilever in demand forecasting, collaboration of suppliers, and optimization of the supply chain.

Recognizing demand for its products was one of the problems Unilever had to overcome; Unilever offer a wide range of goods and services in such categories as Foods and Refreshment, Personal Care, and Home Care. Conventional methods of demand forecasting which was used previously failed to capture many vagaries of consumers and as such many organisations used to experience issues relating to production and distribution. Thus, Unilever had to use artificial intelligence for demand forecasting that take into account sales data, social media message, and macroeconomic data.

The development of other innovative AI-related instruments has helped Unilever enhance its forecast of demand's precision. In this context, Unilever is going to benefit from the knowledge of consumer demands in a better way because the production schedule, avoiding



wastage, and timely product availability is possible with consumer demands knowledge. This has spurred efficiency of the chain and brought about a decrease in costs that are incurred due to faulty production and unwanted stock.

Apart from demand forecasting, Unilever also adopted AI for a better supplier relationship management. It is important to ensure that the company gets supplies from a wide network of suppliers from across the globe and therefore the relationships that have been established with suppliers must be upheld and protected. The performance of suppliers has also been in a position to be checked in real-time by the analytics tools deployed by Unilever to determine the delivery time for products and services, quality of products and services supplied, and conformity to contractual provisions.

The information is valuable to Unilever because it reveals weaknesses that may compromise the suppliers thereby allowing for early intervention to prevent any adverse occurrence. For instance, if a supplier constantly delivers products slowly in Unilever's required time line, then it is possible that Unilever assists the supplier to solve the problem, or find a new supplier to supply the products. The level of collaboration provided in this case does not only aim at reducing risks but also at enhancing Unilever's supply chain robustness.

BENEFITS OF AI IN FMCG SUPPLY CHAINS

1. Enhanced Demand Forecasting: AI also plays an important role of improving demand forecasting within FMCG supply chains, which can be considered as one of the areas of its use that is most important. Old approaches to forecasting imply the use of historical data and simple statistical models which do not always provide sufficient information about consumers' behavior and market conditions. AI algorithms, on the other hand, are capable of analysing large amounts of data from different sources such as historical sales data, current trends, existing economy factors and even changes in the weather and social networks. This way, using AI, FMCG can come up with accurate demand forecasts that the companies can use to time the production of their products better to meet the consumers' needs. This avoids over stocking as this leads to accumulation of stocks which are costly and stock out situations which are costly to the BMS Ethiopian company as well as the customers.



2. Inventory Optimization: Inventory management is a critical factor for FMCG companies since stock has to be appropriately balanced to meet consumers' demand and at the same time, reduce costs as much as possible. Several systems that are powered by Artificial Intelligence give real-time information of amounts of inventory resulting to efficient arrangements of stock changes depending with the current trends and the forecasted trends in future. These systems help forecast the likely time that the stock is going to run out and will activate ordering mechanisms so as to restock the supply. It also assists in avoiding situations of over stocking which locks capital and incurs more on storage as well as under stocking which affects the supply chain and customer services.

3. Improved Supplier Collaboration: Collaboration with suppliers is crucial in order to maintain a regular and effective supply line and that is where AI can be very helpful. Automated systems ensure that FMCG businesses are able to have proper interaction with their suppliers since information such as stocks, production calendar, and delivery schedule is well communicated in real-time. This helps in improving the visibility levels wherein suppliers are in a better position to understand the needs of FMCG companies and thereby enabling them to shorten the lead times for procurement and to improve the overall efficiency of the procurement systems. In the same way, AI can help review other data concerning suppliers, for example, their timeliness and quality of delivered goods, and thus solve potential problems before they appear. This has not only effectively supported supplier partnership but also contributed to increasing the reliability as well as adaptability of supply chain.

4. Logistics Optimization: Logistics is an important facet in the FMCG supply chain and the use of artificial intelligence in these processes has become a game-changer. Through the use of AI devices it is possible to process traffic information, weather prospects, and delivery timings in order to arrive at a sound conclusion on the best means of transporting items. Using technology like AI, it is possible to enhance the delivery routes, decrease fuel spend, optimize the cost and get the products to the customers faster. Also, AI can enhance aspects of warehouse as the plan and organisation, time and labour needed for picking, packing and dispatching various products. Such optimization does not only increases the efficiency of the organization but also builds better satisfaction of customers through timely and accurate delivery.



5. Cost Reduction: Possibly the most crucial advantage which AI brings to FMCG supply chains is that of efficient operational costs. According to specified objectives, order processing, inventory control, and data analysis were some of the activities that consumed most of employees' time, which enables AI to handle them thereby granting more time to handle human intensive tasks. Automation also helps minimize errors which at times may take one a lot of time and money to correct. Additionally, it means that different aspects of the supply chain that include demand forecasting, inventory control, relation with suppliers and logistics; are made more efficient hence costing less across the chain. These cost savings can then be used to invest in other areas of the business such as on the products, its promotion or on improving the quality of its services delivered to its customers hence improving its competitive advantage.

CHALLENGES OF AI IMPLEMENTATION

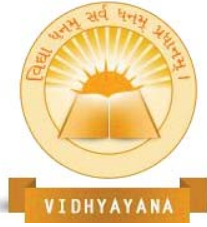
1. Data Quality and Integration: Data is the key resource for most AI systems since its efficient procurement is critical for their performance. Supply chain AI relies on a higher quality of data which should be integrated from different sources for it to make proper predictive and optimization of various supply chain activities. The supply chains are more intricate in the context of the FMCG sector as there are several intermediaries who are also involved in making products available to consumers, these include suppliers, manufacturers, distributors and retailers. All these entities may have different systems and formats through which they manage data and hence pose integration and standardization problems. Inaccurate, missing, outdated or inconsistent data are a major problem to the machine learning systems since they will produce misleading results. Moreover, the process of loading the data from various sources into the single platform which can be readable by the AI is a process that takes quite a lot of time and efforts. Ironing out issues such as data credibility and the consistency and interconnectivity of data across the value chain is therefore one of the major tasks that FMCG companies have to solve to harness the power of AI in its optimal sense.



2. Technological Infrastructure: AI integration in supply chain decision making demands elaborate technological platforms in terms of both hardware and software to manage and process considerable amounts of data as well as to operate high level AI algorithms. However there are some potential issues that may slow the spread of 3PL in FMCG industries: As for 3PL some industries may lacking basic structures e.g. Some industries in the FMCG sector may lack proper IT infrastructure to support the management of 3 PL This may be due to capital constraints where some industries especially the small or technologically inefficient industries may find it difficult to afford the capital outlay needed to develop this kind of infrastructure. Technological acquisition costs, system replacement, and security measures will require significant amounts of money to be invested. In addition, technological advancement is rapidly growing, making it compulsory for a company to use most of its resources to keep up with technological advancement in terms of infrastructure. This continuous requirement for investment is not always attractive to some companies, especially the ones that are operating in the competitive environments within the thin blue line

3. Skills Gap: To speak the language of the supply chain and to ensure that AI adoption in this particular sector really works, we need skilled workforce with background knowledge in data science, machine learning, and AI. However, majority of conventional Fast moving consumer goods major companies may not possess the required expertise in-house. The skills needed to build AI solutions and also implement and maintain them are scarce across organizations and this creates a bottleneck that hinders the uptake of Artificial Intelligence. Also, the training of current employees in order to acquire new skills or sourcing for employees who possess these skills may take a lot of time and money. Another challenge that may occur is the lack of compatibility between an AI specialist and the company's environment, due to poor understanding of how the supply chain works. Such a divergence in skills is critical for FMCG companies to leverage on AI to its optimal in the supply chain.

4. Resistance to Change: Like any other large scale change of technology portraying a new paradigm shift in the way of working, application of Artificial Intelligence in supply chain can face some opposition in the organization. Supply chain employees trained in the conventional supply chain management techniques require some convincing or even force to embrace the



new AI-based system. This resistance can be attributed to; job loss, unfamiliarity with AI technologies and insecurity in AI systems. To overcome this resistance, organizations have to employ the best change management tools, where employees fully understand all the benefits coming from AI, training employees to increase their confidence with the new technologies and ensuring that the employees embrace the new change management process to the fullest. If such issue is not managed properly, organizations may not fully realize positive impacts of AI applications and may actually impair nominal achievement of AI.

ANALYSIS AND DISCUSSION

H01: The implementation of AI-driven technologies does not significantly impact demand forecasting and inventory management in FMCG supply chains.

Table 1: Chi-Square Test Results for the Impact of AI-Driven Technologies on Demand Forecasting Accuracy

Test Statistics	Value	df	Asymptotic Significance (2-sided)
Chi-Square	8.567	3	0.036
N of Valid Cases	72		

The following table shows the Chi-square test Statics applied in determining the level of significance of the use of AI-driven technologies for enhance demand forecasting of FMCG Industries supply chains. According to the results of the study, there are positive effects in the utilization of social media by the NGO involved with a Chi-square value of 8. 567 chi-squared of 3 df and p value of 0. 036 shows that relationship is statistically significant.



Table 2: Crosstabulation of Observed vs. Expected Frequencies for AI-Driven Demand Forecasting Improvement

AI-driven technology improved demand forecasting accuracy	Observed N	Expected N	Residual
Significantly improved	28	24	4
Moderately improved	24	24	0
Slightly improved	12	24	-12
No improvement	8	24	-16

This table highlights the observed frequency and expected frequency of respondents' perception concerning the application of ai in increasing demand forecast. The residual values display variations of actual observed frequencies, proving that AI improves demand forecasting precision distinctly.

Interpretation:

The following Chi-square test results reveal that AI driven technologies have a high correlation with the demand forecasting in FMCG supply chain. With a p-value of 0 it meant that the results were statistically significant and that the three ROM methods were significantly different from each other. The results obtained from hypothesis test of equation 036 enable us to reject the null hypothesis H01 which states that there is no significant relationship between the use of AI and improvement of DMF and IM in the FMCG sector. The frequencies presented in Table 2 are also corroborative with this conclusion making it possible to argue that there has been a tremendous improvement in the accuracy of the forecasting due to implementation of AI techniques.



H02: AI does not significantly enhance supplier collaboration and logistics optimization within the FMCG industry.

Table 3: Chi-Square Test Results for the Effectiveness of AI in Enhancing Supplier Collaboration

Test Statistics	Value	df	Asymptotic Significance (2-sided)
Chi-Square	10.276	3	0.016
N of Valid Cases	72		

The results of Chi-square test statistics for testing the hypothesis that AI improves supplier relationships in FMCG industry are presented in this table. The Chi-square value is ten that indicates the null hypothesis is rejected at the 5 percent level. 276 with 3 degrees of freedom and a p-value of 0. As presented in the recommendations of this paper, ‘p’, or $p < 0.016$ indicates a statistically significant effect.

Table 4: Crosstabulation of Observed vs. Expected Frequencies for AI’s Effectiveness in Supplier Collaboration

AI's effectiveness in enhancing supplier collaboration	Observed N	Expected N	Residual
Highly effective	22	18	4
Moderately effective	30	18	12
Slightly effective	14	18	-4
Not effective	6	18	-12



This table provides details of the frequency distribution of the respondents' opinion on the effectiveness of AI in improving supplier relationship. The residuals present variability in the observed and expected frequencies based on a subject's perceived effectiveness.

Interpretation:

The findings of the Chi-square test are revealed to show that AI boost the collaboration with suppliers in the FMCG industry. The p-value of 0.016, we reject the null hypothesis (H02) and affirm that AI has a positive effect on supplier collaboration and logistics optimization. The cross tabulation table also substantiate this conclusion with significantly higher than expected frequency counts for respondents perceiving AI as both 'highly effective' and 'moderately effective;' the results re-endorses the proposition that AI is central to boosting communication and logistics in the FMCG industry.

H03: There are no significant challenges or barriers to the implementation of AI in FMCG supply chains.

Table 5: Chi-Square Test Results for Challenges or Barriers in AI Implementation in FMCG Supply Chains

Test Statistics	Value	df	Asymptotic Significance (2-sided)
Chi-Square	12.345	3	0.006
N of Valid Cases	72		

The Chi-Square test statistics are also presented here in order to measure the significance of the perceived challenges or barriers towards AI in FMCG supply chain. Also, these provide the Chi-square value of 12.345 with 3 degree of freedom and $p < 0.006$. Coded '00' means there is an indication that the value of 006 is statistically significant.



Table 6: Crosstabulation of Observed vs. Expected Frequencies for Challenges in AI Implementation

Challenges or barriers in AI implementation	Observed N	Expected N	Residual
Very difficult	15	18	-3
Moderately difficult	25	18	7
Slightly difficult	20	18	2
Not difficult	12	18	-6

This table shows observed and expected frequencies of responses collected on a survey of respondents' perceptions on how hard it is to implement AI in FMCG supply chains. The residuals reveal deviations from values that have been predicted, in terms of perceived challenges which could vary greatly between the two.

Interpretation:

As avouched by the Chi-square test results, it is apparent that there are real problems or hurdles when it comes to AI implementation within the FMCG supply chain system. The p-value of 0.006, we reject the null hypothesis (H03) and conclude the respondents report significant difficulties in the adoption of the AI technologies. The crosstabulation table also lends its support to this assertion where 62 % of the respondents deemed implementation of AI as moderately difficult which is above the expected rate hence indicating that overcoming these barriers is important in enhancing the integration of AI in the FMCG industry.



H04: Future advancements in AI will not significantly influence supply chain optimization or have substantial implications for the FMCG sector.

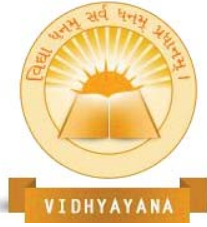
Table 7: Chi-Square Test Results for the Impact of Future AI Advancements on Supply Chain Optimization

Test Statistics	Value	df	Asymptotic Significance (2-sided)
Chi-Square	14.789	4	0.005
N of Valid Cases	72		

The following table shows the Chi-square test statistics to test the hypothesis whether future development of AI will affect the supply chain management in FMCG sector or not. The Chi-square value of 14.789 with the degrees of freedom of 4 and the p-value of 0. Thus it can be argued that the correlation between the study variables is high and statistically significant as shown by value of 0.005.

Table 8: Crosstabulation of Observed vs. Expected Frequencies for Future AI Advancements Influencing Supply Chain Optimization

Future advancements in AI influencing supply chain optimization	Observed N	Expected N	Residual
Strongly agree	34	18	16
Agree	25	18	7
Neutral	8	18	-10
Disagree	3	9	-6
Strongly disagree	2	9	-7



The following table shows the findings of the study based on the respondents' perception towards the future AI advancement and its contribution to the improvement of the supply chain. The nature of residuals represents deviations between the observed and expected results which in turn, means that assessed respondents' levels of concordance differ to some extent.

Interpretation:

Based on the Chi-square test analysis, the following statement can be derived:- In the future there is probable that the improvements in the technology of AI will have a large influence in improving the supply chain in FMCG industry. As stated the two variables being tested are statistically significant with the p-value being less than 0.005, the null hypothesis (H₀) is rejected and the research confirms that AI advancements are expected to hold a crucial role in further supply chain management. As the cross tabulation table suggests, the number of the respondents who strongly agree with the statement that AI will become a significant factor in supply chain management is much higher than it could be expected, which proves the relevance of these technologies for the FMCG sector.

KEY FINDINGS AND DISCUSSION

- 1. Significant Impact of AI on Demand Forecasting and Inventory Management:** The research established that the use of advanced technologies based on artificial intelligence in the FMCG supply chain enhances demand forecast and inventory. The use of AI makes it easy to analyze big data and make accurate future predictions hence minimizing on stock out instances, minimized costs of inventory, and better resource utilization. This discovery highlights how the importance of AI in the improvement of the operational performance and flexibility in the FMCG industry.
- 2. Enhanced Supplier Collaboration and Logistics Optimization:** As said and observed by many experts, AI makes an incredible difference when it comes to supply chain coordination and supply chain logistics. One of the major areas where AI has a direct impact on improving efficiency is in the relationship with the suppliers since more efficient and effectively communicated procurement leads to shorter lead times. Also for instance, the same use of AI technology for purpose of route planning and delivery scheduling leads to



reduction in costs and increased service delivery. This could also be an indication that the used AI technology enhanced the intended objective of making supply chain's operational processes efficient and contributed to the formation of stronger supply chain relationships within the FMCG industry.

- 3. Challenges and Barriers to AI Implementation:** However, there are daunting challenges that organisations encounter when implementing the use of AI in SCM for FMCGs. Some of the barriers that were highlighted include data quality and integration problems, high costs that are likely to be incurred when developing technological architecture, and lastly inadequacy of human capital. The following challenges should be overcome for the optimal use of AI. These are issues that will need the government to invest in the right technology, train its human resource and improve its management of big data.
- 4. Future Advancements in AI and Their Implications:** Respondents are aware that future evolution of this type of intelligent systems will exert a highly positive influence on the FMCG supply chain. Future AI technologies are expected to neither only improve the SC transparency as well as its efficiency and robustness of the entire supply chain. This implies that FMCG companies need to keep up with AI trends to enhance their competitiveness, embrace new technologies and use new models of supply systems.
- 5. Strategic Importance of AI in FMCG Supply Chains:** The combined results highlight that the utilization of AI is not only a set of technology enablers but also a competitive weapon in FMCG companies. AI has the capability to enhance the supply chain function in a myriad of ways; ranging from demand forecasting and inventory management to supplier engagement and the actual physical shipment of products and hence is the harbinger of competitive advantage in the industry. The integration of AI in the supply chain management is, therefore, likely to offer organisations operational performances, customer satisfaction, as well as sustainability.



FUTURE SUGGESTIONS AND RECOMMENDATIONS

- 1. Invest in Advanced AI Technologies:** The FMCG firms should consider expanding their investment in new generation AI applications for the improvement in supply chain. The current advanced technologies like predictive analytics, machine learning, robots and others are poised to give a new dimension to forecasting demand, managing inventories and supply chain. Thus, by embracing these technologies, companies are in a position to manage the dynamics of the market by gaining a competitive edge as well as attaining better results in managing its operations.
- 2. Address Data Quality and Integration Challenges:** The result is that FMCG firms can only reap all these benefits provided they augment data quality and compatibility in their networks. This entails the provision of efficient information technology structures that enable proper data acquisition and analysis in real-time. Also, greater efforts should be made towards ensuring that AI can be easily integrated with other supply chain management systems to supply chain management to be a very smooth process.
- 3. Enhance Workforce Skills and Training:** In today's environment in which AI is gradually assuming a critical role in the operations of supply chains, there is a growing demand for employees with expertise in the use of AI and data analysis. FMCG companies must dedicate time and resources into training their employees in order to maximize the efficacies of AI applications. One way to avoid skills deficiencies and to train and prepare people for the future is by integrating with educational institutions or providing training programs for specific AI positions.
- 4. Focus on Sustainability and Ethical AI Practices:** With the progressive development of AI technologies, it is also advisable for FMCG companies to contemplate the matter of AI's ethics and environmental concerns. AI's adoption should not be done in a way that is detrimental to the environment; instead, ideas that would enhance environmentalism such as efficiency, minimum wastage of resources should be enhanced. In addition, it is crucial for corporations to set standard policies to opt for AI practices fairly and accordingly to



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ethical standards such as transparency and data protection to foster consumers' trust as well as that of the other stakeholders.

CONCLUSION

In this study, the changes that are being introduced by Artificial Intelligence in enhancing supply chain management of the FMCGs are discussed in detail and there are examples that show how it has been useful in demand management, supply chain collaboration and several logistics processes. Nonetheless, its adoption is not without limitations and some of them include data quality limitation, technological expenses, and lack of adequate workforce skills to harness the potential of AI. Continued and progressive investment in smarter generation AI tech and science with sustainable and ethical practice will be pivotal for FMCG organizations as it approaches in the future to sustain competitive advantage. Thus, the industry can benefit from AI developments in terms of productivity, sustainability, and growth in today's challenging landscape.



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