Impact of Supply Chain Management on Productivity of Dairy Industry in India - A Literature Review

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OPEN ACCESS

Manuscript ID:
MGT-2024-12048559

Volume: 12

Issue: 4

Month: April

Year: 2025

P-ISSN: 2321-4643

E-ISSN: 2581-9402

Received: 15.01.2025

Accepted: 10.03.2025

Published Online: 01.04.2025

Citation:
Lakshmi Priya, A., and R. Vanathi. "Impact of Supply Chain Management on Productivity of Dairy Industry in India – A Literature Review." *Shanlax International Journal of Management*, vol. 12, no. 4, 2025, pp. 126–34.

DOI:
https://doi.org/10.34293/management.v12i4.8559

Abstract
For the dairy business to guarantee product quality, reduce losses, and boost market competitiveness, effective supply chain management is required. The study examines important strategies for enhancing supply chain effectiveness, resolving issues, and implementing sustainable practices. Dairy operations require strong cold chain infrastructure, digital integration, and efficient logistics. However, supply chain performance is hampered by issues such milk perishability, transportation constraints, regulatory compliance, and variable demand. Looking ahead, technological developments, automation, and data-driven decision-making will improve operational effectiveness and transparency. Cost-effectiveness and environmental sustainability are enhanced by the use of green techniques, such as waste minimization, energy-efficient processing, and eco-friendly packaging. The dairy business may enhance operations, increase profitability, and lessen its environmental impact by implementing sustainable initiatives and contemporary supply chain tactics. The study discloses the importance of sustainability and innovation to maintain a strong and organized dairy supply chain for the future.
Keywords: Supply Chain Management, Productivity, Dairy, Green Practices, Strategies

Introduction

India is the largest dairy producer in the globe, which contributes nearly 23% of global milk production. Accordingly, India's dairy industry has contributed significantly to the economy of the nation. Dairy activities in India are an essential part of the rural economy because they provide the majority of jobs and earnings. As a result, it's been viewed as a tool for achieving socioeconomic advancement. India has a massive population, and the estimated per capita milk consumption is roughly 471 grams per day in 2023-24. In India, dairy products are primarily eaten domestically, with the majority sold as fluid. To accommodate expanding consumer demand, dairy companies are investing heavily in and considering supply chain management as a growth area. India aims to boost its dairy products and global share, with a target of contributing more than 30% of the world's share by 2030. In India, milk production is currently estimated around 239.3 MMT in 2023-24, with a 3.78% surge than the previous years. The compound annual growth rate is 6% percent than the past decade, it shows the potential for growth in dairy management in India (Purohit et al.).

At present, India's dairy industry is primarily unstructured, with 20% organized and 80% unorganized markets. The unorganized milk market lacks technology adoption and innovation, resulting in more waste, fluctuating quality, low customer satisfaction, and so on. Efficient firms in dairy sector

are currently making significant investments in supply chain optimization to boost consumer happiness and internal output (Kanna and Amudha). Customers receive the best value for the least amount of money. As a result, optimizing the supply chain to meet future domestic demand is essential for enterprises to remain competitive in the global market. The Indian government has implemented a number of development programs to enhance the dairy sector, and private sector participation continues to grow. Establishment of an efficient supply chain at all stages, including procurement, production, and exports, is important for the industry's success in both home and international markets (Singh and Pal). As a result, improvement of the supply chain remains a major task for the dairy industry in order to meet future demand while preserving a global competitive advantage. Dairy farming in India began on a local scale, with farmers keeping only enough cows to supply home milk needs. Traditional methods were used, with minimum processing or value addition. However, the cooperative movement led by the National Dairy Development Board (NDDB) changed the terrain of Indian dairy production dramatically. Cooperatives provided various benefits, including enabling farmers through a structured platform that allowed them to negotiate fair pricing and access critical resources like technical help.

Furthermore, cooperatives played an important role in reducing the power of intermediaries and developing direct connections between farmers and consumers. This not only secured higher financial returns for farmers, but also enhanced product quality for customers. The formation of cooperative networks resulted in the development of efficient milk procurement systems, which were supported by improved refrigeration equipment. In the 1970s, the Operation Flood effort effectively joined small-scale dairy producers under cooperative organizations, marking a watershed moment in this development. These cooperatives delivered significant benefits, such as improved procurement processes, streamlined marketing channels, and higher wages for farmers across the country. Village-level societies and several milk processing facilities were established, making it easier for farmers to pool their milk, negotiate better rates, obtain veterinary services, and use advanced processing equipment (Kumar). The effort had three main goals: increase milk production, construct collection and chilling facilities, and develop processing infrastructure. Through training, technical supervision, and financial assistance, Operation Flood enabled farmers to market their milk jointly, gain higher prices, and improve their economic conditions.

Statement of the Problem

The Indian dairy business contributes significantly to the economy, but its supply chain management faces numerous obstacles, including logistical inefficiencies, excessive waste, and environmental issues. Productivity in supply chain management has become a critical issue, necessitating the implementation of green methods to increase efficiency while reducing environmental effect. However, incorporating sustainable approaches into existing supply chains presents a number of challenges, including insufficient infrastructure, high implementation costs, and reluctance to change. These difficulties are being addressed through strategies such as improved cold chain logistics, waste reduction measures, and eco-friendly packaging. Despite these efforts, there are still gaps in the alignment of productivity and operational efficiency. The influence of green practices on supply chain performance needs to be investigated further to establish their success in terms of cost savings, productivity increases, and long-term viability. Realizing these dynamics is critical for building a strong and sustainable dairy supply chain. The study examines present tactics, identify difficulties, and investigate future opportunities, with an emphasis on how sustainable activities affect efficiency and overall supply chain performance.

Need for the Study

The rising demand for dairy products in India has heightened the requirement for an efficient and sustainable supply system. Traditional supply chain systems confront issues such as excessive waste, transportation inefficiencies, and environmental concerns. Adopting sustainable methods can help solve these challenges while also boosting

operational efficiency. However, it is unclear how much green initiatives improve efficiency in the dairy supply chain. The study is essential for determining how sustainability-focused measures, such as eco-friendly packaging, waste management, and optimized logistics, contribute to cost savings, resource conservation, and better supply chain efficiency. Examination of the challenges of implementing green practices will provide viable answers for the sector's long-term survival. As a result of evaluating the impact of these actions, this study will assist stakeholders establish a more robust and efficient dairy supply chain in India.

Purpose and Methods

The present study is an extensive literature review on supply chain management of dairy industries in India. The study planned review scholarly articles from various research journals, government reports and case studies. The present research has been divided into four major parts, which are strategies of supply chain management, challenges of supply chain management, future prospects of supply chain management, and impact of green practices on productivity. Therefore, present options, use of technology, pricing practices, and green supply chain management have been critically reviewed.

Discussion

Strategies of Supply Chain Management in Dairy Industry

Efficient supply chain management in the dairy business is critical for ensuring the smooth flow of dairy products from farms to consumers. Dairy products are perishable, therefore improving every stage of the supply chain is crucial for maintaining quality, eliminating losses, and ensuring punctual delivery (Kumar). Various solutions have been devised to overcome these difficulties, increase efficiency, and boost profits. A well-organized milk procurement system is the foundation of a streamlined dairy supply network. Establishment of organized collection centers in rural areas allows farmers to deliver milk at specific locations, lowering transportation costs and assuring quality control (Sale et al.). Cooperatives and individual dairies use bulk milk refrigerators at collecting stations to keep milk fresh. Digital payment solutions improve procurement by ensuring timely payments to farmers and minimizing reliance on intermediaries (Heinzova et al.). Dairy products require controlled storage conditions, therefore establishing a strong cold chain network is essential. It comprises refrigerated trucks, milk chilling devices at collection sites, and temperature-controlled warehouses. Effective cold chain management reduces spoilage, increases shelf life, and ensures product quality (Naganboyina and Kaple).

Companies also employ remote temperature monitoring devices to monitor storage conditions and take corrective action as needed. The integration of numerous technologies, including artificial intelligence, aids in tracking milk quality, monitoring storage conditions, and maintaining transparency (Zheng et al.). Technology is very useful for ensuring traceability, allowing stakeholders to check product legitimacy and safety along the supply chain. For fresh dairy products to arrive on schedule, transportation efficiency is essential (Pappa et al.). Fuel usage and transit time can be decreased by effective delivery routes with GPS tracking and route planning software. Raw milk is transported safely from farms to processing facilities by milk tankers outfitted with real-time monitoring devices (Mor et al.). In order to improve distribution efficiency, businesses also use hybrid transportation models that combine rail and road transit. The management of the dairy supply chain is increasingly arranging sustainability. To reduce their environmental impact, businesses are using waste management strategies, energy-efficient refrigeration systems, and biodegradable packaging (Ding et al.).

Operating costs are also decreased by using renewable energy sources, such as cooling systems that run on solar power. Wastewater treatment facilities contribute to sustainability by reusing water used in dairy production. Strong partnerships with dairy farmers and suppliers assure a consistent and high-quality supply of raw milk (Beber et al.). Training in optimum farming methods, cow health, and milk cleanliness increases productivity and quality. Long-term contracts and fair pricing structures also motivate farmers to produce consistent high-quality milk. Strict quality control methods

are required in the dairy business (Muhammad et al.). Regular contamination testing, adherence to food safety rules, and the establishment of quality assurance processes all help to guarantee that dairy products meet industry requirements. Automation in quality testing improves accuracy while reducing human errors. The strategies can improve efficiency, minimize costs and fulfill growing consumer demands to ensure long-term sustainability (Tripathi and Trivedi).

Challenges of Supply Chain Management

The dairy business relies on an effective supply chain to ensure that milk and dairy products move smoothly from producers to consumers. However, various difficulties impair the performance of supply chain operations, resulting in inefficiencies, losses, and higher costs. Addressing these difficulties is important for maintaining product quality, decreasing waste, and increasing overall supply chain performance (Boland et al.). The limited shelf life of milk and dairy products presents one of the most significant challenges in dairy supply chain management. Milk is highly perishable, therefore it must be processed immediately, stored properly, and transported quickly (Abdul Khadar Aneesh and Sandesha). Delays at any point of the supply chain can result in spoilage, financial losses, and supply disruptions. To address this, strong cold chain infrastructure is required, although its implementation varies between locations (Srivastava and Barathwal). Dairy products must be kept in a good cold chain to maintain their freshness. However, a lack of adequate refrigeration facilities in many places, particularly rural ones, causes food to spoil while being stored and transported. Product deterioration due to inadequate temperature management compromises both quality and customer confidence (Azizsafaei et al.).

Investments in cold storage facilities, refrigerated transport vehicles, and real-time temperature monitoring systems are required to stop these losses. Increasing fuel prices, ineffective route planning, and inadequate road infrastructure in some places make it extremely difficult to transport dairy products efficiently (Kumar and Ansari). Since milk and dairy products need to be delivered quickly, logistical inefficiencies affect supply reliability and raise operating expenses. Real-time tracking technologies, hybrid transportation models, and optimized route planning can all be used to cut expenses and increase efficiency (Borah). The major concern is making sure dairy products are safe and of high quality. The quality of a product can be harmed by things like contamination, adulteration, and incorrect handling. Milk quality varies because many small-scale dairy farmers do not have access to adequate facilities for quality testing. Adopting automated inspection methods, conducting routine testing, and fortifying quality control procedures are all crucial to upholding industry standards (Talukder et al.).

Small-scale farmers who frequently lack access to modern agricultural methods, veterinary care, and financial resources provide a significant amount of India's dairy supply. As a result, milk quality varies and production capacity is constrained. The dependability of the milk supply can be increased by bolstering farmer assistance programs, offering training, and making sure that fair pricing procedures are in place (Singh and Pal). In the dairy supply chain, there is still little use of cutting-edge technology. Conventional approaches continue to predominate, which results in inefficiencies and decreased transparency. Modern technology integration helps improve decision-making, improve inventory management, and increase traceability (Yang et al.). Significant environmental problems are caused by the dairy sector, such as excessive water use, greenhouse gas emissions, and waste management problems. To lessen the industry's environmental impact, sustainable practices like eco-friendly packaging, renewable energy sources, and effective trash disposal techniques must be put into place. To overcome these obstacles and establish a more sustainable and effective dairy supply chain, all parties like farmers, processors, distributors, and legislators should work together (Mangla et al.).

Future Prospects of Supply Chain Management

The dairy sector is changing quickly, and supply chain management will be shaped by sustainability initiatives and technology breakthroughs. Businesses are concentrating on increasing productivity, cutting waste, and guaranteeing environmental sustainability as customer demand for premium dairy products

rises (Vladova et al.). The management of the dairy supply chain is anticipated to be significantly impacted by technology in the future. Adoption of blockchain technology, artificial intelligence, and Internet of Things devices will boost traceability, increase transparency, and improve real-time monitoring (Raparla et al.). Temperature, quality, and storage conditions will be monitored with the use of smart sensors in milk collection facilities, delivery trucks, and storage facilities. Facilitating end-to-end traceability, blockchain-based systems will guarantee data integrity, lower fraud, and enhance food safety (Shingh et al.). Dairy products will require investments in cutting-edge cold chain systems to prolong their shelf life and prevent spoiling. In order to maintain ideal storage conditions, future advancements will include solar-powered chilling units, energy-efficient refrigeration systems, and enhanced insulation techniques (Kanna and Amudha).

Automated temperature controls and smart refrigeration systems will assist save energy while maintaining product freshness. It is anticipated that the dairy sector will transition to more ecologically friendly supply chain procedures (Abdirad and Krishnan). To lessen their impact on the environment, businesses will implement water conservation measures, waste recycling systems, and biodegradable packaging materials. In order to make dairy supply chains more sustainable, renewable energy sources like solar and biogas-powered dairy farms will be essential (Jachimczyk et al.). In order to guarantee the timely delivery of dairy products, efficient transportation is essential. In order to increase efficiency and lower fuel costs, future logistics tactics will concentrate on automated route optimization, electric delivery trucks, and drone-based milk deliveries (Khanna et al.). Logistics systems driven by AI will examine weather and traffic trends to augment delivery times, reducing losses and delays. Stronger cooperation between farmers, cooperatives, and processing facilities will be a key component of dairy supply chain management in the future (Zhang et al.). Increasing the number of digital platforms for direct farmer-to-market sales will guarantee fair pricing and lessen reliance on intermediaries. Initiatives from the public and commercial sectors will keep helping farmers improve the quality of their milk and their ability to produce it by providing financial support, veterinary care, and training programs (Kumar and Kumar).

Efficient transportation is key to ensuring timely delivery of dairy products. Future logistics strategies will focus on automated route optimization, electric delivery vehicles, and drone-based milk deliveries to improve efficiency and reduce fuel costs. AI-powered logistics systems will analyze traffic patterns and weather conditions to optimize delivery schedules, minimizing delays and losses (Choyal). The future of dairy supply chain management will emphasize stronger collaboration between farmers, cooperatives, and processing units. Expansion of digital platforms for direct farmer-to-market sales will reduce dependency on middlemen and ensure fair pricing (Malik et al.). Government and private sector initiatives will continue supporting farmers with training programs, veterinary services, and financial assistance to enhance milk quality and production capacity. Higher productivity and higher-quality milk will result from the application of genetic selection techniques, feed management technologies, and automated milking systems (Rajeev Kumar). The development and distribution of value-added goods like probiotic yoghurt, organic milk, and plant-based dairy substitutes will be the main emphasis of future supply chain initiatives. These goods give dairy companies access to new markets and satisfy shifting customer tastes (Singh and Khatib).

Impact of Green Practices on Productivity

The global food supply chain depends heavily on the dairy industry, but it also has a big impact on the environment. Sustainability issues are caused by a number of factors, including excessive water use, greenhouse gas emissions, energy use, and waste production (Meneghetti and Monti). Green techniques are being included into dairy supply chain management to address these problems, which will increase product quality, lower prices, and increase efficiency. For milk collection, transportation, pasteurization, refrigeration, and packaging, dairy processing facilities need a lot of energy (Njeri). Reliance on traditional power systems can be greatly

decreased by using renewable energy sources like wind, solar, and biogas. Nowadays, a lot of dairy farms use biogas plants to turn cow excrement into energy that may be used for equipment operation, lighting, and heating (Cankaya and Sezen). Dairy products are also kept at ideal temperatures with the least amount of energy waste thanks to the use of energy-efficient refrigeration and cooling equipment. Streamlining production schedules and cutting down on wasteful power use, advanced automation in processing facilities significantly enhances energy management (Abdul-Rashid et al.).

Dairy production and processing depend on water, but overuse can put a strain on nearby water supplies. Dairy farms can improve their water management by putting in place rainwater collection and recycling systems. Water used for washing and processing can now be cleaned and utilized again for irrigation other non-potable uses thanks to the use of wastewater treatment plants by contemporary dairy businesses (Yusuf). Dairy enterprises may maintain their water efficiency by maximizing use and detecting leaks with the aid of automated water monitoring systems. Significant waste is produced by the dairy sector, including manure, packing materials, and spoilt milk. Putting waste management techniques into practice reduces environmental impact while increasing efficiency (Hongquan and Abdullah). Dairy waste can be composted and used as organic fertilizer to enhance soil quality and promote sustainable farming. Plastic pollution is also decreased by recycling packaging materials and switching to reusable or biodegradable alternatives (Maina et al.). Nowadays, a lot of dairy companies are concentrating on zero-waste techniques, which make effective use of all byproducts from the dairy process. For instance, instead of being thrown away, whey protein, a byproduct of making cheese, is turned into dietary supplements. In addition to lowering milk loss, effective logistics planning guarantees that goods are delivered to customers on schedule (Malliaroudaki et al.).

Collaboration with vendors who use chemical-free and organic livestock feed guarantees better milk production and lowers carbon emissions. Furthermore, fuel consumption and emissions are decreased via environmentally friendly transportation options like electric delivery trucks and well-functioning logistics networks (Purohit et al.). It ensures that dairy products are shipped via the quickest and most effective routes, route optimization software reduces operating expenses and expedites delivery times. In the dairy sector, sustainable packaging improves productivity while lessening its negative effects on the environment. To reduce plastic waste, several businesses are switching to recyclable, biodegradable, and reusable packaging materials (Pacarada et al.). To encourage customers to return and reuse packaging instead of throwing it away, several dairy manufacturers, for instance, have implemented deposit-return schemes for glass milk bottles. The shift to environmentally friendly dairy farming is further supported by government grants and incentives for implementing eco-friendly technologies (Kirilova and Vaklieva-Bancheva). Dairy companies that invest in sustainable dairy production can also benefit from low-interest loans and grants offered by numerous financial institutions. Adoption of environmentally friendly innovations that strike a balance between environmental responsibility and productivity is key to the future of dairy supply chain management (Ferraeira et al.).

Conclusion

The global food supply chain depends heavily on the dairy sector, and fulfilling rising demand, cutting prices, and preserving product quality all depend on effective supply chain management. Streamlining logistics, embracing cutting-edge technology, and improving inventory control, supply chain management techniques improve operational efficiency. Improving the overall effectiveness of the supply chain requires addressing issues including milk perishability, inefficient transportation, and regulatory compliance. The dairy industry's supply chain management prospects for the future center on automation, digital transformation, and sustainable practices. Predictive analytics, and AI advancements will further improve efficiency and traceability, guaranteeing a more robust supply chain. Furthermore, incorporating green practices enhances resource use, decreases waste, and conserves energy, all of which support environmental sustainability. In addition to reducing their negative effects on the

environment, eco-friendly technology, renewable energy sources, and effective waste management systems also increase cost-effectiveness and competitiveness in the market. Dairy companies that adopt sustainability will assure long-term prosperity and win over customers. In order to stay effective, competitive, and sustainable in a market that is becoming more and more dynamic, the dairy sector must keep changing in the future by using creative supply chain tactics and ecologically friendly methods.

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