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Sustainable Supply Chain Management Practices in the Dairy Industry: A Comparative Study of Leading Dairy Firms and Future Research Directives

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ABSTRACT

The Indian dairy industry is one of the fastest growing industries in the world which employs millions of farmers directly and also participates more than five per cent in the economy as well. As the industry continues to expand there is a growing need to adopt sustainable practices in the supply chain to minimize negative impact on the environment and society and ensure viability. The present research aims at examining the supply chain management practices of the two leading dairy firms-Amul and Danone. The study relies primarily on secondary sources like peer-reviewed journals, authentic websites and reports. A case study-based approach has predominantly been used to compare two leading firms in the dairy industry with respect to sustainable practices across the supply chain. Key aspects such as the scale of dairy production, technology adoption, pricing, traditional supply chain management, artificial intelligence in sustainable supply chains and logistics management in select dairy firms have been critically reviewed for comparison purposes. The study identified the various problems and challenges being faced by the Indian dairy industry. The study found that Amul and Danone both have focused on sustainable and green practices. However, Danone's ability to incorporate and enable technology has helped in improving efficiency across the supply chain making the chain sustainable. On the other hand, Amul lacked the adaptation of emerging technologies across its supply chain. The study suggested the exploration of artificial intelligence that might help in achieving a sustainable supply chain in Indian dairy firms.

Key words: Artificial intelligence, Dairy industry, Dairy supply chain, Food waste, Reverse Logistics, Sustainable supply chain.

The entire world faces the consequences of the overutilization of natural resources and the generation of waste from industrial operations (Bag *et al.,* 2021). The dairy industry is a significant contributor to the global economy and it plays an important role in the food and agriculture sector. The industry involves the production, processing and distribution of dairy products such as milk, cheese, butter and yogurt to name a few. In terms of global milk production, the top dairy-producing countries are India, the United States of America, China, Brazil and Russia (FAO, 2018). The United States is the largest producer of cow milk, while India is the largest producer of buffalo milk. In terms of dairy exports, New Zealand is a significant player, accounting for around 30% of global dairy exports. Globally production of milk has surged during the past three decades, going from 522 million tonnes in 1986 to 798 million tons in 2016 *i.e.*, a 53% increase (FAO, 2021). Recently, the Food and Agricultural Organization (FAO) reported that more than 6 billion people worldwide consume milk and dairy products, with the majority of them residing in developing nations (FAO, 2021). A period of oversupply and low prices for milk products from China has resulted from trade restrictions against Russia and the elimination of "milk quotas" inside the EU (Brien, 2015). In spite of this, the dairy sector is expanding and is projected to produce 177 million tons of powdered milk by 2025, growing at a rate of 1.8% each year (Ministry of Fisheries, Animal Husbandry and Dairying, 2022). This rise is the result of expanding urbanization and growing income in developing economies (Houhou *et al*., 2021). The FAO of the United Nations Statistics Division published information on the global dairy industry from 2000 to 2010 that lists the major milk-producing nations (Fig 1).

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The Indian dairy industry

The dairy industry is a major economic activity in India, with milk production representing the most significant agricultural activity. The sector contributes significantly to the country's economy and provides employment opportunities to millions of people. The dairy market of India was valued at INR

13,174 billion and is expected to increase to INR 30,840 billion by 2027 (Khanna *et al*., 2022). Research by the National Dairy Development Board (NDDB) estimates that by 2023, India will produce 266.5 million metric tons of milk. As per the estimate, states like Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat and Andhra Pradesh would be the leading milk producers. Furthermore, the Indian government has introduced various National Dairy Projects to increase the production of milk, increase cattle productivity and ultimately improve farmer livelihoods while meeting the growing needs of Indian consumers. The sector is dominated by small-scale dairy farmers, with nearly 90 per cent of milk production coming from small and marginal sectors like dairy cooperatives and private companies (IBEF, 2021). Thus, The Indian dairy industry is also characterized by a high degree of fragmentation and inefficiency. A large number of farmers operate in an informal and unregulated market, with a lack of proper infrastructure and a lack of access to technology and capital.

The Indian dairy industry has had slower growth than expected for a number of reasons, including the employment of non-scientific procedures, ineffective cattle breeding, lack of adherence to quality standards, transparency and most importantly, a lack of proper technological support which eventually leads to the information asymmetric in the multilayer supply chain which hinders the sustainability. Modern sustainable development is primarily concerned with how plants and new, quickly expanding road infrastructure affect our environment (Boruszko *et al*., 2018). Promoting sustainable production and distribution in the food business is crucial (Boruszko *et al*., 2018). To achieve the objectives of greater social, economic and environmental performance, sustainability-oriented food supply chains incorporate all forward (materials procurement, manufacture and distribution) and reverse operations (collection and return of used products) (Paul *et al*., 2020) and focused more on depending upon green energy rather than, the traditional one for the purpose of production and distribution. Green supply chain management (GSCM) refers to the process of integrating environmentally friendly practices into all stages of the supply chain, from product design to end-of-life disposal. The goal of GSCM is to reduce the environmental impact of the supply chain while maintaining or improving its economic performance. It includes sustainable sourcing, energy-efficient transportation, waste reduction, product design and environmental performance tracking. Implementing GSCM practices can benefit companies by reducing costs, enhancing brand reputation and complying with regulations. It can also help companies to stay competitive by meeting the increasing demand for sustainable products and services. Sustainable supply chain practices refer to those actions and activities that deal with the environmental, financial and social aspects of manufacturing firms (Kumar *et al*., 2022). Organizational performances have been positively impacted by sustainable supply chain and logistics practices (Sinha, 2022).

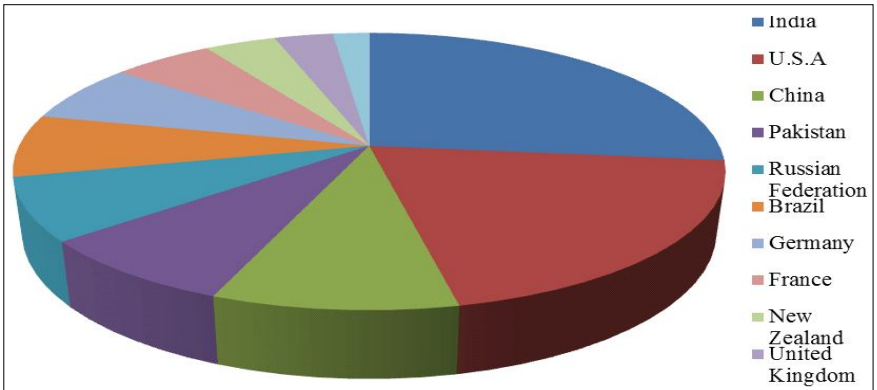
Objective of the study

There are primarily three objectives.

- To gain insight into the supply chain management practices employed in the Indian dairy industry.
- To examine the sustainable practices in the Indian dairy supply chain vis-à-vis the French dairy supply chain.
- To identify the role of artificial intelligence in achieving a sustainable supply chain in Indian dairy firms.

Research methodology

The present research has relied on secondary sources. Various research articles from the peer-reviewed journals available in Scopus and Web of Science databases, government reports and case studies have been accessed and reviewed. A case study approach has been applied for the study purpose. The study was conducted at Bennett University between April 2022 and April 2023. The studies have been divided into four major sections which are (i) Introduction to the dairy industry at global and the national level (ii) Traditional and modern supply chain management practices of AMUL, a leading dairy firm in India (iii) Supply chain management practices at Danone, a leading French dairy firm (iv) A comparative analysis between Amul and Danone with respect to sustainable supply chain practices



Source: Kumar *et al.* (2022).

Fig 1: Milk producer in the world.

(v) Role of artificial intelligence in dairy firm (v) Future research direction. Scale of dairy production, technology adoption, pricing, traditional supply chain management, artificial intelligence in sustainable supply chains and logistics management in select leading dairy firms have been critically reviewed for comparison purposes.

Indian dairy supply chain: A comprehensive analysis

The dairy sector in India, being one of the largest producers and consumers of milk, has experienced a remarkable transformation in its supply chain over the years, owing to various socio-economic factors and concerted efforts by industry stakeholders.

Evolution of the Indian dairy supply chain

Initially, dairy farming in India was characterized by small-scale subsistence practices whereby farmers raised only enough cows or buffaloes needed for providing milk for their households while following traditional farming methods with little value addition or processing. Nevertheless, this changed due to the advent of the cooperative movement led by the National Dairy Development Board (NDDB) that transformed Indian dairy farming altogether. Through cooperatives' introduction into the industry came various benefits such as farmer empowerment through providing them with an organized platform that gave room for negotiating fair prices while granting access to crucial resources such as technical support. Additionally, cooperatives played a critical role in reducing middlemen resulting in direct farmer-to-consumer connections that led to increased returns for farmers and superior quality products for consumers Moreover, robust milk procurement systems with efficient refrigeration infrastructure were facilitated by the establishment of cooperative networks. The pivotal role played by the Operation Flood initiative during the 1970s cannot be undermined as it successfully organized small-scale dairy farmers under cooperative umbrella organizations. Farmers benefited greatly from these organizations due to improved procurement practices and streamlined marketing systems that led to significant increases in their income levels countrywide through the widespread establishment of various village-level societies along with numerous milk processing facilities provided by well-established co-operatives. These collective organizations made it easier to pool milk, negotiate fair prices, offer veterinary services and gain access to cutting-edge processing facilities. The three main goals of the program were to increase milk production, set up milk collection and chilling facilities and build processing infrastructure. Through training, technical assistance and financial support, Operation Flood helped farmers market their milk collectively, gain access to better prices and enhance their socioeconomic circumstances. The Gujarat Cooperative Milk Marketing Federation (GCMMF), also known as Amul, is a significant example of success within this cooperative network.

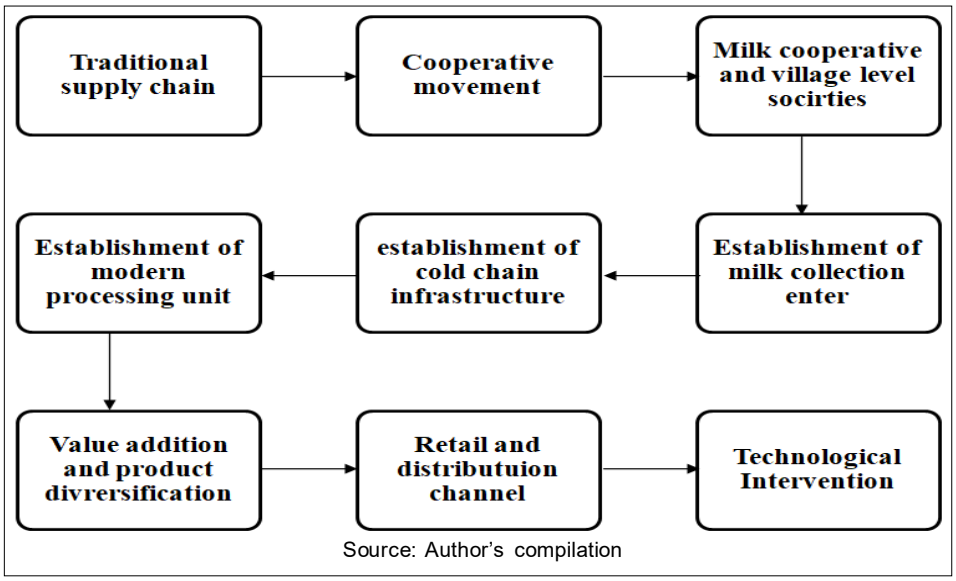
The creation of milk collection centers at the village or district level was crucial for streamlining milk procurement. These centers served as middlemen, collecting milk from farmers and ensuring its prompt and effective delivery to processing facilities. They acted as centers for gathering milk from various sources, streamlining the collection procedure and easing logistical difficulties. By offering a centralized location for milk collection, quality assurance inspections and storage prior to transportation to processing units, milk collection centers contribute to the overall efficiency and dependability of the dairy supply chain. Larger-scale milk collection was made much simpler as a result of this action and as the industry expanded, it was essential to create a reliable cold chain infrastructure. Refrigerated storage and transportation facilities were set up to maintain the quality and freshness of milk throughout the supply chain. These investments increased product safety standards, reduced spoilage and extended shelf life. In order to satisfy the rising demand for processed dairy products, cutting-edge processing facilities were needed. To heighten the efficiency and output of dairy processing operations, forward-thinking facilities have implemented the latest equipment and technology. The efficient pasteurization, homogenization and packaging of milk made possible by these cutting-edge tools ensure the superior quality and safety of dairy products. Additionally, in order to meet the constantly shifting demands of the market, these facilities are able to produce a wide variety of high-value goods like butter, cheese, ghee, milk powder, yoghurt and ice cream. Modern processing facilities also enhanced product standardization and quality assurance procedures. These facilities adhere to strict quality standards and implement advanced testing procedures to ensure that dairy products meet regulatory requirements and consumer expectations. This fostered consumer trust and confidence in Indian dairy products, contributing to their market competitiveness both domestically and internationally. Recognizing changing consumer preferences, processors and cooperatives shifted their focus to value addition and product diversification. Through research and development initiatives, new dairy products were introduced to cater to evolving tastes and demands. This strategic shift allowed the industry to tap into new market segments and enhance revenue streams. The growth of organized retail chains, including supermarkets and hypermarkets, played a significant role in reshaping the distribution of dairy products. These modern retail formats established direct links between processors and consumers, offering increased product visibility, wider market reach and more efficient supply. Mishra and Shukla (2022) discussed the innovative approach of a dairy retail firm that used an app-based application to enable self-orders and brought digital transformation to the dairy business. Kumar and Nambirajan (2014) observed that supply chain competency like ability to fill orders with accuracy, forecasting sales with accuracy *etc*. have positive impact on supply chain performances.

However, the dairy industry in India has been grappled with many problems due to the dominance of unorganized players (individual milkmen) contributing approximately 60% of the total milk procurement and the remaining 40% by the organized players such as dairy cooperatives and private companies (IBEF, 2021). It has traditionally been dominated by unorganized small-scale producers supplying milk directly to consumers or local aggregators (Shashidhar, 2016). The supply chain of organized players in the dairy industry is highly structured whereas the supply chain of the unorganized players is unstructured. Fig 2 reflects the evolution of supply chain management practices in Indian dairy supply chain.

Structured Vs Unstructured supply chain in Indian dairy industry

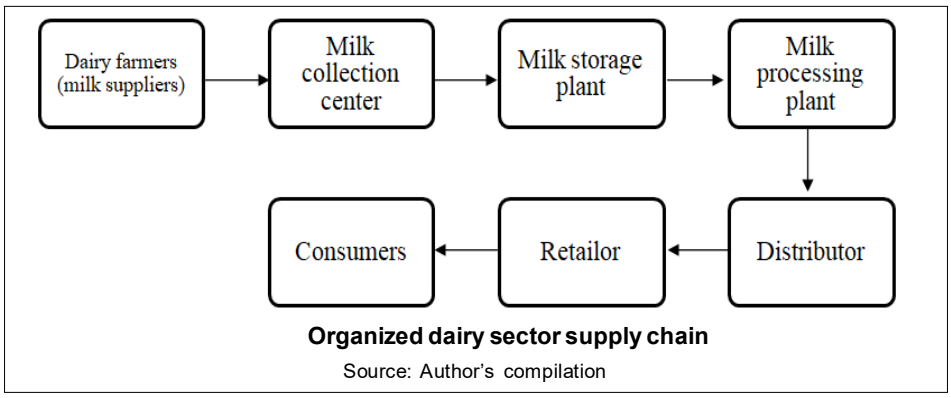
India is one of the world's largest milk producers, with a production level estimated at around 164 million tones per year. There are many factors that contribute to the large-scale milk production, which is around 164 million tones per year. The factors include favorable weather conditions for the dairy industry but are also attributed to how milk is sourced from farmers within India's largely unstructured supply chain system (Pandey *et al.*, 2020). With an increased demand for hygienic and quality products, India saw the emergence of organized supply chains offering cold chain infrastructure, traceability systems and efficient distribution networks. At present, producers are using both structured and unstructured supply chains for selling their products to consumers (The Economics Times, 2019). Fig 3 and Fig 4 represent organized and unorganized dairy sector supply chain in India.

The structured system refers to organized milk cooperative societies or private dairies that collect raw milk directly from registered members who have taken up the membership provided by them. These cooperatives operate mostly on village level collecting milk during the morning time each day which subsequently goes through stringent quality testing processes before being processed and sold throughout various parts of the country (Shashidhar, 2016). This chain relies on intermediaries such as distributors or wholesalers to facilitate transactions between farmers/



Source: Author's compilation

Fig 2: Evolution of Indian dairy supply chain.



Organized dairy sector supply chain

Source: Author's compilation

Fig 3: Structured supply chain in Indian dairy industry.

producers and retailers. Product quality control, timely delivery and other important aspects related to production-consumption linkages also depend upon such intermediaries (Khanna *et al*., 2022). The structured supply chain of the Indian dairy industry is managed by large, organized players and cooperatives like Amul, Mother Dairy and Nandini, which have a significant presence in the market. These players leverage a cooperative network, robust processes and strong distribution channels to ensure efficient and reliable delivery of dairy products Unlike its counterpart, the unstructured supply chain of the Indian dairy industry is characterized by a lack of organization and formalization. It is dominated by small-scale dairy farmers, traders and local vendors who operate in a decentralized manner. This model has no formal organization associated with it; instead, independent agents (marginal milk vendors) establish individual links between buyers and sellers locally outlining informal systems operating mainly on a cash basis rather than enabled operations. Further, it lacks dependable storage facilities hampering proper warehouse management leads in keeping expiry dates intact eventually forcing them into adopting alternative distribution strategies including doorstep deliveries with high variable costs involved making difficult processes inaccessible sustainably (Burkitbayeva *et al*., 2023). The unstructured supply chain followed by unorganized players, often relies on local networks and informal relationships but may face limitations in terms of scalability and consistency.

Supply chain management of Amul

Traditional supply chain of Amul

The leading dairy cooperative in India is called “Amul,” standing for Anand Milk Federation Union Limited. The structure is three-tiered, starting with a dairy co-operative society at the local or village level which will be federated within milk unions at various district level, It also falls under the State milk federation, which operates at the provincial level. Milk is collected at the village level by milk collection facilities; milk is procured and processed at the district level by milk unions; and milk and milk products are marketed by the relevant state milk federation. Fig 5 shows traditional supply chain of Amul.

The Supply chain of AMUL is described as under:

Milk collection

Amul has a network of over 18,000 village-level milk collection centers, known as Village Dairy Cooperatives (VDCs). These VDCs collect milk from local farmers, who are also members of the cooperative.

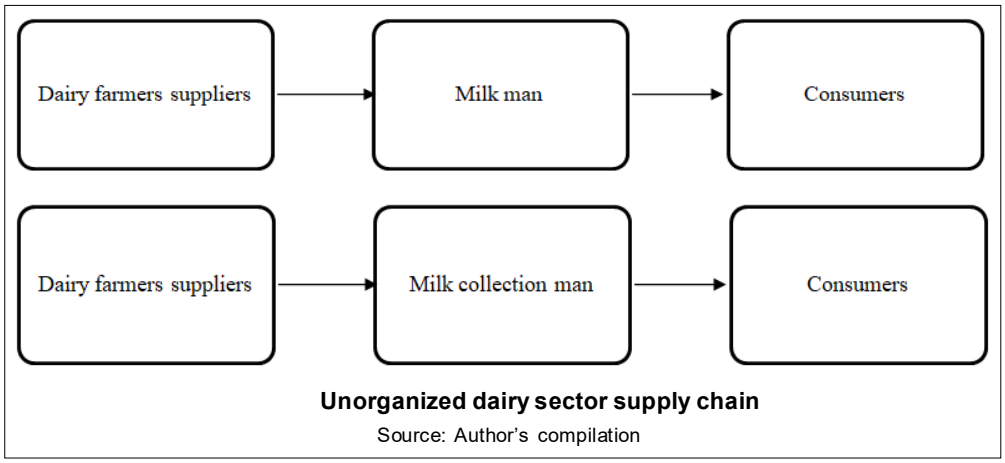


Fig 4: Unstructured supply chain in Indian dairy industry.

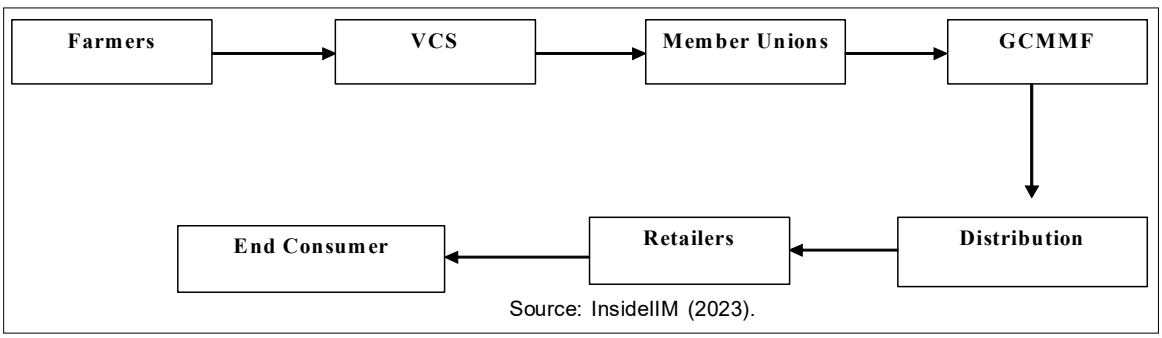


Fig 5: Amul's traditional supply chain.

Milk processing

The collected milk is transported to processing plants, where it is pasteurized, homogenized and packaged into various products such as milk, butter, cheese and ice cream.

Distribution

The packaged products are then distributed to various retail outlets and distributors across India. Amul has a strong distribution network, with over 3,500 distributors and 1 million retail outlets.

Sale and marketing

All efforts are made towards promotions and market development including retail promotional schemes supported by continuous engagement among a wide spectrum of customers.

Amul supply chain integrated with artificial intelligence

Amul is integrating artificial intelligence into its supply chain in order to improve efficiency. This integration of AI will help the company achieve a number of goals. It improves accuracy and reduce errors within their system by using automated processes that are driven by data analysis and machine learning algorithms and Optimize delivery routes, utilizing real-time traffic data to identify the most efficient paths for shipments. Amul has implemented electronic transaction system which increases the transparency and also fasten the payment process to farmers which eventually creates a mutual trust on each other furthermore, Amul has also implemented Internet of things (IoT) in their transportation process to monitor quality and temperature of milk to the consumers thus, system helps them to track the transportation more efficiently. This process help's in early detection of any issue with the product therefore, it ensures the milk arrives in optimal condition to the processing plant. Amul has also established a live monitoring system that allows remote access to their processing facilities. The use of sensors to track temperature, pressure and humidity in their processing plants ensures that the milk undergoes processing under the best possible conditions. To make sure that their products are properly maintained and delivered on time, Amul has put in place a sophisticated logistics network that includes cold storage and refrigerated trucks. They have implemented a routing system that optimizes the delivery routes and they use Radia Frequency Identification (RFID) and Global Positioning System (GPS) tracking to keep track of their delivery vehicles. For perishable goods like milk or milk products, reverse logistics is essential for waste management and minimising supply chain operations' negative environmental effects. Reverse logistics, whereby the company's field executives and logistics team collect faulty or outdated goods from distributors and retailers, is another design feature of Amul. Products that can be processed again are sent to Amul's manufacturing facilities to be recycled or used again and products that cannot be processed again are disposed of in an environmentally friendly way. The "Amul Milk Bag Return System" is a system that Amul has established to coordinate the collection of empty milk pouches. Customers can return their used milk pouches at collection points Amul has set up at various retail locations under this system. The logistics team at Amul then collects the used pouches and delivers them back to the recycling facilities. The supply chain for AMUL is integrated with artificial intelligence in Fig 6.

Supply chain of Danone

French multinational food and beverage company Danone has a sizable presence in the dairy sector. One of the top producers of dairy products in the world, Danone was established in Barcelona, Spain, in 1919. It is renowned for its dedication to sustainability and good health. The company operates in various markets worldwide, including Europe, North America, Asia and Africa, offering a diverse range of dairy products that cater to different consumer preferences and nutritional needs. At the core of Danone's business philosophy is a commitment to improving the health and well-being of individuals and communities. The company's vision is reflected in its dual project, which aims to bring economic success and social progress together. Danone embraces a set of values that guide its operations, including a focus on people, accountability, courage and openness. These values shape the company's decision-making processes, sustainability efforts and partnerships with stakeholders.

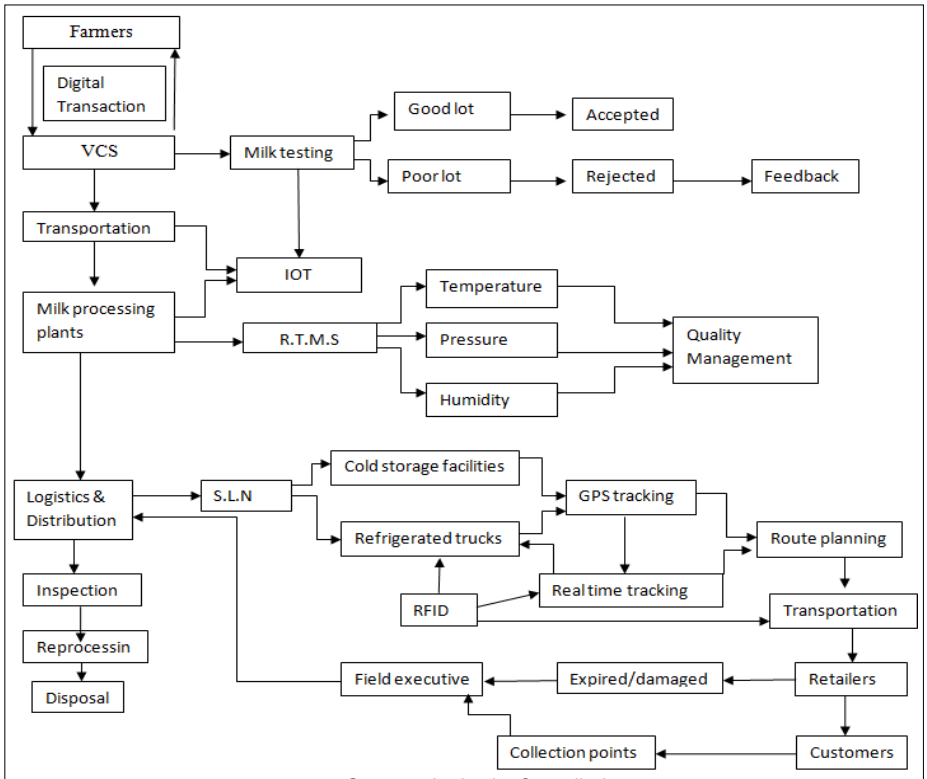
Milk powder is the main raw material of Danone dairy Firm which it imports from New Zealand and Australia by using marine transport to Malaysia. The shipment usually arrived at port KL, the material then moved by using road transportation to its production center which is situated in Nilai, negeri Sembilan where it is used, collectively with other raw material which is eventually sourced into manufacturing to produce its final product. After production, the commodities are either exported to other Southeast Asian nations, mainly Thailand, Cambodia, Vietnam and Indonesia, or they are quality checked before being delivered within 14 days to their various locations around Malaysia. These are shipped by employing outside logistics service providers that Danone has worked with over the course of many years in Malaysia and have trust. It also uses various technologies to track down the logistics. Customers' and retail outlets' feedback is collected and the company's internal specialists use it to estimate the output in the future. Fig 7 shows the supply chain management of Danone dumex being practiced in Malaysia.

Although milk powder, the major raw ingredient, is normally transported by using water transport, it is occasionally transported by air for speed in particular circumstances. The raw materials are carried by road transportation such as land trucks, usually Ten wheelers, to the production site in Nilai once they arrive in Malaysia. It takes roughly an hour and a half to travel the seventy-four kilometers between the 2 distinct locations. The primary component, Milk Powders blended using a unique DANONE

formula to produce the finished items. The company has third-party logistics partners to ship the finished goods to four important locations: the Northern Region, Southern Region, East Coast and exports.

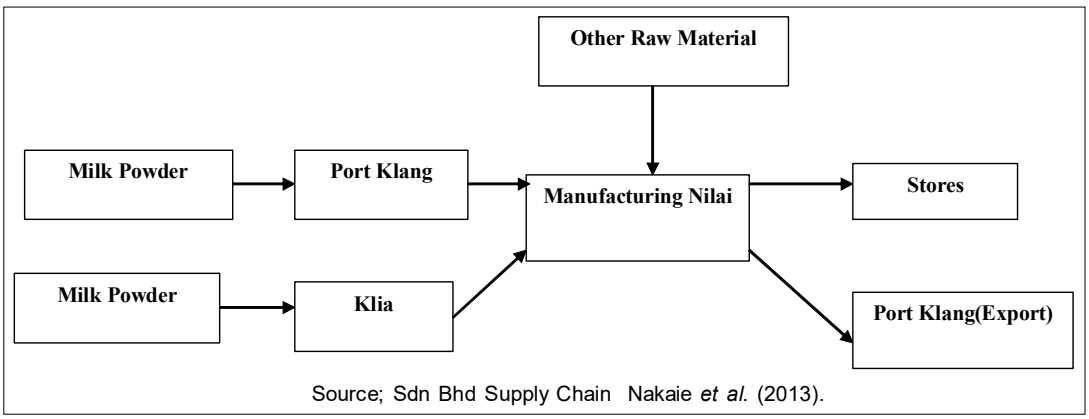
Supply chain of Amul and Danone: A comparative analysis

Amul and Danone are the two biggest players in Indian and French dairy industry respectively, each with a distinct supply chain strategy that leverages Industry 4.0 technologies to optimize their operations. Supply chain management is a critical aspect of any business and the dairy industry is no exception. It involves a series of interconnected activities that range from milk procurement and transportation to processing, packaging and distribution. Industry 4.0, also known as the Fourth Industrial Revolution, has offered a wide range of technologies that can significantly enhance the efficiency and effectiveness of these activities. Table 1 shows a comparative analysis between Amul and Danone with respect to each supply chain elements.



Source: Author's Compilation

Fig 6: Amul's supply chain integrated with AI.



Source; Sdn Bhd Supply Chain Nakaie *et al.* (2013).

Fig 7: Danone dumex (Malaysia).

Milk procurement

This is the very first stage where Amul has implemented a digital payment system that makes it easier for farmers to get paid thus, this system also helps in reducing the duplication of work and faster the payment system which eventually, increases the trust between them therefore, Amul also uses Internet of things (IoT) sensors to keep track of the temperature and quality of milk during transportation. This system allows the problem to be detected at a very early stages and make sure that only milk with high quality reaches to the processing plants for the further process. On the other hand, block chain is being used by Danone to improve transparency and traceability in the supply chain therefore they have a very decentralized strategy of milk procurement. Danone have collaborated with local and farmers and created a system or built a platform where farmers can update real time information about their milk quality and the output at the same time after which Danone confirm the truthiness of the data provide.

Milk processing

Both Amul and Danone have adopted Industry 4.0 technologies in their milk processing plants. Amul utilizes sensors to monitor temperature, pressure and humidity in their facilities to ensure optimal milk processing conditions. They have also implemented a real-time monitoring system that enables remote supervision of processing equipment. Danone, on the other hand, to improve the efficiency of milk processing operation it has embraced advance analytics and machine learning algorithms to their supply chain further, they have also employed predictive maintenance to address any equipment failure issues before they become more severe and thus they can limit the wastage by proper maintenance at an very early stage furthermore, Danone also uses virtual reality (VR) system to simulate various processing scenarios, helping them to improving their processing process and make the process more effective.

Packaging and distribution

Amul has established a sophisticated logistics network that ensures prompt delivery of their products. They have incorporated a routing system that efficiently optimizes delivery routes and utilizes GPS tracking to monitor their fleet of delivery vehicles. Furthermore, Amul has recently launched a blockchain-based platform that enables customers to trace the production and quality of their products. While Danone has set up a comparable logistics system that tracks its delivery vehicles using GPS. In order to streamline their delivery routes and guarantee on-time delivery, they also use data analytics. Danone has also put in place a digital platform that enables customers to comment on their goods and follow the status of their orders easing scenarios to find areas that could use improvement.

Industry 4.0 technologies have been implemented throughout the supply chains of Amul and Danone. Danone employs a more decentralized supply chain strategy than Amul, which is more centralized. However, in order to improve their supply chain operations, both businesses have made use of advanced analytics, IoT sensors and machine learning algorithms. They have been able to raise customer satisfaction while decreasing costs and improving product quality thanks to these technologies.

Procurement

To guarantee that the raw materials used in their products are sourced sustainably, Amul has placed a green procurement policy. They collaborate closely with nearby farmers to advance environmentally friendly farming methods and raise milk quality. Additionally, Amul has a system in place to monitor the source of milk and make sure it satisfies their quality requirements. Danone has also put in place a sustainable procurement strategy that emphasizes ethically sourced raw materials. To encourage sustainable agriculture, biodiversity and water management, they have established the “One Planet, One Health, One Nestlé” program. Working with farmers to enhance their practices and lessen their environmental impact is a crucial part of the program.

Manufacturing

Amul has seamlessly integrated eco-conscious practices into their processing facilities, encompassing rainwater collection, solar energy utilization and a zero-water

Table 1: Comparative analysis of amul and danone.

Supply chain elements	Amul	Danone
Procurement	Cooperative model, promotes sustainability farming practices	Responsible sourcing,Supports farmers in sustainable practices
Production	Solar- powered plants, efficient water management	Renewable energy, water conservation, resource efficiency
Distribution	Focus on reducing carbon footprint by use electric vehicles	Data-driven logistics, optimized routes to reduce carbon emission
Inventory management	AI-based monitoring and optimization in milk processing	AI-driven demand forecasting, inventory optimization
Customer engagement	Promotes eco-friendly practices, consumer awareness	Transparency about sustainability, responsible production

Source: Author’s compilation.

discharge policy. Moreover, they have implemented a reverse logistics system for product packaging, focusing on waste reduction and sustainability. Similarly, Danone prioritizes environmental sustainability through the adoption of eco-friendly packaging and product designs. Furthermore, they have established a closed-loop system that facilitates the recycling and reuse of materials for product packaging.

Distribution

Amul has implemented an eco-friendly distribution strategy aimed at minimizing their carbon footprint. They transport their goods using a hybrid fleet of automobiles, which includes electric and biodiesel models. Additionally, Amul has established a system of solar-powered cold storage facilities and warehouses. The "Logistics of the Future" program, launched by Danone, aims to lower their carbon footprint and boost logistics productivity. The program entails using electric vehicles, implementing smart logistics technologies and optimizing their transportation routes. The green supply chain management used by Indian and Danone differs in a number of ways. This is caused by a variety of elements, including various environmental regulations and varying levels of consumer awareness in India and Europe. Differences also result from how these two companies have approached sustainable sourcing and production methods.

The level of production, the degree of technological adoption and supply chain management procedures could all be areas where the Amul and Danone dairy supply chains either differ or reflect similarities from each other.

Scale of production

Danone dairy supply chains typically operate on a larger scale compared to Amul owing larger processing facilities and technologically more advanced, allowing for higher yields and more efficient production processes.

Technology adoption

Compared to Amul, Danone dairy supply chains frequently employ more advanced technological methods which involves using modern milking equipment, automatic feeding processes and automated monitoring systems, all of which serve to boost productivity and efficiency.

Supply chain management

Danone has more advanced supply chains often have more advanced supply chain management practices compared to Amul. This includes the use of sophisticated inventory management systems, real-time tracking of product flows and advanced logistics systems, which help to optimize the movement of products through the supply chain. Danone employed automatic and ERP system to manage the logistics system.

Price sensitivity

Dairy products are frequently regarded as necessities in India, where consumers are more price sensitive. Consumers of Danone, on the other hand, are less price sensitive and are willing to pay more for high-quality dairy products.

Challenges for Indian dairy supply chain

Due to increasing customer awareness and governmental regulations, corporations are under pressure to include sustainability into all of their essential systems, including operational, technical and welfare systems (Fredriksson and Liljestrand, 2014). In order to save transportation cost, owners and managers in the dairy firms have started taking initiatives to grow the majority of their produce nearby (Douphrate *et al*., 2006). Sustainable development in the dairy industry is critically at risk since businesses do not employ eco-friendly refrigerants in their shipping trucks or cold storage facilities (Khan *et al*., 2021). In the dairy industry, a prevailing issue often observed is the inadequate coordination between logistics, warehouses and cold storage facilities. Unfortunately, this lack of coordination often results in heightened carbon emissions on a broader scale. Organizations should use more combination modes of transportation (railroad, road-ship and road-air) in the dairy sector (Mangla *et al*., 2019). Table 2 shows the carbon footprint of dairy waste categories in 1000 tomes of CO_2 equivalent.

More than half of all dairy food waste along the value chain is composed of up of milk, which is then followed by cheese (23%), yoghurt (20%) and cream (8%). Emissions from dairy food waste account for more than 50% of the total carbon footprint, with processing coming in at 20%, consumption at 10% and retailing at 5% (Al-Obadi, 2021) therefore, Traditional supply chain management in the Indian dairy industry which are still practiced by various firms, face s several major challenges.

Quality management

Quality management is a major challenge in the Indian dairy industry as it is harvested by small farmers who do not have the resources to manage good model. Cooperatives or private companies have to ensure that the milk they collect meets from sources the already set standards. This requires regular testing as well as the monitoring of milk to ensure it is safe for human consumption. Table 3 highlights the waste matrix for Indian dairy industry with respect to supply chain elements.

Transport

Transport is a challenge for the dairy industry in India as milk has to be transported from remote locations to factories. The lack of suitable processing and transport facilities often causes the milk to deteriorate and be of poor quality. Milk is

Table 2: Carbon footprint of dairy waste categories in 1000 tones CO_2-eq.

Dairy waste category	CO_2 Equivalent emission	Percentage %
Milk	10950	84.99%
Cheese	1190	9.25%
Yogurt	570	4.46%
Cream	113	1.3%

Source: (Al-Obadi, 2021).

a nonperishable product that requires proper storage facilities to preserve its freshness and quality.

Storage

Storage is another challenge for the Indian food industry as milk must be kept at a certain temperature to stay healthy. The lack of proper storage facilities often causes milk to deteriorate and look unsightly. Proper storage is essential to preserve the freshness and quality of breast milk.

Supply chain visibility

Supply chain visibility is a huge challenge for the Indian dairy industry because the supply chain has many stakeholders including small farmers, handicraft, dairy companies, distributors and retailers. It is difficult to track the movement of milk from farm to warehouse using old and traditional practices.

Price volatility

Price volatility is a major issue for the Indian dairy industry as milk prices are determined by market forces. Small farmers producing milk often cannot get a fair price for their milk because they have to sell their milk to middlemen or intermediaries at a low price.

Role of artificial intelligence

Logistics have been managed through enterprise resource planning (ERP) from a long period of time. It is worth to mentioned that more than seventy five per cent of ERP projects failed in post operations because of various of reasons like inefficient logistic planning and process of replenishment due to unpredictable and fluctuating market demand. Excess supply of milk by farmers led to the more wastage. While there is a lack of safe food in some rising economies and on the other hand food is also being wasted by other economies (Banaeian *et al*., 2018). Supply chain management in the Indian food industry is complex and multi-stakeholder. The industry faces many challenges such as quality control, transportation, storage, supply chain visibility and price volatility as explained earlier. As per the literature it is observed that due to distorted information regarding the market forecast leads to inefficient supply of milk thus results in more wastage of products, higher inventory cost, higher transportation cost and inaccurate future prediction Artificial intelligence (AI) has the potential to significantly improve the supply chain of the Indian dairy industry by optimizing operations, reducing costs, improving quality and enhancing overall firm performance. Major advantages, the Indian dairy firm can look for are briefly summarized as follows.

Predictive analytics

Dairy companies can forecast milk production, demand for dairy products and other important variables with the aid of AI-powered predictive analytics. This can assist businesses in streamlining their production procedures, cutting waste and ensuring a consistent supply of dairy products of the highest quality.

Quality control

Artificial intelligence (AI) can monitor and analyse data from sensors, cameras and other sources to find quality problems during production. By doing so, dairy companies can reduce waste and raise the quality of their products by identifying quality issues early and taking corrective action.

Route optimization

By examining data on traffic patterns, weather and other factors, AI can be used to reduce transportation costs, speeding up deliveries and preserving the quality of their goods.

Inventory management

By examining information on demand, production capacity and other factors, AI-powered inventory management systems can assist dairy companies in optimizing their inventory levels. This can lower inventory costs for businesses, cut down on waste and guarantee a consistent supply of dairy products.

Table 3: Indian dairy waste matrix.

Supply chain element	Waste categories	Waste metrics
Raw material sourcing	• Energy waste, Material waste	• Percentage of wasted raw materials • Energy consumption per unit of raw material sourced
Production	• Energy waste, Material waste • Water waste	• Percentage of rejected or defective products • Water usage per unit of production
Transportation	• Energy waste, Carbon emissions	• Fuel consumption per mile or kilometer • Emissions per shipment
Warehousing	• Energy waste, Material waste	• Inventory obsolescence rate • Energy consumption per unit of stored inventory
Packaging	• Material waste, Packaging waste	• Percentage of unused or excess packaging materials • Packaging weight per product
Distribution	• Material waste, Carbon emissions	• Percentage of damaged products during transportation • Distance traveled per unit of product distributed

Source: Author compilation.

Supply chain visibility

AI has the potential to give supply chains real-time visibility, enabling dairy companies to follow the path of their products from the farm to the consumer. This can aid businesses in locating bottlenecks, speeding up deliveries and ensuring the quality and freshness of their goods.

Overall, The efficiency, quality and overall firm performance of dairy companies could be significantly enhanced by the application of AI in the Indian dairy supply chain. Dairy companies can optimize their operations, cut costs, raise quality and become more competitive in the market by utilizing AI-powered tools and analytics. To meet these challenges, the supply chain must be improved and integrated with technology and automation. This will result in better management, reduced transport and storage and better prices for small farmers.

CONCLUSION AND RECOMMENDATIONS

The current study has discussed traditional as well as modern supply chain management in Indian dairy industry with special reference to Amul. Comparative analysis of Amul with Danone clearly indicated the importance and need of sustainable supply chain management practices. The study found that availability of real time information as well adoption of modern technology like artificial intelligence across the supply chain might lead to accurate assessment of demand and supply situation which alternatively might resulted in reduced wastages of resources and products. There are two major limitations of the present study. First, it primarily focused supply chain management for only Amul and Danone, which are market leaders in India and France respectively. Second, the analysis for both firms were relied on scholarly literatures or report available. Further research can be done to examine the role of artificial intelligence and its impact on supply chain performance with special reference to sustainability through empirical study in the Indian dairy industry.

Conflict of interest

All authors declare that they have no conflicts of interest.

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