

Review

Digital Transformation in the Food and Beverage Industry: Best Practices for Supply Chain Optimization

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Abstract: This paper explores the transformative role of digital technologies in optimizing supply chain processes within the food and beverage industry. It discusses the current challenges faced by supply chains, including inefficiencies, food safety concerns, and regulatory compliance issues. The paper highlights key digital technologies driving this transformation, such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, and Blockchain. These technologies enhance operational efficiency, improve decision-making, and provide greater transparency and traceability throughout the supply chain. The paper also outlines best practices for implementing digital transformation, including strategic planning, integration of digital tools, change management, and continuous improvement. By examining case studies of leading companies, the paper demonstrates the potential for digital technologies to address supply chain challenges and improve overall performance. The findings suggest that the successful adoption of these technologies can lead to increased efficiency, enhanced food safety, and improved consumer trust, ultimately driving better business outcomes.

Keywords: digital transformation; food and beverage industry; supply chain optimization; Internet of Things (IoT); Artificial Intelligence (AI); big data analytics; blockchain; transparency; traceability; food safety

1. Introduction to Digital Transformation in the Food and Beverage Industry

1.1. Overview of Digital Transformation

Digital transformation involves integrating technologies like AI, IoT, big data, and cloud computing to improve business processes. In the food and beverage industry, it has become essential for optimizing supply chains, enhancing product quality, and meeting consumer demands for transparency and efficiency.

This sector, driven by global supply chains and fast-changing market trends, benefits from digital tools that enable real-time tracking, data-driven decisions, and greater operational efficiency. IoT devices, for example, monitor product conditions throughout the supply chain, while AI helps forecast demand and optimize inventory. Blockchain also enhances traceability and product authenticity, fostering trust.

Embracing digital transformation allows food and beverage companies to reduce costs, enhance resilience, and adapt to changing consumer needs, positioning them for future growth.

1.2. Current Challenges in Food and Beverage Supply Chains

The food and beverage supply chain faces key challenges, including the need for greater transparency and traceability to meet consumer demands for information on food origins and safety. Supply chain disruptions, driven by global events like the COVID-19

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pandemic and extreme weather, lead to delays, increased costs, and inventory shortages, exposing the lack of resilience in current systems.

Food waste is another issue, with inefficiencies in production, storage, and transport causing spoilage and losses. Additionally, shifting consumer preferences and regulatory requirements demand more agile supply chains, but many companies still rely on outdated systems that struggle to keep pace. Addressing these challenges calls for the adoption of digital technologies to enhance transparency, efficiency, and flexibility.

1.3. Role of Digital Transformation in Addressing Supply Chain Issues

Digital transformation plays a crucial role in solving many of the food and beverage industry's supply chain challenges. Technologies like the Internet of Things (IoT) provide real-time monitoring of products throughout the supply chain, enhancing transparency and traceability. This ensures better quality control, reduces food waste, and builds consumer trust by offering detailed insights into product origins and handling.

Artificial intelligence (AI) and data analytics improve demand forecasting, allowing companies to optimize inventory levels, reduce overproduction, and avoid shortages. These tools also enhance decision-making by predicting disruptions and suggesting more efficient logistics routes.

Blockchain technology adds another layer of traceability, ensuring the authenticity and safety of products while simplifying compliance with regulatory standards. By leveraging these digital tools, food and beverage companies can build more resilient, agile, and efficient supply chains that are better equipped to handle disruptions and adapt to market changes.

Digital transformation not only addresses current issues but also positions companies for long-term success by enabling them to be more responsive, data-driven, and sustainable.

2. Key Digital Technologies Driving Supply Chain Optimization

2.1. Internet of Things (IoT) in the Food and Beverage Supply Chain

The Internet of Things (IoT) is transforming the food and beverage supply chain by providing real-time monitoring and data collection throughout the entire process, from production to distribution. IoT devices, such as sensors and smart tags, track key factors like temperature, humidity, and location, ensuring that perishable goods are stored and transported under optimal conditions. This reduces spoilage, improves product quality, and enhances food safety.

IoT also strengthens traceability, allowing companies to monitor the movement of products at each stage of the supply chain. This increased visibility helps businesses quickly identify and address issues like contamination or delays, improving overall operational efficiency. For consumers, IoT-driven transparency boosts trust, as they can access detailed information about the origin and journey of their food products.

Furthermore, IoT enables predictive maintenance of equipment and vehicles, minimizing downtime and ensuring smooth supply chain operations. By integrating IoT into their supply chains, food and beverage companies can reduce costs, improve sustainability, and respond more swiftly to market demands and disruptions [1].

Specific Case Studies:

- 1) **Walmart and IoT for Food Safety:** Walmart has implemented IoT technology to enhance food safety in its supply chain. By using IoT sensors to monitor temperature and humidity in storage facilities and transportation vehicles, the company ensures that perishable items, such as dairy and meat, are kept under ideal conditions. This proactive approach reduces spoilage rates and enhances food safety, as any deviations can be addressed immediately.
- 2) **Nestlé's Smart Packaging:** Nestlé has introduced smart packaging equipped with IoT sensors that provide real-time data on the freshness and quality of its

products. These smart tags allow retailers and consumers to monitor the condition of products, enhancing traceability and ensuring optimal quality. This initiative not only improves customer satisfaction but also reduces food waste by ensuring that products are consumed before they spoil.

- 3) Heineken's Brewery Operations: Heineken has integrated IoT technology into its brewery operations to optimize production and supply chain efficiency. Sensors monitor equipment performance and environmental conditions, enabling predictive maintenance to prevent breakdowns. This integration has led to improved efficiency, reduced downtime, and enhanced sustainability by minimizing energy consumption during production.
- 4) Coca-Cola's Smart Vending Machines: Coca-Cola has deployed IoT-enabled vending machines that collect data on consumer preferences and inventory levels. This technology allows the company to optimize restocking schedules based on real-time sales data, reducing waste and ensuring that popular products are always available. The smart vending machines also enable Coca-Cola to engage with customers through personalized promotions based on their purchasing habits.

2.2. Artificial Intelligence and Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML) are revolutionizing the food and beverage supply chain by enhancing decision-making and automating processes. AI algorithms analyze vast amounts of data to optimize key operations, such as demand forecasting, production planning, and inventory management. This allows companies to better predict market demand, reducing overproduction and stockouts, ultimately cutting costs and waste.

ML models improve supply chain efficiency by learning from historical data to suggest optimal logistics routes, adjust production schedules, and even predict potential disruptions. This proactive approach helps companies respond quickly to changes in demand or external factors, ensuring smoother and more resilient operations.

Additionally, AI-powered analytics enable real-time monitoring of supply chain performance, identifying bottlenecks and inefficiencies that can be addressed promptly. AI is also used in quality control, where it detects anomalies in production, such as defective products or safety issues, helping to ensure consistent quality and compliance with regulations [2].

By integrating AI and ML into supply chains, food and beverage companies can streamline operations, reduce costs, and respond more effectively to market shifts while continuously improving supply chain performance.

Specific Case Studies:

1. PepsiCo's Demand Forecasting: PepsiCo has leveraged AI and ML to improve its demand forecasting capabilities. By analyzing historical sales data, market trends, and external factors, PepsiCo's AI algorithms can predict demand with high accuracy. This enhanced forecasting helps the company optimize production schedules and inventory levels, significantly reducing waste and ensuring product availability.

2. Nestlé's Supply Chain Optimization: Nestlé employs AI-driven analytics to optimize its supply chain operations. The company uses machine learning models to analyze data from various sources, including weather patterns, social media trends, and consumer behavior. This data-driven approach allows Nestlé to make informed decisions regarding production planning, logistics, and inventory management, ultimately improving efficiency and reducing costs.

3. Coca-Cola's AI-Powered Logistics: Coca-Cola utilizes AI to optimize its logistics operations by analyzing traffic patterns, weather conditions, and delivery schedules. Machine learning algorithms recommend the most efficient routes for delivery trucks, minimizing fuel consumption and reducing delivery times. This technology not only improves

operational efficiency but also contributes to sustainability efforts by lowering the carbon footprint of their logistics operations.

4. Unilever's Quality Control: Unilever has implemented AI technologies in its quality control processes. By using machine learning algorithms to analyze production data, Unilever can detect anomalies and quality issues in real time. This proactive approach ensures that defective products are identified and addressed quickly, maintaining consistent quality standards and compliance with safety regulations.

2.3. Big Data and Advanced Analytics

Big data and advanced analytics are critical for optimizing the food and beverage supply chain by providing deeper insights and more accurate decision-making. With the ability to process large volumes of data from various sources—such as sales trends, customer preferences, and supply chain performance—big data helps companies better understand market dynamics and consumer behavior.

Advanced analytics tools can identify patterns and trends in supply chain operations, allowing for more accurate demand forecasting, efficient inventory management, and streamlined logistics. By analyzing real-time data, companies can predict potential disruptions, optimize delivery routes, and adjust production schedules to avoid bottlenecks, reducing costs and enhancing operational efficiency.

Moreover, big data analytics play a vital role in improving food safety and quality control. By monitoring data from IoT devices and other sources, companies can track product conditions, detect risks, and ensure compliance with regulatory standards. This helps maintain consistent product quality and reduce food waste.

Overall, leveraging big data and advanced analytics enables food and beverage companies to enhance supply chain transparency, agility, and sustainability, driving better performance and customer satisfaction.

Specific Case Studies:

- 1) Kraft Heinz's Demand Forecasting: Kraft Heinz employs advanced analytics to improve its demand forecasting accuracy. By analyzing historical sales data, market trends, and social media insights, the company can predict consumer demand for its products more effectively. This data-driven approach minimizes stockouts and overproduction, ultimately leading to cost savings and improved customer satisfaction.
- 2) AB InBev's Supply Chain Optimization: Anheuser-Busch InBev (AB InBev) utilizes big data analytics to optimize its supply chain processes. The company analyzes data from various sources, including sales patterns, weather forecasts, and local events, to enhance inventory management and distribution strategies. This helps AB InBev ensure that products are available in the right places at the right times, reducing waste and improving efficiency.
- 3) Dole Food Company's Food Safety Monitoring: Dole Food Company leverages big data analytics to enhance food safety and quality control. By integrating data from IoT sensors monitoring temperature and humidity in storage and transportation, Dole can track the condition of its products throughout the supply chain. This proactive monitoring allows the company to quickly identify and address potential risks, ensuring compliance with safety regulations and maintaining product quality.
- 4) Starbucks' Customer Insights: Starbucks uses advanced analytics to gain insights into customer preferences and behaviors. By analyzing purchasing data and customer feedback, the company can tailor its product offerings and marketing strategies to better meet consumer demands. This data-driven approach not only enhances customer satisfaction but also optimizes inventory management and reduces waste.

2.4. Blockchain for Transparency and Traceability

Blockchain technology is transforming the food and beverage supply chain by enhancing transparency and traceability. As a decentralized and tamper-proof digital ledger, blockchain allows every transaction or movement of goods within the supply chain to be securely recorded and verified. This provides an immutable record of a product's journey, from its origin to the final consumer, ensuring full traceability.

For food safety, blockchain helps quickly trace the source of contamination or recalls, reducing risks to public health and minimizing disruptions. It also assures consumers that products meet safety, quality, and sustainability standards, fostering greater trust in the supply chain.

Blockchain further simplifies regulatory compliance by creating a transparent and auditable record of product data. This helps companies prove the authenticity of their products and comply with food safety regulations, reducing the risk of fraud or mislabeling [1,2].

By integrating blockchain into their supply chains, food and beverage companies can enhance transparency, improve efficiency, and build stronger relationships with consumers and partners, all while ensuring better product safety and authenticity.

Specific Case Studies:

- 1) **Walmart's Blockchain Food Safety Initiative:** Walmart has implemented blockchain technology to improve food safety and traceability in its supply chain. The company uses IBM's Food Trust blockchain to track the journey of fresh produce, enabling it to trace the origin of food products within seconds. In one instance, Walmart successfully traced a shipment of mangoes back to its source in just 2.2 seconds, compared to the previous method that took days. This rapid traceability enhances food safety and allows for quicker responses to contamination issues.
- 2) **Nestlé's Blockchain Pilot:** Nestlé is testing blockchain technology to enhance transparency in its supply chain, particularly for its coffee products. Through a pilot program in partnership with IBM, Nestlé allows consumers to trace the origin of their coffee from farm to cup using a blockchain system [3]. This initiative not only provides consumers with information about the sourcing and quality of their coffee but also supports farmers by ensuring they are fairly compensated.
- 3) **Tyson Foods and IBM Food Trust:** Tyson Foods has joined the IBM Food Trust network to utilize blockchain for improving traceability in its supply chain. The company aims to enhance the safety and quality of its chicken products by providing detailed information about the farming, processing, and distribution stages. By sharing this information with consumers and partners, Tyson Foods can build trust and ensure compliance with food safety regulations.
- 4) **Cargill's Digital Traceability Program:** Cargill has implemented a blockchain-based digital traceability program for its beef supply chain. This initiative allows consumers to access information about the origin of their beef products, including details about the farms where the cattle were raised [4]. By enhancing transparency, Cargill aims to address consumer concerns about food safety and sustainability while improving its overall supply chain efficiency.

3. Best Practices for Implementing Digital Transformation in Supply Chain Optimization

3.1. Strategic Planning and Goal Setting

Successful digital transformation in supply chain optimization begins with strategic planning and clear goal setting. Companies must first assess their current supply chain

operations, identifying areas where digital technologies can drive the most significant improvements. This involves understanding key pain points, such as inefficiencies in logistics, lack of transparency, or difficulties in demand forecasting.

Once areas for improvement are identified, businesses should set measurable goals aligned with their broader strategic objectives. These goals could include reducing lead times, minimizing costs, enhancing product traceability, or improving customer satisfaction. A well-defined roadmap for digital transformation should prioritize initiatives based on their potential impact and ease of implementation [5-7].

Additionally, companies must ensure that their digital transformation strategies are flexible and adaptable, allowing them to respond to changing market conditions or new technological advancements. This strategic alignment ensures that the integration of digital tools like AI, IoT, or blockchain directly supports the company's overall growth and efficiency goals.

By taking a thoughtful and goal-oriented approach, food and beverage companies can ensure that their digital transformation efforts are targeted, effective, and aligned with long-term success.

3.2. Integration of Digital Tools Across the Supply Chain

Integrating digital tools across the supply chain is essential for maximizing the benefits of digital transformation. This process involves adopting and seamlessly incorporating technologies like IoT, AI, big data, and blockchain into every stage of the supply chain, from production and procurement to logistics and distribution [8].

To achieve this, companies should start by implementing IoT devices for real-time monitoring of inventory, production processes, and transportation conditions. These devices provide crucial data on product quality, storage environments, and location, helping to optimize operations and reduce waste.

AI and machine learning can be integrated into demand forecasting and logistics planning, allowing companies to make data-driven decisions that improve efficiency and reduce costs. Big data analytics further enhances this by offering insights into consumer behavior, market trends, and supply chain performance, driving more precise decision-making.

Blockchain technology can be applied to enhance traceability and transparency, ensuring every step in the supply chain is secure, verifiable, and compliant with regulatory standards [9].

The key to successful integration is ensuring these tools work together seamlessly, creating a unified digital ecosystem. This requires strong collaboration across departments and clear communication to ensure all stakeholders understand the benefits and capabilities of these technologies. By fully integrating digital tools, companies can create a more efficient, resilient, and customer-focused supply chain.

3.3. Change Management and Workforce Adaptation

Change management is crucial for successfully implementing digital transformation in the supply chain, as it ensures that employees and stakeholders are aligned with new processes and technologies. Workforce adaptation is a key component, as employees must be prepared to use new digital tools effectively [10].

To facilitate this, companies should provide comprehensive training programs that familiarize staff with technologies such as AI, IoT, and blockchain. This empowers employees to leverage these tools in their daily operations, improving efficiency and decision-making.

Effective communication is also essential. Leaders must clearly convey the benefits of digital transformation, address concerns, and foster a culture of innovation. Encouraging collaboration and feedback ensures that the workforce remains engaged and responsive to the changes [11,12].

Additionally, adapting to digital transformation may require restructuring roles or workflows to fully integrate new technologies. Companies should be flexible and open to refining processes to ensure smooth implementation and long-term success.

By focusing on change management and workforce adaptation, businesses can ensure that their employees are equipped to embrace digital transformation, driving continuous improvement across the supply chain [13].

3.4. Continuous Monitoring and Improvement

Continuous monitoring and improvement are essential to the success of digital transformation in the supply chain. After implementing digital tools, businesses must establish systems for ongoing performance tracking [14]. This involves using real-time data from IoT sensors, AI analytics, and other digital platforms to monitor key supply chain metrics such as lead times, inventory levels, and product quality.

Regular analysis of this data allows companies to identify inefficiencies, bottlenecks, or disruptions and make proactive adjustments. Continuous improvement frameworks like Six Sigma or Lean can be integrated with digital tools to refine processes and enhance operational efficiency over time.

Feedback loops are also crucial. By gathering insights from employees, customers, and stakeholders, companies can adapt their digital strategies and technologies to evolving market conditions and needs. This approach ensures that the supply chain remains agile, resilient, and optimized for long-term success.

Through continuous monitoring and improvement, food and beverage companies can sustain the benefits of digital transformation, stay competitive, and drive innovation in their supply chains.

4. Case Studies and Future Trends in Supply Chain Digitalization

4.1. Case Study: Digital Transformation in a Leading Food and Beverage Company

A leading food and beverage company successfully implemented digital transformation to optimize its supply chain, addressing key challenges like inefficiencies in logistics, inventory management, and product traceability. By integrating IoT sensors throughout its supply chain, the company gained real-time visibility into product conditions, including temperature and humidity, which significantly reduced spoilage during transport and storage [15].

The company also adopted AI-driven demand forecasting, allowing it to predict consumer needs more accurately and reduce excess inventory. Machine learning algorithms were employed to optimize logistics routes, reducing delivery times and operational costs. Additionally, blockchain technology was used to ensure full traceability of products from farm to consumer, enhancing food safety and building consumer trust.

As a result, the company not only improved its supply chain efficiency but also achieved greater transparency and resilience. This digital transformation enabled them to adapt quickly to market changes, meet regulatory requirements, and strengthen their competitive edge in the industry. The case illustrates how strategic use of digital tools can drive supply chain excellence in the food and beverage sector [16].

4.2. Emerging Trends in Digital Supply Chain Management

Emerging trends in digital supply chain management are reshaping how food and beverage companies operate and compete in the marketplace. Key trends include:

- 1) **Increased Adoption of Artificial Intelligence (AI):** AI is increasingly used for predictive analytics, enabling companies to forecast demand more accurately and optimize inventory levels. This trend helps businesses respond proactively to market changes, reducing waste and costs [17].
- 2) **Sustainability and Circular Supply Chains:** There is a growing focus on sustainability, with companies adopting practices that minimize waste and promote

resource recycling. Circular supply chains aim to reduce the environmental impact of production and distribution, aligning with consumer demand for eco-friendly products.

- 3) **Enhanced Collaboration through Digital Platforms:** Digital collaboration tools facilitate better communication among suppliers, manufacturers, and distributors. These platforms enable real-time data sharing and improve coordination, leading to more efficient operations and quicker responses to disruptions.
- 4) **Blockchain for Enhanced Transparency:** Blockchain technology is becoming more prevalent for ensuring product authenticity and traceability. Companies are leveraging blockchain to provide consumers with verifiable information about product origins, safety, and compliance with regulatory standards.
- 5) **Supply Chain Resilience through Digital Twins:** Digital twin technology allows companies to create virtual replicas of their supply chains, enabling simulation and analysis of different scenarios. This helps businesses identify vulnerabilities and develop strategies to enhance resilience against disruptions.
- 6) **Focus on Cybersecurity:** As supply chains become increasingly digitized, the importance of cybersecurity grows. Companies are investing in robust security measures to protect sensitive data and ensure the integrity of their operations [18,19].

4.3. Challenges and Opportunities Ahead

As the food and beverage industry embraces digital supply chain management, several challenges and opportunities emerge:

Challenges:

Integration Complexity: Implementing new digital technologies often involves integrating multiple systems and platforms. Companies may face difficulties ensuring compatibility and data flow between existing and new technologies, leading to potential disruptions in operations.

Cost of Implementation: The initial investment required for digital transformation can be substantial, particularly for small to medium-sized enterprises. Companies must balance upfront costs with the long-term benefits of enhanced efficiency and productivity.

Data Security and Privacy: As supply chains become more digitized, the risk of cyberattacks and data breaches increases. Companies must invest in robust cybersecurity measures to protect sensitive information and maintain consumer trust.

Workforce Resistance: Employees may be hesitant to adopt new technologies or change established workflows. Effective change management strategies and ongoing training are essential to foster a culture of innovation and adaptability.

Opportunities:

Enhanced Efficiency and Cost Reduction: Digital technologies can streamline operations, reduce waste, and optimize resource allocation, leading to significant cost savings and improved profitability.

Improved Consumer Engagement: With increased transparency and traceability, companies can build stronger relationships with consumers. Providing detailed product information and engaging customers through digital platforms can enhance brand loyalty.

Agility in Response to Market Changes: Digital supply chains enable companies to respond swiftly to shifts in consumer demand or market conditions. This agility allows businesses to capitalize on emerging trends and stay competitive.

Sustainability Initiatives: Digital tools can help companies track their environmental impact and implement sustainable practices throughout the supply chain. This focus on sustainability can attract eco-conscious consumers and differentiate brands in the marketplace.

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