ỨNG DỤNG DỮ LIỆU LỚN VÀ INTERNET VẠN VẬT TRONG QUẢN LÝ CHUỖI CUNG ỨNG THỜI TRANG TẠI VIỆT NAM: TRƯỜNG HỢP UNIQLO VÀ CÁC ĐỀ XUẤT CHO DOANH NGHIỆP THỜI TRANG VIỆT NAM

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Tóm tắt

Chuỗi cung ứng ngành thời trang đã thay đổi sâu sắc nhờ việc ứng dụng của phân tích Dữ Liệu Lớn và các nền tảng Internet Vạn Vật, giúp quản lý chuỗi cung ứng toàn diện với khả năng theo dõi thời gian thực, dự báo nhu cầu và kiểm soát tồn kho tự động. Trường hợp của UNIQLO cho thấy cách các "nhà máy thông minh" tích hợp Internet Vạn Vật tại Trung Quốc, cùng hệ thống bù đắp hàng theo phương thức sản xuất tức thời dựa trên công nghệ nhận dạng qua tần số vô tuyến và hệ thống quản lý chuỗi toàn diện, có thể đơn giản hóa khâu mua sắm nguyên liệu, sản xuất, lưu kho, vận chuyển và phân phối bán lẻ trên một nền tảng số duy nhất. Nghiên cứu sử dụng phương pháp nghiên cứu tình huống định tính, kết hợp phân tích các báo cáo ngành, tài liệu học thuật và báo cáo bền vững của UNIQLO, áp dụng khung phân tích SWOT. Các chỉ số hiệu suất chính bao gồm giảm thời gian chu trình, vòng quay tồn kho và độ chính xác dự báo đã được so sánh giữa hoạt động toàn cầu của UNIQLO và các dự án đầu tiên tại Việt Nam. Nghiên cứu này phân tích việc ứng dụng Dữ Liệu Lớn và Internet Vạn Vật trong quản lý chuỗi cung ứng thời trang tại Việt Nam dựa trên hành trình chuyển đổi số của UNIQLO, nhằm xác định điểm mạnh, điểm yếu, cơ hội và thách thức, đồng thời đề xuất các khuyến nghị thực tiễn cho các doanh nghiệp thời trang Việt Nam trong quá trình triển khai chuyển đổi số.

Từ khoá: quản lý chuỗi cung ứng, dữ liệu lớn, internet vạn vật, ngành thời trang, UNIQLO

APPLICATION OF BIG DATA AND INTERNET OF THINGS IN VIETNAM'S

FASHION SUPPLY CHAIN MANAGEMENT: THE CASE OF UNIQLO AND RECOMMENDATIONS FOR VIETNAM'S FASHION FIRMS

Abstract

The fashion supply chain has experienced a major change with the arrival of Big Data analytics and Internet of Things (IoT) platforms, making complete supply chain management (SCM) possible with real time visibility, demand forecasting, and automated inventory control. UNIQLO's example shows how IoT enabled smart factories in China, RFID driven Just in Time (JIT) replenishment, and a Total Chain Management system can simplify procurement, production, warehousing, logistics, and retail on a single digital platform. A qualitative case study approach was used, drawing on industry reports, academic literature, and UNIQLO's sustainability and integrated reports, combined with a SWOT framework. Key performance indicators such as lead time reduction, inventory turnover, and forecast accuracy were compared between UNIQLO's global operations and initial projects in Vietnam. This study examines the application of Big Data and IoT in Vietnam's fashion SCM by learning from UNIQLO's digital transformation. It aims to identify internal strengths and weaknesses, external opportunities and threats, and to develop practical recommendations for Vietnamese fashion firms adopting digital transformation.

Key words: supply chain management, big data, internet of things, fashion industry, UNIQLO

Introduction

The global fashion industry has entered an era of digital transformation, driven by the combination of Big Data analytics and the Internet of Things in end-to-end supply chain management. In particular, UNIQLO's implementation of IoT enabled smart factories in China, where production lines are activated automatically and real-time operational status is shared with headquarters in Tokyo, demonstrates how real-time tracking, predictive analytics, and integrated SCM platforms can simplify procurement, manufacturing, inventory control, logistics, and retail on a single digital platform. By using Big Data-driven demand forecasting and improved inventory planning, UNIQLO has achieved increased supply chain visibility, cut stock-out risks, and enhanced customer responsiveness.

Despite clear benefits, many Vietnamese fashion firms struggle to replicate such digital SCM models due to fragmented data sources, limited IoT infrastructure, early-stage analytics capabilities, and concerns over data security. These challenges impede accurate demand forecasting, efficient warehouse management and end-to-end logistics coordination, especially critical in a post-pandemic environment where resilience and flexibility are crucial. Without a clear digital SCM strategy, firms risk excess inventory, longer lead times, and lower competitiveness in both domestic and e-commerce channels.

This study applies a SWOT framework to evaluate the integration of Big Data and Internet of Things technologies in Vietnam's fashion supply chain management, and offers practical recommendations for fashion firms. We address these research questions:

1. What strengths and weaknesses do Vietnamese fashion companies exhibit when adopting

Big Data-driven demand forecasting and IoT based real-time tracking in their SCM processes?

2. Which opportunities and threats influence the digitalization of procurement, production scheduling, warehouse operations, and last-mile delivery in Vietnam's fashion sector?

3. How can lessons learnt from UNIQLO's end-to-end SCM implementation inform best practices for technology integration among Vietnamese fashion firms?

4. What strategic recommendations should fashion companies in Vietnam follow to improve data governance, strengthen cybersecurity in SCM, and enhance customer experience through personalized offerings?

This analysis reveals that adopting Big Data and IoT can transform Vietnam's fashion SCM into a more flexible, transparent, and customer-focused network. UNIQLO's best practices, such as weekly data-driven production adjustments, RFID-ERP integration, and customer feedback loops, offer actionable insights for enhancing supply chain responsiveness and resilience in Vietnam. A detailed digital roadmap supported by workforce training, infrastructure investments, and public-private partnerships is essential to overcome current limitations and build long-term supply chain resilience.

1. Theoretical framework

1.1. Overview of Fashion Supply Chain Management in Fashion Industry

1.1.1. Fashion Supply Chain

The fashion supply chain refers to the entire process of creating and delivering fashion products, from the initial design and manufacturing of garments to their distribution and retailing. The movement of a garment from concept to customer involves several key stages under supply chain management and logistics.

It starts with Tier 4 sourcing of natural fibers (cotton, wool, silk, jute) and petrochemical feedstocks, vetted through strategic procurement and sustainability audits. Fibers move into Tiers 3 and 2 for spinning and fabric formation under quality-controlled processes. At Tier 1, the lead firm balances in-house production and contract manufacturing, using production-planning systems, in-line inspections and SPC. Finished goods enter the export network, buying offices or trading companies manage documentation, customs and multimodal TMS routing then flow into WMS-driven distribution centers for put-away, inventory visibility and pick-and-pack. Finally, retail and e-commerce channels use POS data and CRM to drive replenishment and promotions, while reverse logistics handles returns and feeds insights into forecasting.

Figure 1: The Textile and Clothing Supply Chain
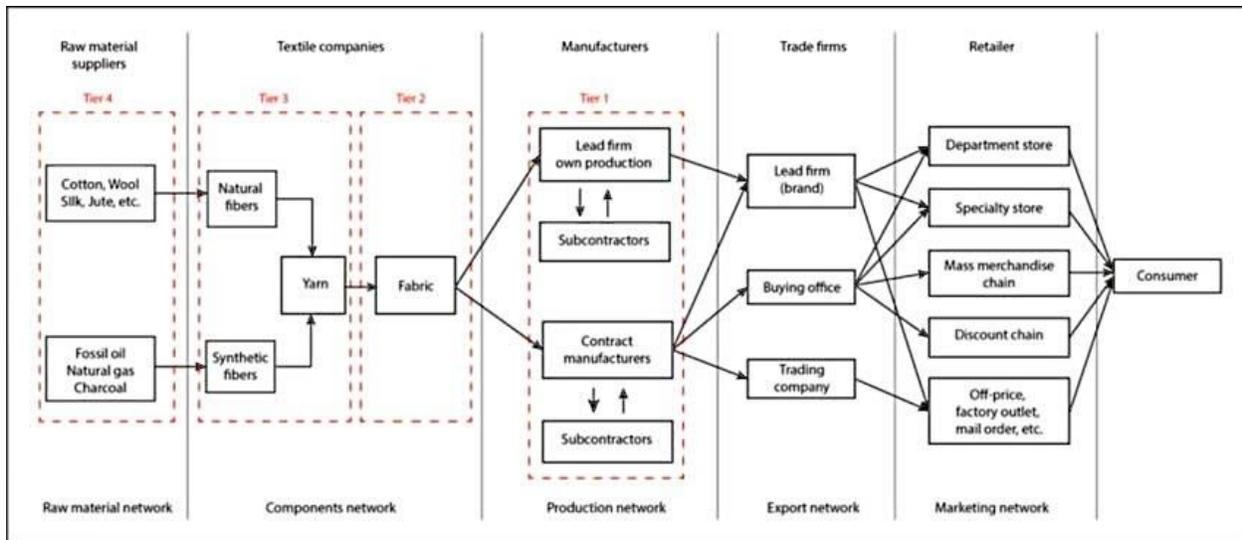
An effective supply chain brings together design, sourcing, production, logistics and retail to help fashion brands lower costs, speed up product launches, and tap into global expertise. By coordinating suppliers, manufacturers, transport partners and stores, companies can cut waste, control inventory, and respond quickly to changing trends. At the same time, a focus on sustainable sourcing and ethical manufacturing reduces environmental impact. Clear communication across all stages, from raw material procurement to last-mile delivery, ensures smooth operations, keeps lead times short, and maintains quality, making it vital for success in today's fast-paced market.

1.1.2.   Current status of Fashion Industry in Vietnam

Vietnam's fashion industry has grown rapidly over the past decade, transforming from an agriculture-based economy into a global manufacturing hub. Garment and textile products rank as the country's second-largest export category. Major markets include the United States, the European Union, and Japan, all of which demand high quality and strict compliance with lead-time schedules. This success relies on a skilled, low-cost workforce, which has drawn foreign direct investment into both company-owned plants and local subcontractors.

On the domestic front, rapid urbanization, rising incomes, and a young population are driving demand for both budget-friendly and premium brands.. International brands such as Zara, H&M, UNIQLO, and Gucci continue to expand their store networks, using data-driven inventory management and integrated logistics to improve sales efficiency. Local labels are increasing their physical presence, meeting consumers' growing preferences for homegrown fashion and traditional wear.

Despite these strengths, Vietnam's fashion supply chain faces several critical challenges. First, raw material sourcing remains heavily dependent on imports particularly cotton and yarn, exposing companies to price swings and delivery delays. Moreover, distribution channels are often fragmented: small-scale retailers and informal markets coexist alongside modern retail and e-commerce platforms, complicating order fulfillment and last-mile delivery.

1.2. Big Data and IoT in Fashion Supply Chain Management

1.2.1. The Concept of Big Data and IoT

The rapid evolution of technology in recent decades has transformed traditional supply chain management into data-driven and technology-integrated systems. Two critical enablers of this transformation are Big Data and the Internet of Things (IoT).

Big Data refers to the ability to collect, process, and analyze massive volumes of structured and unstructured data in real-time. In the context of the fashion industry, this includes customer purchasing behavior, social media trends, sales transactions, and operational data. Leveraging Big Data allows companies to forecast demand more accurately, optimize inventory, and personalize customer experiences (Majeed and Rupasinghe, 2017).

IoT, on the other hand, connects physical objects such as RFID tags, sensors, and smart devices to digital systems, enabling real-time data capture and communication across the supply chain. This connectivity facilitates end-to-end visibility from production to delivery, allowing companies to track the status and location of materials, monitor production performance, and manage inventory levels dynamically (Majeed and Rupasinghe, 2017).

The integration of Big Data and IoT supports the vision of Industry 4.0, where cyber-physical systems, cloud computing, and smart factories create intelligent, adaptive, and highly responsive supply chains (Majeed and Rupasinghe, 2017).

1.2.2. Key applications in Fashion Supply Chain Management

Quick Response (QR) and Demand-Driven Production

Fashion supply chains are highly sensitive to changing consumer preferences and market volatility. Leveraging Big Data enables fashion brands to shift from forecast-driven production to demand-driven models, allowing faster response to real-time market signals (Wei, 2017).

Real-Time Inventory and Warehouse Management

IoT technologies such as RFID enable real-time tracking of inventory, improving stock visibility and reducing manual errors. By integrating RFID with ERP systems, companies can automate inbound and outbound processes, reducing processing times and increasing operational efficiency (Majeed and Rupasinghe, 2017). This is particularly relevant in fast fashion supply chains where time-to-market is critical.

End-to-End Supply Chain Visibility and Traceability

IoT enables continuous tracking of garments through RFID tags and smart sensors. This real-time visibility improves logistics management, reduces stockouts, and supports sustainability goals by ensuring transparency in sourcing and distribution (Sharma, 2024).

Process Automation through SAP BAPI and RFID

Integrating SAP BAPI (Business Application Programming Interface) with RFID allows fashion brands to automate data entry and transaction execution in ERP systems. This reduces labor costs, minimizes errors, and accelerates order processing, enhancing the overall efficiency of inbound and outbound logistics (Majeed and Rupasinghe, 2017).

IoT in Brand Protection

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IoT technologies like RFID tags and QR codes play a vital role in brand protection, allowing customers to verify product authenticity and helping brands combat counterfeiting and unauthorized distribution (Sharma, 2024).

Preparation for Future Smart Factories and Industry 4.0

The integration of IoT supports the development of smart factories, where connected machines and systems enable self-optimizing, real-time manufacturing. This shift towards Industry 4.0 positions fashion brands to improve productivity, reduce waste, and stay competitive in the digital economy (Majeed and Rupasinghe, 2017).

2. Application of Big Data and Internet of Things in UNIQLO's Supply Chain Management

2.1. Overview of UNIQLO's Supply Chain Strategy

2.1.1. Overview of UNIQLO

Uniqlo is one of the world's most recognized fashion brands and is a subsidiary of Fast Retailing, the largest value-focused apparel retailer. Established by Tadashi Yanai in 1949 in Ube, Yamaguchi, Japan, Uniqlo embraces the principles of Shun and Kino-bi. To uphold these philosophies, the company continuously refines its supply chain management, boosting agility, reducing lead times, and optimizing time-to-market to ensure products reach consumers at precisely the right moment (Hyde, 2007).

UNIQLO's global expansion has positioned the brand in major markets such as the United States, China, Europe, and Southeast Asia. UNIQLO differentiates itself from fast fashion competitors by designing products six to twelve months in advance, focusing on timeless and high-quality basics instead of rapidly changing fashion trends (Antoni and Mao, 2022).

2.1.2. Overview of UNIQLO's Supply Chain Management

UNIQLO's supply chain is anchored in material-centric demand planning and long-cycle R&D. Annual roadmaps are set via trend forecasting and lifestyle analytics at Tokyo and New York hubs, feeding into PLM one year before launch. POS data drives iterative prototyping with cross-functional reviews, while ongoing customer feedback is funneled through a web-based CSQ into continuous product refinement.

The SPA model enables UNIQLO to control all key supply chain stages from product planning, material procurement, and manufacturing to retail operations by eliminating intermediaries (Wei, 2017). This direct control reduces costs, improves quality management, and accelerates the connection between production and customer demand (Lan, 2024). Procurement leans on SRM with tier-1 partners like TORAY for co-development of HEATTECH and Silky Dry fabrics, enforcing ethical sourcing policies to avoid forced-labor regions, and embedding risk-sharing clauses for supply disruptions.

UNIQLO applies **a dual production strategy**, combining in-house manufacturing with partnerships with over 70 manufacturers worldwide. These manufacturers are selected through strict screening processes, and UNIQLO maintains consistent product quality through technical support systems like the Craftsman System (Wei, 2017). Production follows an asset-light OEM strategy, leveraging over 120 partners across Asia to optimize unit costs via bulk buys and direct

negotiation. External labs and the veteran Takumi Team perform compliance testing (formalin, durability, colorfastness) and on-site audits to standardize processes.

In logistics, Fast Retailing's ¥100 billion investment in AS/RS and robotic picking (with Daifuku & Mujin) slashed manual labor by 90% and enabled 24/7 operations. A hub-and-spoke network with 3PLs funnels goods from factories to regional DCs, ensuring agile replenishment. Real-time inventory visibility via Casio IT-300 devices and data-driven JIT planning, bolstered by the TCM system (weekly HQ–store syncs), drives ten-day restocking and superior responsiveness

Figure 2: UNIQLO's original supply chain model
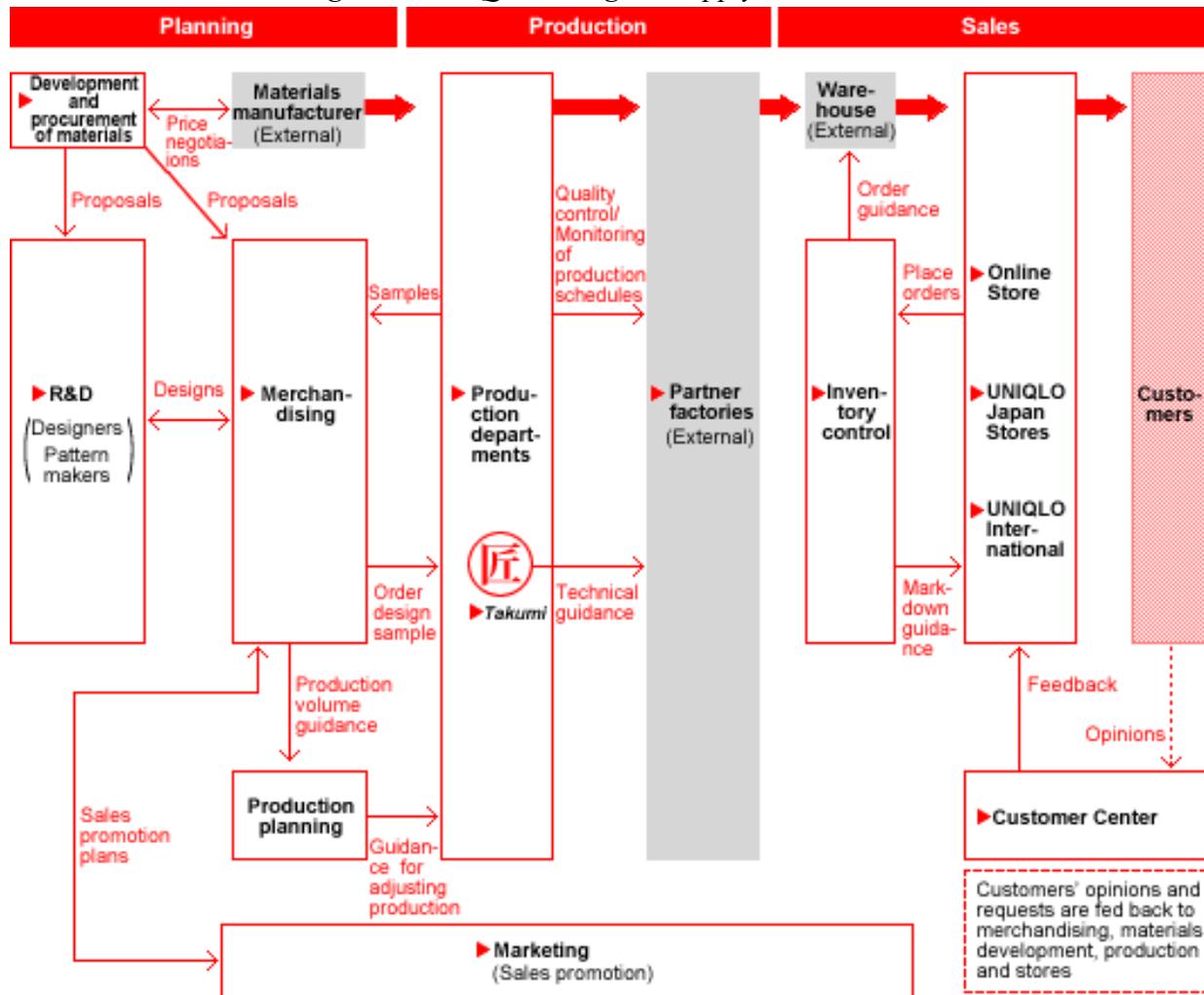
Source: Fast Retailing 2013

2.2. Implementation of Big Data and IoT in UNIQLO's Supply Chain Management

UNIQLO, a subsidiary of Fast Retailing and Japan's largest apparel retailer, has undertaken a comprehensive digital transformation to shift its supply chain from a traditional manufacturing-led approach to a consumer-driven, data-integrated model. CEO Tadashi Yanai articulated this strategic change as a move from "Made for All" to "Made for You", highlighting a commitment to personalization and responsiveness (Satoshi, 2017). This transition is not merely technological but also structural, as demonstrated by the 2017 opening of UNIQLO's Tokyo headquarters,

which was co-located with a major distribution center to facilitate cross-functional collaboration and real-time data sharing. Central to this transformation is the integration of Big Data and Internet of Things (IoT) technologies across every stage of the supply chain, from demand forecasting to retail operations.

Figure 3: UNIQLO's redesigned supply chain
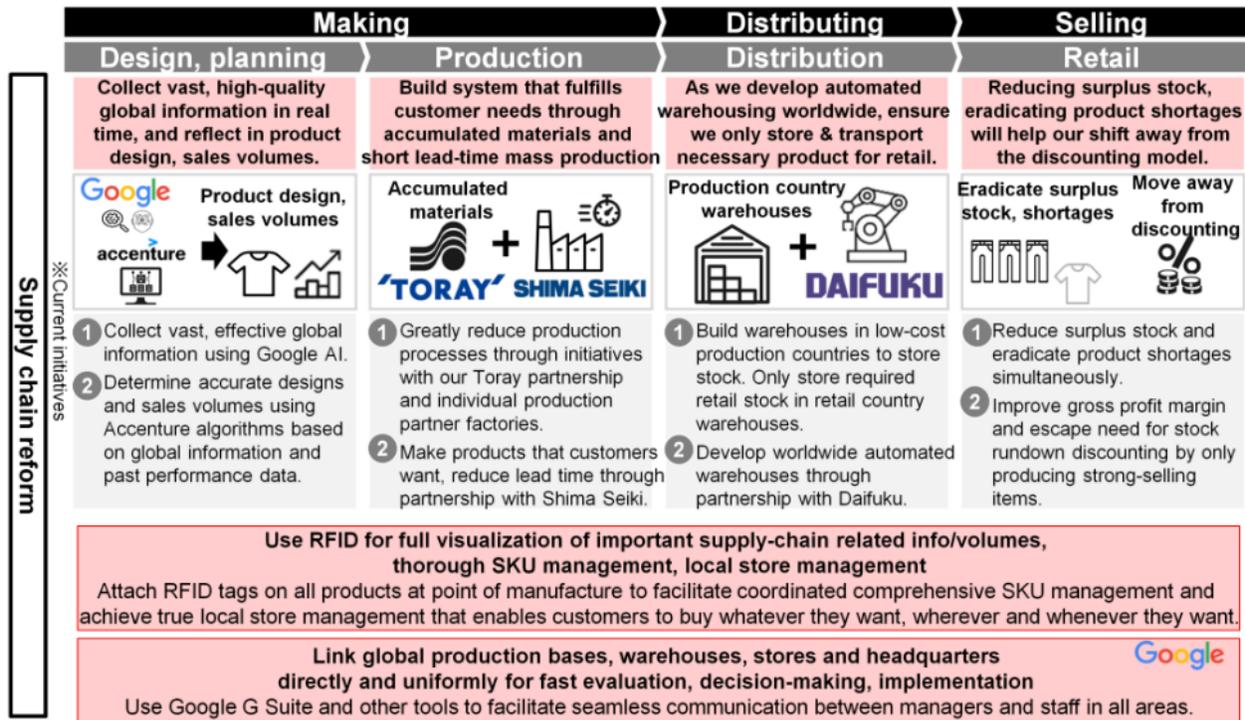
2.2.1. Demand Forecasting and Planning

In the past, UNIQLO required 6 to 12 months to bring new products to stores, resulting in frequent mismatches between offerings and actual consumer demand (Satoshi, 2017). To overcome this rigidity, the company partnered with Accenture to build a digital infrastructure that collects and analyzes real-time customer insights across all retail channels (Fast Retailing Sustainability Report, 2015). By leveraging Big Data and cloud-based technologies, this early transformation laid the groundwork for more accurate demand forecasting and data-driven decisions in product development and inventory planning.

As technological capabilities matured, UNIQLO further enhanced its demand forecasting through the integration of IoT systems with POS and sales data analysis. These systems collect real-time data on purchasing trends and inventory movement, allowing the company to adjust production and distribution on a weekly basis and minimize stock outs or overstock situations (Wei, 2017).

Today, Big Data serves as a transformative force in UNIQLO's forecasting and planning. The company collects massive volumes of structured and unstructured data from sources such as online purchases, browsing history, mobile apps, weather patterns, and regional fashion trends to

develop highly accurate demand predictions (Fast Retailing Sustainability Report, 2021). UNIQLO also incorporates qualitative insights from frontline staff into its centralized data platform, employees contribute valuable feedback on customer preferences and complaints, which is then integrated into broader analysis at the retail level.

By analyzing both internal and external data, UNIQLO can predict consumer trends, adjust product development, and optimize manufacturing plans accordingly. Ultimately, Big Data supports the company's commitment to "Produce only what can be sold", helping reduce waste, shorten lead times, and deliver a seamless, personalized shopping experience (Kamvyssi, 2025).

2.2.2. *Production and Inventory Tracking*

To streamline production and inventory control, UNIQLO has actively integrated IoT technologies, most notably RFID (Radio Frequency Identification) into its supply chain operations. At the production stage, RFID chips embedded into clothing tags allow for real-time, automated tracking of inventory from production through distribution. This enhances efficiency, minimizes errors, and reduces labor costs across the supply chain (Guo & Luo, 2024).

Additionally, IoT-based systems support live data sharing between manufacturing sites and UNIQLO's headquarters in Tokyo. UNIQLO has required its partner factories to implement IoT-based automated production systems that update real-time status reports to the central management platform (Satoshi, 2017). This digital connectivity allows for better production scheduling, early detection of bottlenecks, and rapid response to fluctuations in demand. These IoT-driven capabilities not only optimize inventory levels and reduce the risk of overproduction or stock outs but also lay the foundation for a more responsive and resilient supply chain.

2.2.3. *Logistics and Distribution*

UNIQLO has strategically integrated Big Data and IoT technologies into its logistics and distribution systems to enhance agility, visibility, and cost-efficiency across its global supply chain. Through centralized data platforms, the company collects and analyzes real-time information on inventory levels, shipping status, and delivery timelines (Satoshi, 2017). This data-driven approach enables accurate demand forecasting and delivery route optimization, which shortens lead times, reduces transportation costs, and enhances delivery reliability (Fast Retailing Sustainability Report, 2018).

UNIQLO's logistics system leverages IoT technologies to enhance automation and efficiency. Automated sorting, real-time shipment tracking, and integration with centralized data systems enable better inventory control and reduce delivery time from warehouse to retail stores (Zheng, 2024). This automation reduces manual labor, accelerates sorting and packing, and improves inventory visibility throughout the distribution process. By combining IoT-enabled RFID tracking with centralized data platforms, UNIQLO streamlines its logistics chain while minimizing errors and handling costs.

To enhance its logistics and distribution efficiency, UNIQLO has implemented data-driven automation at its flagship Ariake distribution center in Tokyo. As part of the company's digital transformation strategy, this fully automated warehouse utilizes real-time sales and

customer feedback data to forecast demand at the SKU level. By integrating Big Data analytics into its distribution operations, UNIQLO streamlines warehouse efficiency, improves SKU-level replenishment accuracy, and ensures faster inventory turnover, essential for meeting real-time customer needs in diverse markets (Fast Retailing Integrated Report, 2024).

2.2.4. *Retail Operations and Customer Feedback Loop*

At the retail level, UNIQLO demonstrates an innovative integration of Big Data and IoT technologies to optimize store operations and establish a dynamic customer feedback loop. One of the key innovations is the implementation of IoT-enabled RFID technologies, which serve as both data collection tools and enablers of customer-centric services. Since 2017, UNIQLO and its parent company Fast Retailing have rolled out RFID across 5,000 global stores, transforming the traditional retail model into a highly automated and data-rich environment. These technologies also enable in-depth customer behavior tracking, capturing how shoppers interact with products in real time. In-store IoT technologies like RFID mirrors and smart shopping carts capture real-time customer behavior, such as product trials, movement patterns, and abandoned purchases. These data-driven insights allow UNIQLO to adjust store layouts and merchandising in response to actual customer engagement, enhancing both sales and shopping experience (Zheng, 2024). In addition to customer-centric technologies, UNIQLO utilizes IoT-enabled environmental sensors in its stores to monitor and control lighting, temperature, and airflow. These smart systems automatically adjust brightness based on ambient light and optimize indoor climate, enhancing customer comfort while reducing energy consumption (Fast Retailing Sustainability Report, 2025).

Big Data analytics also plays a vital role in synthesizing feedback from diverse digital touchpoints, such as online reviews, customer return reasons, loyalty program interactions, and social media sentiment. Each year, UNIQLO processes over 30 million customer comments, using natural language processing and machine learning models to categorize and prioritize feedback. A prime example is UNIQLO's well-known Oxford shirts, which are consistently updated based on customer suggestions to maintain their classic appeal while improving in quality and durability (Retail News, 2024). As a result, design iterations are faster, better aligned with actual demand, and more responsive to shifting market trends (Fast Retailing, 2021).

Additionally, Big Data allows UNIQLO to perform location-specific analysis, using in-store sales data and behavioral patterns to adjust inventory levels, visual merchandising, and promotional strategies at each outlet. This is especially valuable given UNIQLO's presence in over 2,500 stores across 26 markets (Fast Retailing, 2025). While digital data forms the analytical backbone, leadership also emphasizes physical observation, with senior executives regularly visiting stores to validate insights and gather qualitative input from frontline employees, further enriching the feedback ecosystem (Fast Retailing Integrated Report, 2024).

In essence, UNIQLO's retail operations reflect a tightly integrated system in which IoT devices generate high-frequency, real-time data, and Big Data analytics transforms this raw input into actionable insights. This synergy allows the company not only to optimize operational

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efficiency but also to co-create value with customers by embedding their voices into every stage of the retail experience.

2.3. *Successes of Big Data and IoT Integration in UNIQLO's Supply Chain Management*

UNIQLO's strategic adoption of Big Data and IoT technologies has delivered significant breakthroughs across its supply chain, particularly in enhancing responsiveness, inventory accuracy, customer-centered design, and automation.

One of the most notable successes is UNIQLO's ability to respond rapidly to shifting market demand. By analyzing real-time sales trends, weather patterns, and regional behaviors, the company can detect which products are gaining traction and immediately adjust production or reallocate stock. For instance, in response to a sudden cold wave, UNIQLO's system quickly boosts distribution of HEATTECH apparel in affected regions, reducing the lag from market demand to store availability from months to mere days (Fast Retailing, 2023).

Another major success lies in its precise and efficient inventory management system. With RFID tags tracking every item in real-time, UNIQLO has gained full visibility into stock levels across all stores and warehouses. This minimizes stockouts and overproduction, allowing the company to maintain lean inventory while significantly cutting waste. At the Ariake distribution center, RFID technology has helped reduce inventory handling time by up to 90%, contributing to both operational efficiency and environmental goals (Fast Retailing Integrated Report, 2024).

UNIQLO has also leveraged Big Data to place customers at the center of its product design process. By analyzing millions of customer reviews, sales patterns, and product return reasons, the company can iterate and improve designs with pinpoint accuracy. For example, customer feedback on fit and fabric softness led to subtle but effective redesigns of core items like the Oxford shirt, resulting in improved satisfaction and repeat purchases (Retail News, 2024).

Finally, the integration of IoT has driven warehouse automation and operational streamlining. At flagship logistics hubs such as Ariake, automated sorting, replenishment, and delivery scheduling are all controlled via centralized data platforms. This integration has cut delivery lead times and labor costs while improving accuracy and service reliability (Zheng, 2024).

3. Application of Big Data and Internet of Things in Vietnam's Fashion Supply Chain Management

3.1. *Contextual Comparison: UNIQLO vs. Vietnamese Fashion Firms*

UNIQLO's use of Big Data and IoT has transformed its supply chain in four key areas, all of which any Vietnamese fashion firm can learn from.

First, UNIQLO can spot and react to changes in customer demand almost instantly. Its system pulls in live sales figures, local weather updates and shopper habits to see which items are selling fast. When a cold snap hit Japan, for example, the platform automatically diverted

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more HEATTECH jackets and tops to those regions, cutting the usual wait of weeks or months down to just a few days.

Second, thanks to RFID tags on every garment, UNIQLO always knows exactly how many items are in each store or warehouse. This real-time inventory view prevents both empty shelves and excess stock. At its main Ariake hub, RFID tracking has slashed the time staff spend handling inventory by about 90%, which also helps reduce waste.

Third, Big Data drives UNIQLO's design updates. By mining customer reviews, purchase histories and return reasons, the company pinpoints what works and what doesn't. Feedback on the fit and feel of its Oxford shirts, for instance, led to small tweaks that made them noticeably more comfortable and boosted repeat buys.

Finally, IoT connects every step in UNIQLO's logistics network. Automated systems at key distribution centers handle sorting, restocking and delivery planning through one central platform. The result is faster shipping, lower labor costs and fewer mistakes.

Together, these four advances show how data and smart devices can make a fashion supply chain faster, leaner and more customer-focused.

3.2.   *Lessons Learnt from Applying Big Data and IoT in Vietnam's Fashion Supply Chain Management*

Before proposing tailored solutions for Vietnamese fashion firms, it is essential to assess the internal and external factors influencing the adoption of Big Data and IoT. The following SWOT analysis outlines the strengths, weaknesses, opportunities, and threats shaping the digital transformation of Vietnam's fashion supply chain.

3.2.1.   *Strengths*

Strategic Geographical Position and Global Integration

Vietnam holds a highly strategic geographical position in Southeast Asia, serving as a pivotal logistics hub for regional and global supply chains. The country shares land borders with China to the north, and Laos and Cambodia to the west, facilitating overland trade and raw material sourcing from neighboring economies. To the east, Vietnam's 3,260 km long coastline opens directly to the South China Sea, one of the world's most active maritime trade routes. Additionally, Vietnam sits at the heart of major regional transport corridors such as the East-West Economic Corridor (EWEC), which links Myanmar, Thailand, Laos, and Vietnam, terminating at Da Nang port. This corridor allows landlocked economies to access Vietnam's seaports for international exports, further solidifying Vietnam's role as a trade facilitator in Indochina.

Vietnam's location is complemented by its membership in high-standard Free Trade Agreements (FTAs) such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the EU-Vietnam Free Trade Agreement (EVFTA). These agreements offer tariff reductions and broader market access, boosting Vietnam's global trade capacity. According to Nayak et al. (2019), Vietnam exports textiles and garments to over 180 countries, with the U.S., EU, Japan, and South Korea being the largest markets. In 2017 alone, total export turnover in the textile and garment sector reached USD 31 billion, a sharp increase from USD

27.5 billion in the previous year. This level of global integration enhances the scalability and competitiveness of Vietnam's fashion supply chain.

Competitive Labor Advantage and Cost Efficiency

Vietnam's fashion supply chain maintains a significant cost advantage due to its low labor costs and a large, skilled workforce, making it an attractive destination for global apparel manufacturing.

As of 2020, the average hourly labor cost in Vietnam was approximately USD3, making it one of the most cost-effective manufacturing hubs in Southeast Asia. Meanwhile, China's average hourly labor cost was about USD6.5 in the same period, more than double that of Vietnam (Vietnam Briefing, 2024). This substantial difference in labor costs has prompted many global brands to shift their manufacturing operations to Vietnam. For example, Vietnam accounted for 50% of total Nike brand footwear production, followed by China and Indonesia with 27% and 18%, respectively. This data underscores Vietnam's critical role in Nike's global supply chain (The Investor, 2025).

Moreover, Vietnam's textile and garment industry employs approximately 2.7 million workers, with about 72.6% being women. The country hosts over 3,800 textile and garment factories, indicating a robust infrastructure to support large-scale manufacturing (Asia Garment Hub, 2023). This extensive workforce and infrastructure enable Vietnam to offer competitive production costs while maintaining quality standards, thereby solidifying its position in the global fashion supply chain.

Proven IoT Pilot Projects Led by Vietnamese Fashion Enterprises

Prominent Vietnamese firms have begun integrating IoT into supply chain operations, particularly in logistics and agriculture. For example, ViettelPost's deployment of IoT technologies has resulted in a 15% reduction in vehicle downtime, 98% delivery accuracy, and a 40% decrease in lost shipments, showing how real-time tracking and sensor networks enhance operational performance (Tuan, 2025). Similarly, VinEco, a subsidiary of Vingroup, uses IoT-driven environmental monitoring to achieve a 30% increase in water efficiency and a 20–25% boost in crop yields through automation and real-time data analytics in its agri-logistics chain (Tuan, 2025). These outcomes provide a replicable model for fashion firms, especially in areas like inventory control and warehouse automation.

Vinatex, one of the largest state-owned textile corporations, piloted IoT sensors at its Nam Dinh spinning factory to monitor energy consumption in real time. This initiative led to a reduction in energy usage by approximately 1.5 - 2% per kilogram of fiber produced, aligning with European Union environmental standards and enhancing the factory's sustainability profile (Giz, 2024). Nayak et al. (2022) note that RFID technology, a form of IoT, is being adopted gradually despite cost barriers. Enterprises using RFID report improvements in speed, accuracy, and information availability, all of which contribute to social, environmental, and economic sustainability.

3.2.2. *Weaknesses*

Low adoption rate among SMEs

Despite governmental initiatives promoting digital transformation, the adoption of Big Data and IoT technologies among small and medium-sized enterprises (SMEs) in Vietnam's fashion industry remains limited. As of 2023, only 35% of Vietnamese apparel factories had implemented digital production management systems, compared to 60% in China and 45% in Bangladesh, indicating a significant digital gap (Groyyo, 2024). In practice, few small or medium fashion suppliers have the capital to invest in sensors or Big Data platforms. This leaves many companies lagging in data-capture capabilities. Most Vietnamese fashion firms still rely on traditional methods, with limited digital integration in logistics, production, or customer-facing operations. According to Tuan (2025), only 48% of surveyed Vietnamese supply chain professionals reported IoT implementation, with RFID adoption still in its infancy. This limited adoption hampers operational efficiency and responsiveness to market demands.

Skills and training gaps

According to a recent report brought out by the International Labour Organization and Viet Nam Textile and Apparel Association, Vietnam's textile and garment industry is supported by 577 vocational training institutions and 38 universities offering related programs. However, declining enrollment and outdated curricula have undermined the sector's ability to supply qualified workers for high-value tasks such as supply chain management, digitalization, and sustainable production. A critical issue is the limited exposure of trainers and graduates to real-world production technologies. Surveys indicate that employers find new hires lacking in practical digital and managerial skills, especially in areas such as ERP systems, data analytics, and smart manufacturing. The report also reveals that only 1.1% of workers are in technician or mid-level professional roles, while nearly 89.4% are production-line operators, indicating a heavy tilt towards low-skilled labor. This skills gap hinders the effective utilization of advanced technologies and limits the industry's capacity for innovation and growth.

Infrastructure limitations

The technological infrastructure needed to support Big Data and IoT adoption in Vietnam's fashion supply chain remains uneven and underdeveloped. While major urban centers like Hanoi and Ho Chi Minh City benefit from advanced digital connectivity, rural and industrial zones, where many garment factories are located, suffer from inadequate broadband coverage and unreliable internet speeds. According to Nayak et al. (2022), only 10% of logistics firms in Vietnam have adopted Enterprise Resource Planning (ERP) systems, 19% use transportation management software, and just 17% rely on electronic data interchange (EDI). Moreover, Vietnam currently lacks sufficient hyperscale data centers to support large-scale Big Data processing and cloud storage. Although major tech firms such as Google and Alibaba have expressed interest in building data infrastructure in Vietnam, progress has been slowed by electricity supply instability and limited international cable capacity (Reuters, 2024). These issues constrain domestic firms' access to high-performance cloud analytics, which are foundational to predictive modeling and supply chain optimization.

Fragmented Supply Chain Structure

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Vietnam's fashion industry is characterized by a fragmented and loosely coordinated supply chain, especially in upstream segments like raw material sourcing and subcontracted manufacturing. Nayak et al. (2019) highlight that most Vietnamese textile and garment enterprises continue to operate in silos without integrated planning systems or standard protocols for sharing information across the supply chain. According to the "Towards a Sector Skills Strategy" report (ILO & VITAS, 2024), micro, small, and medium enterprises (MSMEs) dominate the sector, comprising 89.4% of the total 14,313 registered textile and garment firms in 2022. Yet, these MSMEs often lack formal management structures and technical capacity, with many continuing to rely on cut-make-trim (CMT) production - a low value-added method that discourages investment in digital transformation. Additionally, informal subcontracting relationships, usually prevalent in rural areas, make quality assurance and labor standard enforcement difficult, reducing supply chain resilience and brand accountability. These decentralized, informal arrangements are ill-suited for the standardized data collection and predictive analytics that underpin IoT and Big Data applications.

3.2.3. Opportunities

Government Agenda and Support Policies

Vietnam's government actively promotes Industry 4.0 in manufacturing. Resolution No. 52-NQ/TW (2019) sets ambitious targets, such as achieving universal broadband coverage at the commune level, positioning the digital economy to contribute 20% of GDP by 2025, and increasing labor productivity by over 7% per year. It also encourages regulatory reform to support the development of new business models, including those based on Big Data, IoT, and platform-based logistics systems.

Complementing this resolution is Decision No. 749/QĐ-TTg (2020), which approves the National Digital Transformation Program to 2025 with a vision to 2030. This decision sets out comprehensive goals, such as digitizing 100% of enterprises by 2030, ensuring at least 80% of public services are delivered at level 4 online, and raising the share of the digital economy to 30% of GDP by 2030. Importantly, it identifies manufacturing and logistics as priority sectors for digital transformation, directly benefiting fashion firms engaged in production and distribution. Under this program, fashion enterprises can access state-supported funding mechanisms, participate in government-led digital infrastructure development, and benefit from capacity-building programs aimed at SMEs.

Expected Rapid Digital Economy Growth

Vietnam's fast-expanding digital economy offers a critical opportunity for the fashion industry to integrate Big Data and IoT technologies. According to the Vietnam Technology Trends 2023-2025 report by FPT Digital, the country's digital economy is expected to reach between USD 90-200 billion by 2030, driven by strong investments in data analytics, AI, and cloud computing. Specifically, the Big Data & Analytics market is forecast to grow at a compound annual growth rate (CAGR) of 30.4%, with applications in logistics, supply chain, and retail being prioritized for scale-up by 2025. This digital acceleration provides fashion firms

with more affordable and scalable access to cloud-based platforms and real-time analytics tools necessary for predictive modeling, demand forecasting, and automated inventory management.

Growing Emphasis on Sustainability and International Standards

Vietnam's fashion firms face increasing global pressure to meet sustainability and ESG standards, which creates an opportunity to leverage IoT and data-driven solutions for compliance. Nayak et al. (2022) emphasize that RFID and IoT technologies in Vietnamese fashion supply chains have been linked to improvements in energy use, information availability, and supply chain visibility, which are directly related to sustainability metrics. In parallel, the Vietnamese government has enforced more stringent policies, such as the Law on Environmental Protection (2020) and Decree 06/2022/ND-CP, mandating enterprises to conduct carbon inventory assessments and adopt digital environmental monitoring systems (Fast Fashion Legal Aspects Report, 2024). These changes create strong incentives for fashion firms to adopt sensor-based monitoring, lifecycle tracking, and data visualization platforms that align with global buyers' expectations.

Access to International Markets through FTAs

Vietnam's integration into high-standard Free Trade Agreements (FTAs) such as the EU-Vietnam Free Trade Agreement (EVFTA) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) has significantly enhanced its textile and garment industry's access to international markets. Under the EVFTA, 100% of Vietnam's textile products will enjoy a 0% import tariff after a maximum of seven years from the agreement's entry into force, providing a substantial competitive advantage in the European market (Báo Nhân Dân, 2024). The implementation of the EVFTA has led to a notable increase in Vietnam's exports to the EU. In 2024, Vietnam's exports to the EU reached nearly USD52 billion, marking an 18.5% increase compared to the previous year. This surge contributed to a record trade surplus of USD35.2 billion with the EU, the highest among Vietnam's FTAs (Báo điện tử Đầu tư, 2025). Similarly, the CPTPP has had a more pronounced impact on Vietnam's textile exports compared to the EVFTA. This is attributed to the CPTPP's broader market access and more favorable tariff reduction schedules, which have notably boosted Vietnam's export potential in key markets such as Canada, Japan, and Mexico.

However, to fully capitalize on these FTAs, Vietnamese textile and garment enterprises must comply with stringent rules of origin and meet high-quality standards. The adoption of Big Data and IoT technologies can facilitate real-time tracking and transparency, ensuring adherence to international standards and enhancing operational efficiency. These technologies enable firms to monitor supply chains, manage inventories, and ensure product quality, thereby meeting the rigorous requirements of FTAs and strengthening their position in global markets.

3.2.4. Threats

Intensifying Regional Competition and Eroding Cost Advantages

Vietnam's textile and garment industry has historically leveraged its cost-effective labor to attract foreign investment and establish itself as a key player in the global apparel market. However, this competitive edge is increasingly under threat due to the country's rising labor

costs and intensifying competition from neighboring countries such as Bangladesh, Cambodia, and Myanmar (Fibre2Fashion, 2024). As of 2023, the average monthly wage for garment workers in Vietnam was approximately USD251, which, while lower than China's USD250-USD346, is significantly higher than Bangladesh's USD113. This wage disparity positions Bangladesh as a more attractive destination for cost-sensitive apparel manufacturing (VinMake, 2024). Moreover, Cambodia has been proactive in adjusting its minimum wage to remain competitive. In 2024, Cambodia's minimum wage for the garment sector was set at USD204 per month, increasing to USD208 in 2025, still below Vietnam's average wage (ASEAN Briefing, 2024). Labor productivity is another critical factor influencing competitiveness. A study indicates that Vietnam's labor productivity in the textile industry is approximately 90% of China's and 85% of Thailand's, suggesting room for improvement (Le, 2023). This productivity gap, coupled with rising wages, underscores the urgency for the industry to evolve beyond traditional low-cost manufacturing. Investing in automation, enhancing labor productivity, and moving up the value chain are imperative strategies.

Insecure Financing for technological advancements

Access to financing remains a significant barrier for Vietnamese fashion SMEs aiming to adopt Big Data and IoT technologies. Despite the government's efforts to promote digital transformation, many SMEs struggle to secure funding for technological upgrades due to limited financial resources and lack of tailored financial products. This financial constraint hampers their ability to invest in necessary digital infrastructure, training, and innovation, thereby limiting their competitiveness in the global market. A study by Nguyen Truong (2022) highlights that financial investment is a critical factor influencing the adoption of Big Data in Vietnamese SMEs. The research indicates that without adequate funding, these enterprises risk falling behind in the digital transformation journey, affecting their ability to meet international standards and customer expectations.

The World Bank's "Firm-Level Technology Adoption in Vietnam" survey (2021) found that nearly 50% of small enterprises identify lack of finance as one of the top three obstacles to adopting new technologies. The report also highlighted that only around 20% of small firms had access to formal loans, compared to 30% of medium firms and 25% of large firms. Even among those that secured financing, high interest rates and inadequate tailoring of financial products to technology investment needs limited their effectiveness. This financial exclusion affects not only hardware procurement but also hampers investment in digital training, change management, and cybersecurity measures. Moreover, the survey indicates that while large firms with stronger balance sheets can often absorb the upfront costs of innovation, SMEs in Vietnam typically struggle to generate the liquidity or collateral necessary to secure loans from commercial banks. The absence of targeted government subsidies, credit guarantees, or fintech-backed SME lending schemes exacerbates this gap. This situation places many SMEs at risk of digital stagnation, particularly as international brands increasingly require transparent, tech-enabled supply chains for sustainability and traceability compliance.

Cybersecurity Risks and Data Privacy Concerns

As Vietnamese fashion firms increasingly adopt digital technologies, they become more vulnerable to cybersecurity threats and data privacy issues. Recently, in April 2025, CMC Corporation, a major Vietnamese ICT conglomerate, suffered a ransomware attack by the Crypto24 group, resulting in the loss of approximately 2 terabytes of data (Vietnam Investment Review, 2025). These incidents underscore the escalating cyber threats facing Vietnamese enterprises. The use of IoT devices such as RFID tags and sensors enhances operational efficiency but also expands the attack surface for potential cyber threats. To mitigate these risks, it is imperative for these enterprises to invest in cybersecurity infrastructure, seek expert guidance, and enhance employee training on data protection practices. Additionally, government support in the form of subsidies or training programs could play a crucial role in assisting SMEs to navigate these challenges effectively.

3.3. Recommendations for Applying Big Data and IoT in Vietnam's Fashion Firms

3.3.1. Inventory and Warehousing Optimization

To improve inventory visibility and reduce manual errors, Vietnamese fashion firms should adopt ***RFID-based tracking systems in key warehouses and production units.*** UNIQLO's full-scale integration of RAIN RFID across its global operations has allowed it to maintain real-time inventory accuracy and reduce shelf-out scenarios by automating stock monitoring and replenishment (Impinj, 2022). For Vietnamese SMEs, a practical first step is to pilot RFID or QR-code tagging for high-turnover SKUs using handheld readers or mobile apps. This approach is cost-effective and allows firms to achieve inventory accuracy targets of over 95% within 6 to 12 months. Larger domestic enterprises or exporters may subsequently scale to IoT-enabled smart warehousing systems, including conveyor automation and real-time dashboards, with full deployment achievable within 2–3 years.

3.3.2. Demand Forecasting & Customer-Centric Analytics

Vietnamese fashion firms should prioritize the ***systematic integration of Big Data analytics*** to enhance demand forecasting precision and deepen customer insight. UNIQLO's supply chain exemplifies this approach through its strategic partnership with Accenture, where AI and machine learning are used to process large volumes of real-time customer behavior and sales data, enabling hyper-localized inventory and style allocation. For large domestic enterprises such as Vinatex, TNG, or IVY Moda, they can partner with technology consulting firms like FPT Smart Cloud, NashTech, FPMG Vietnam or global SaaS vendors with a local presence (e.g., SAP, Oracle, Microsoft Dynamics 365) to help implement cloud-based analytics platforms, configure demand-sensing algorithms, and train in-house data teams. These collaborations can accelerate deployment while reducing technical risk. Such strategic partnerships are essential in the Vietnamese context, where many firms face shortages of internal data science talent and lack the infrastructure to independently develop end-to-end Big Data systems.

3.3.3. Logistics and Real-Time Visibility

To address persistent inefficiencies in transportation and distribution, Vietnamese fashion firms should implement ***GPS and IoT-based systems*** that enable real-time shipment tracking, environmental monitoring, and logistics performance optimization. UNIQLO's global supply

chain model places strong emphasis on centralized, real-time logistics coordination, which allows the company to minimize lead times from product design to store delivery. By embedding digital tracking across its distribution network, UNIQLO ensures on-time inventory replenishment and agile response to demand fluctuations.

Vietnamese firms, especially those managing export-oriented or multi-channel distribution networks, can adopt a phased approach to logistics digitization. In the short term, small and medium-sized enterprises (SMEs) can partner with third-party logistics (3PL) providers that offer GPS-enabled platforms such as Boxme, GHN, or VNPost Smart Logistics. These platforms provide real-time tracking dashboards, delivery alerts, and route optimization features accessible via web or mobile interfaces.

Mid-sized exporters or vertically integrated manufacturers (e.g., TNG Investment & Trading or Garco 10) can go further by installing IoT sensors in shipping containers or delivery fleets. These sensors monitor not only location but also environmental conditions such as temperature, humidity, and shock levels, which are critical for preserving garment quality during international transit. Data from these devices can feed into centralized control towers (similar to UNIQLO's model) enabling proactive intervention if delays or risk thresholds are detected.

In the long term, larger Vietnamese fashion firms can invest in predictive logistics systems by integrating IoT devices with cloud-based analytics platforms. This enables functions such as automated route optimization, fleet maintenance alerts, and carrier performance benchmarking. The implementation of such systems is particularly relevant given Vietnam's current logistics challenges, including port congestion, urban traffic, and inconsistent delivery lead times.

3.3.4. Sustainability, ESG Compliance & Workforce Development

As global buyers and regulatory frameworks increasingly demand environmental and social accountability, Vietnamese fashion firms must embed sustainability monitoring and workforce upskilling into their supply chain transformation strategies. UNIQLO sets a notable benchmark in this regard through its industry-leading efforts to reduce water usage by up to 99% in denim finishing and its commitment to recycled materials and transparent reporting across its global supply chain (UNIQLO Sustainability Report, 2023). These efforts are not only environmental imperatives but also strategic differentiators in a competitive global apparel market.

Vietnamese fashion firms that are involved in energy- and water-intensive processes such as dyeing, washing, or finishing can begin by ***installing IoT-enabled sensors to monitor*** electricity consumption, water usage, and greenhouse gas emissions in real time. As seen in Vinatex's Nam Dinh pilot, such systems enabled a 1.5-2% reduction in energy usage per kilogram of fiber, demonstrating cost-effective environmental gains. A similar system could be piloted by medium-sized manufacturers such as Dugarco or Binh Minh Garment within 6-12 months, using affordable sensor platforms and energy dashboards (e.g., MindSphere or EcoStruxure) tailored for textile operations.

In addition to technological interventions, workforce development is critical for sustainable transformation. Currently, over 89% of Vietnam's textile and garment labor force

occupies low-skilled, production-line roles, with only 1.1% in technical or mid-level positions (ILO & VITAS, 2024). This presents a significant human capital gap. To address this, companies should initiate **short-term digital bootcamps** to train factory line managers and logistics coordinators in the basics of ERP, IoT, and Big Data. These programs can be delivered in partnership with local universities or government-led platforms like SMEdx and are scalable across all enterprise types within 12-18 months. This recommendation draws on UNIQLO's operational practice, where front-line employees are equipped with real-time sales and inventory data to support agile decision-making at the store level (Fast Retailing Integrated Report, 2022).

CONCLUSION

The application of Big Data and Internet of Things (IoT) in the fashion supply chain presents a pivotal opportunity to enhance responsiveness, efficiency, and consumer-centricity in an increasingly dynamic market. As technology becomes integral to supply chain performance, the integration of real-time data and intelligent systems enables fashion companies to better anticipate demand, optimize inventory, and accelerate product delivery.

Drawing from the case of UNIQLO, the implementation of digital tools across forecasting, manufacturing, distribution, and retail operations has demonstrated how a connected and data-driven supply chain can lead to measurable improvements in operational agility and customer satisfaction. IoT-based inventory tracking, RFID-enabled logistics, and predictive analytics have allowed for greater visibility, lower wastage, and faster adaptation to shifting consumer behavior. These advances are not only technical, but also strategic, positioning UNIQLO as a model of digitally-enabled competitiveness in the global apparel industry.

In the context of Vietnam's fashion sector, adopting similar innovations can unlock new value, especially as the country balances its strengths in manufacturing with the urgent need for modernization. While challenges remain ranging from infrastructure limitations to low digital adoption among SMEs, there is growing momentum supported by government initiatives, rising sustainability expectations, and expanding digital capabilities. The path forward requires strategic investment in IoT systems, workforce upskilling, and improved collaboration between brands, manufacturers, and logistics providers.

With targeted action and coordinated transformation, Big Data and IoT can help reposition Vietnam's fashion supply chain from labor-intensive operations to a smart, resilient, and globally competitive system, one that not only meets international standards, but also creates long-term value through transparency, responsiveness, and sustainable growth.

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