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Investigating the factors contributing to stock-outs in online shopping using lean retail in South Africa

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Background: In the rapidly expanding e-commerce sector, stock-outs remain a critical failure, eroding customer trust and revenue. While lean principles are often applied to optimise internal inventory, this study proposes a paradigm shift: leveraging lean to transition the online retailer from a mere inventory holder to a dynamic logistics orchestrator.

Objectives: The objective of this study is to propose a dynamic fulfilment framework, grounded in lean principles, to eliminate stock-outs in online retail by transforming supply chains from static inventories into agile, networked ecosystems.

Method: This research investigated a South African case through 12 semi-structured interviews and workplace observations. It confirms that the root cause of stock-outs is systemic latency, where non-integrated systems and batch-processing create a misleading representation of available stock.

Results: Moving beyond the standard recommendation for system integration, this article introduces a novel dynamic fulfilment framework. We argue that by applying lean value stream mapping to the entire supply network, retailers can pre-empt stock-outs not only by improving forecasting but by creating a resilient, multi-sourced fulfilment ecosystem. When an item is unavailable in the primary warehouse, the system can instantly offer customers alternative fulfilment paths, such as direct supplier shipping or a peer-to-peer store transfer, thereby transforming a potential service failure into a demonstration of agility and customer commitment.

Conclusion: This research provides a forward-leaning, actionable model for using lean retailing to build not just efficiency, but unshakeable competitive resilience.

Contribution: This article contributes to the field of supply chain and retail management by identifying and analysing the key factors contributing to stock-outs in online shopping and demonstrating how lean retail principles can be applied to improve inventory availability and operational efficiency in the South African retail context.

Keywords: online shopping; lean retail; stock-outs; supply chain; inventory; dynamic fulfilment.

Introduction

In the realm of online shopping, stock-outs have become a significant concern, sparking frustration among customers. Significant growth in the global online retail market has been fuelled by the widespread adoption of internet technology, enhanced user proficiency and an increasingly fast-paced society (Islam 2021). Many online shopping customers are disappointed with the unreliability of online shopping because of stock-outs, which have resulted in several inconveniences and a waste of time on their part (Khairi 2021). Online retail is one of the biggest parts of the extensive digital transformation of the economy. E-commerce in South Africa is experiencing significant growth through mobile usage, and the capacity to shop using mobile devices has increased (Rita, Oliveira & Farisa 2019). It has surged especially after the coronavirus disease 2019 (COVID-19) pandemic, prompting many retailers to adapt their sales strategies and rethink their organisational culture to align with current shopping trends (Fabius et al. 2020; Hänninen, Kwan & Mitronen 2021).

Online shopping has gained excellent momentum with consumers, where currently most online stores have an app, which has become easily accessible (Benrqya 2021). In online shopping, retailers leverage lean practices, transforming their relationship with suppliers (Schonberger 2018). A good example is the global retailer Walmart, which employs lean principles in its online shopping to achieve substantial economies of scale, thereby supporting its distinctive business model centred on 'daily price reductions' (Retnowati & Mardikaningsih 2021:36).

The consumer product industry has undergone a significant transformation as a result of rapidly evolving technologies, changing demographics and shifting consumer preferences. In an increasingly competitive online retail marketplace, retailers must integrate innovative technologies with targeted digital marketing strategies to differentiate their offerings. This shift empowers consumers, enhancing their control over purchasing decisions and creating a diverse landscape of choices (Bozarth & Handfield 2019; Huang et al. 2019). Every organisation has a supply chain management (SCM) department that is vital. The SCM department regulates the organisation's procurement, storage, production, distribution, inventory management and order fulfilment activities, as well as the planning, design, implementation and control of those activities (Attaran 2017). The typical supply chain functions as a network that connects several businesses to produce and distribute goods or services.

A 2023 South African e-commerce survey revealed that most online shoppers are woman aged 18–39, with most spending between R250 and R1000 on their purchases (Rafee 2024:88). Despite the growth of online shopping, stock-outs, where products are unavailable for sale on the platform, remain a significant challenge that led to over 1,000 complaints in the past 3 years (Zappone 2021). This article aims to delve into the underlying factors contributing to these stock-out occurrences and explores how lean retail strategies can be implemented to enhance dependability in online shopping by asking: What are the factors that contribute to stock-outs? How can lean retail reduce stock-outs in online shopping? It then proposes a dynamic fulfilment framework, grounded in lean principles, to eliminate stock-outs in online retail by transforming supply chains from static inventories into agile, networked ecosystems.

This article is divided into five sections. The first section started with the introduction. The second section discusses the factors that contribute to stock-outs in online shopping and how lean retail can reduce stock-outs in online shopping. The third section discusses the research methodology, sample size, and the data collection and analysis. The fourth section discusses the empirical data collection, which was collected through work observations and face-to-face semi-structured interviews. The fifth section discusses the research findings and conclusions.

Factors that contribute to stock-outs in online shopping

Online shopping is greatly impacted by stock-outs, when a product is not available for purchase. It can result in missed sales, unhappy customers and possible harm to a brand's reputation (MacCarthy et al. 2016). Because of the unpleasant experience of a stock-out, customers may abandon shopping carts, move to rival websites or refrain from visiting the business again (Mullins, Chase & Friend 2024). The following briefly discusses the factors contributing to stock-outs in online shopping.

Supplier relationship management

According to Lambert and Schwieterman (2012), supplier relationship management (SRM) establishes and maintains business connections along the supply chain by combining cooperation and communication between organisations and suppliers. According to Li, Tsang Wu and Lee (2024), SRM is a scientific process for reviewing suppliers, creating plans to boost operational efficiency and figuring out how much each supplier contributes to the organisation's success.

Segmenting, regulating and Performance management and supplier development are all ongoing processes under SRM (Zhechev 2024). Supplier relationships aim to minimise costs, maximise levels of trust, emphasise accountability and improve the technological and planning capabilities of supply chain partners (Al-Shboul 2024). These relationships also aim to position capabilities, create learning patterns and minimise or do away with unnecessary tasks and time-wasting activities. Stock-outs could be mitigated if an organisation could establish solid working relationships with its suppliers (Li 2024). When SRM is poorly handled, it can directly or indirectly cause stock-outs in online or retail environments (Louis 2024), leading to poor communication and information sharing, where suppliers are not given accurate sales forecasts or inventory data, resulting in underproduction or late deliveries.

Depending too heavily on one supplier increases vulnerability (Batwara et al. 2025). If the supplier faces disruptions (strikes, raw material shortages or transport issues), the retailer may quickly run the risk of stock-outs. Long lead times in supplier agreements may not account for demand surges (e.g. promotions, seasonal peaks). Retailers should also implement a strategy for managing potential risk failures. Without proactive risk assessment, such as evaluating risks related to political instability, retail operations may face significant disruptions. Ineffective SRM leads to poor visibility, a lack of trust, and weak coordination, which create mismatches between supply and demand, resulting in stock-outs. Another issue causing stock-outs in online shopping is the supplier policy, which is discussed next.

Understanding the supplier policy

An organisation's supplier policy outlines its guidelines for dealing with its suppliers (Adebayo, Paul & Eyo-Udo 2024). According to Lotfi et al. (2024), it addresses several relationship-related topics, including how orders are placed, what terms and conditions apply and how disagreements are settled. According to Jafari-Raddani et al. (2024), the goal of a supplier policy is to safeguard the organisation's interests and guarantee that it obtains the most value for its money from its suppliers. A supplier policy helps to prevent miscommunications and possible conflict by clearly defining expectations and procedures (Jassem, Zakaria & Che Azmi 2022).

A well-crafted supplier policy must be customised to the particular requirements of the organisation and evaluated

frequently (Bai et al. 2025). All staff members who interact with suppliers should have access to it so that they can understand their responsibilities and follow the policy. If a supplier policy is not well defined, it can cause stock-outs in online shopping. For example, a change in the minimum order quantity or delayed deliveries can disrupt the supply chain and lead to a shortage of inventory. A lack of integration between different systems can lead to inaccurate inventory tracking, poor demand forecasting, and ultimately, products running out of stock. System integration is discussed next.

System integration in supply chain and online retail

In an era where technology, the internet and smartphones give customers more choice and power, retailers are being forced to re-organise to survive technological disruptions (Argyropoulos et al. 2024). Slow economies, droughts, unemployment, and the need to interact with customers on a broad social scale, while addressing issues like sustainability and inequality, are all challenges for retailers to manage in a rising online retail market like South Africa (Tiwari et al. 2024).

To increase profitability, businesses must innovate how they create, deliver and capture value so that clients recognise and are willing to pay for it (Baden-Fuller & Morgan, 2010; Teece 2010). Large multinational firms need to innovate their business models to stay competitive (Ekinci et al. 2024). It will result in new income streams and customer offerings (Anggara, Kaukab & Randikaparsa 2024). Mulder and Frazer (2020) claim that technologies like artificial intelligence (AI), big data and machine learning make retailers anxious because the skills needed to use these systems are still in short supply in the South African retail sector. Artificial intelligence, big data and machine learning can help retailers optimise operations, enhance the customer experience and improve decision-making. These technologies enable real-time insights to improve business strategies, task automation, supply chain efficiency and personalised suggestions (Song et al. 2024). Technology was less advanced 20 years ago, but several new inventions have surfaced, which has altered retail operations in the marketplace (Songalia 2017).

The strategy and operations of a store are impacted by the evolution of technological systems. To satisfy customer demands through a multi-channel supply chain network, system integration plays a critical role in retail (Sadar & Sadar 2016). According to Kersten (2017), the growth of supply chain system integration (e.g. SAP ERP and SAP Ariba) has made it possible to use theoretical operations models, which has resulted in innovative planning and value chain optimisation. According to Swaminathan and Venkitasubramony (2024), the use of system integration has significantly raised living standards and helped supply chains to expand job and skills-development opportunities.

Although technology and supply chain management are developing at an accelerated pace, many retailers are regrettably still stuck with antiquated legacy systems and drawn-out procedures (Hufford 2019). Retailers struggle to accurately predict demand and deal with unforeseen disruptions, which can significantly impact their competitive advantage and capacity to supply goods on time, and this may lead to stock-outs (Bilal, Bititci & Fenta 2024). The organisation risks stock-outs by failing to incorporate modern technologies to analyse sales data, customer demand, and inventory trends for forecasting (Zhang & Niu 2024). Effective system integration across the supply chain and online retail platforms provides the foundational data necessary for accurate demand forecasting.

Demand forecasting

Demand forecasting is a crucial tool for businesses to govern inventory management because stock-outs can be caused by a variety of factors, including the expenses associated with maintaining excess or insufficient inventory. Kotecha & Chanona (2025) discovered that supply chains order either too much or too little of a product because of poor demand forecasting. Retaining existing customers is more cost-effective than trying to acquire new ones. Inaccurate forecasting results in outdated inventory or stock-outs (loss of sales and/or customers), which lowers profitability (Zanfei et al. 2024).

Forecasting models that depend only on past sales may fail when demand shifts suddenly (new trends, competitor promotions or economic changes may occur). For example, online fashion retailers often face stock-outs when a celebrity promotes an item, because past data did not capture that surge. When the retailer does not account for seasonality, special events, weather or competitor activity, it can experience understocking. Stock-outs also occur when static forecasts fail to adapt to rapid shifts in demand, causing retailers to rely on outdated assumptions and leaving them understocked during unexpected surges (Zhang 2024). Maintaining a continuous and adaptive demand forecasting process is essential for responding proactively to market dynamics.

How can lean retail reduce stock-outs in online shopping

Research consistently shows that stock-outs are a major cause of customer unhappiness with online shopping (Ahlstrom 2004; Martins et al. 2021; Womack & Jones 1996). Lean retail is an adaptation of lean principles to retailing, which can directly help reduce stock-outs by eliminating inefficiencies, improving flow and making inventory management more responsive. These will be discussed in this section.

Creating value to improve demand forecasting (pull system) to minimise stock-outs in online shopping

A cornerstone of lean methodology is the principle of value, which is determined by the customer and measured by the degree to which a product or service fulfils their requirements (Womack & Jones 1996). Chen et al. (2010) characterise value

as the systematic application of technical expertise to eliminate unnecessary costs and ensure worth. In the realm of online retail, value emerges from sensory, emotional and cognitive stimulation, alongside lifestyle-oriented product information that supports purchasing decisions (Bigham 2005; Fiore 2007). This value can stem from both the use of the product and the anticipated interactions consumers have with it (Holbrook 1986; Mathwick et al. 2001).

As a key element of supply chain management, demand forecasting affects an organisation's profitability, inventory levels and competitiveness in the market (Liu & Cao 2016). For businesses, predicting the future's precise course or appearance has never been simple. According to Swaminathan and Venkitasubramony (2024), a significant challenge in demand forecasting lies in the difficulty of anticipating customer needs, a process which demands considerable research to perform accurately. Demand forecasting is a methodical approach that entails predicting future demand for goods and services that an organisation will provide under various unanticipated and competitive pressures (Zhang & Niu 2024).

By analysing real-time sales data, clickstream behaviour, and customer preferences, lean retail enables demand-driven replenishment, allowing retailers to align inventory with actual demand instead of relying on estimates (Constantinides 2004). Using real-time data reduces both overstocking (tying up cash in slow movers) and understocking (stock-outs of popular items). More precise projections could help with inventory management and maximising customer service delivery to add value to online buying (Islam et al. 2024). To accomplish an organisation's long-term and short-term goals and realise its vision, it is crucial that online retailers make every effort to develop efficient forecasting procedures.

By enabling wise supply chain decisions and effective planning for the short and long term, effective demand forecasting is essential for online retailers to maximise business value (Shi & Xu 2024). Planning production procedures, acquiring sufficient resources, keeping an eye on sales, managing finances and setting product prices are some of the plans and choices involved in that process (Nenni, Sforza & Sterle 2019). All these choices aid online retailers in effectively allocating resources throughout their operations to satisfy projected demand and maintain market competitiveness (Liu & Cao 2016). Anchoring the supply chain in actual customer demand through a pull system creates a more responsive and accurate forecasting model, which is fundamental to preventing stock-outs. Having established a pull system to define value from the customer's perspective, the next logical step is to analyse the entire flow of that value using value stream mapping.

Value stream mapping: The supplier collaboration and integration minimise stock-outs in online shopping

According to Franke (2024), a value stream in the lean context encompasses the entirety of the product's life cycle from the raw material stage to the customer's use, and eventual disposal. Implementing the lean model to eradicate waste requires a thorough and precise understanding of the value stream (Zanchi & Gaiardellia 2024). Once the value is defined, the process must create a value stream map that is transparent and accessible to all employees and suppliers, enabling them to monitor all work areas. Lean retail builds closer supplier relationships, improving communication of lead times and stock levels (Geisthardt et al. 2024).

While a value stream map displays each value-adding stage of the process from provider to customer, shared data systems like ERP or SAP Ariba provide suppliers with the necessary visibility into demand trends (Rohani & Zahraee 2015). Value stream mapping (VSM) in online retail involves visually representing the flow of materials and information from customer interaction to product delivery, helping to identify and eliminate waste to improve efficiency, reduce costs and enhance customer satisfaction (Franke 2024). Value stream mapping helps online retailers to understand their supply chain processes and identify areas for improvement to prevent replenishment delays that often cause stock-outs. Therefore, VSM serves as an indispensable diagnostic tool for visualising the flow of goods and information, thereby pinpointing specific sources of wastes and delays that compromise supply chain efficiency.

Implementing just-in-time inventory to create better flow in reducing stock-outs in online shopping

Eliminating waste from the value stream allows value-adding steps to proceed without interruptions or rework. Lean principles encourage keeping only the stock that is needed, at the time it is needed. Retailers should implement a comprehensive risk management strategy to anticipate, manage, and recover from operational, technological, and supply-chain failures. To achieve seamless, waste-removing flow from design to customer, online retailers can utilise fast supplier integration, drop-shipping or regional warehouses (Ramani & Lingan 2019).

According to a McKinsey report, the use of system integration has significantly raised living standards and helped supply chains to expand job and skill-development opportunities (Alicke et al. 2020). When correctly applied, the principle of flow ensures efficient, waste-reducing movement of goods for swift delivery, enabling rapid replenishment to prevent stock-outs and minimise lost sales (Rohani & Zahraee 2015). However, this concept is often misunderstood by online retailers (Sacks 2016).

Elimination of waste to minimise stock-outs in online shopping

The modern retail operating strategy calls for optimum efficiency in addition to the detection and removal of waste. By adopting a streamlined workflow, it minimises inefficiencies and reduces the waste of time, effort, materials, and resources (Oke & Fernandes 2020). By using lean to eliminate activities that hinder operational flow, managers can proactively prevent

issues (Ikpe & Shamsuddoha 2024). The implementation of lean retail theory transforms an organisation's culture by instilling a primary commitment to waste elimination, the heart of the methodology. This culture motivates efficient replenishment and empowers retail managers to identify and eliminate key waste categories such as excess inventory, product flaws and needless motion. By systematically removing these bottlenecks and wasted resources (e.g. effort, time, materials), lean principles increase operational efficiency and improve overall retail performance (Kumar, Gupta & Bapat 2024; Shashank & Behera 2024).

There are major strategic and operational benefits to implementing lean retail in online shopping. Lean retail is essential in the fast-paced e-commerce environment as it focuses on waste reduction, productivity gains and maximising customer value (Chandani & Lamphere 2017). Its methodologies streamline operations by identifying and removing non-value-added processes in order fulfilment, returns and logistics. This includes mitigating delays in warehouse selection, packaging, and distribution, as well as enhancing coordination with suppliers and third-party logistics providers (3PLs) to accelerate order fulfilment.

Continuous monitoring of stock-outs and Kaizen in online shopping

Continuous monitoring of stock-outs with the Kaizen philosophy in online shopping involves using real-time data and analytics to identify and prevent stock-outs through incremental, continuous improvements to inventory management processes (Ikpe & Shamsuddoha 2024). This approach focuses on consistently identifying and eliminating waste, such as lost sales from stock-outs or excess inventory costs, by empowering all team members to contribute ideas and implement small, ongoing changes to improve accuracy, efficiency and customer satisfaction. Online retailers can also consider using the Plan-Do-Check-Act (PDCA) cycle as a framework for implementing improvements. Root cause analysis can also benefit online retailers as it is used to investigate issues such as frequent stock-outs, misplaced inventory or long customer queues. Considering the standardisation of work to reduce variation and improve customer service consistency will help online retailers to retain their customers.

Research methods and design

A qualitative research methodology was adopted to explore and investigate the factors that contribute to stock-outs in online shopping using lean retail in South Africa. The qualitative methodology was appropriate because this research aimed to understand the views of participants rather than to make use of a numerical investigation of the problem (Blumberg et al., 2014:144; Saunders et al. 2016:168). The population studied was a major retailer in South Africa, the second-largest distributor of consumer goods in Africa, with four divisions across 423 stores in 13 sub-Saharan countries. This retailer holds significant market share in general merchandise, liquor, home improvement and wholesale food sectors.

Data were collected using qualitative work observations and semi-structured interviews. Twelve employees representing various levels of the merchandise and supply chain department were purposively selected based on specific criteria, as well as middle management and upper management. These individuals had 3 years of experience and were knowledgeable about the impact of stock-outs in online shopping. The interviews were transcribed using Microsoft 365's dictate feature, with the researcher carefully reviewing the recordings to ensure accuracy. Employees provided operational insights, supervisors contributed operational and strategic viewpoints, and managers offered strategic information. The transcribed data were subsequently analysed using content analysis. This article was written by the authors with the assistance of ChatGPT-4 that was used solely for language polishing and editorial refinement of the authors' original ideas and research findings. The authors have thoroughly reviewed, validated and substantiated all scholarly content and claims.

Work observations at the store and regional distribution centre

Based on the observations, retail replenishment is critically important for preventing stock-outs, which directly impact organisational performance and profitability. The process involves counting existing inventory and strategically reordering stock to regulate its movement from warehouses to stores, ensuring high availability standards. The researcher witnessed firsthand the negative consequences of replenishment failures: an online purchase showed an item as in-stock, but it was unavailable for collection at the store, mirroring customer frustration that leads to negative reviews and lost sales. In another case, non-real-time inventory updates allowed a customer to order an out-of-stock item. This incident underscores how stock-outs create a chain of inefficiency, leading to backorders, potential cancellations, and ultimately, financial damage.

The replenishment team was observed analysing sales trends to identify high-demand products, guiding decisions on what to order or discontinue. Without this, the organisation risks overstocking unpopular items, leading to costly dead stock. The researcher evaluated several replenishment strategies to address these issues. The process relies on the regional distribution centre (RDC), which uses the System X forecasting and replenishment (F&R) system. Stores request stock via this system, and the RDC fulfils orders while maintaining its own safety stock by raising purchase orders with suppliers. System X F&R generates demand forecasts based on a 2-year sales history, excluding promotions, to use an average daily sales figure, aiming to create a more stable and accurate replenishment plan. These observations collectively demonstrate that the current replenishment process, while data-informed, remains susceptible to the core forms of waste targeted by lean: overstock, excess motion, and most critically, the lost sales and customer dissatisfaction from stock-outs. A truly lean replenishment system would therefore require a more seamless, real-time flow of goods and information to pre-empt these failures.

Face-to-face semi-structured interviews

Themes and subthemes were identified from the interview transcripts. Table 1 shows the research objectives, main themes, subthemes, and an extract of examples of direct quotes from the participants.

The rapid growth of online shopping in South Africa presents a significant opportunity for retailers, but it also exposes critical vulnerabilities in their operational frameworks. This investigation, viewed through the lens of lean retail principles, which focus on maximising customer value while minimising waste, uncovers a complex web of interconnected factors leading to frequent stock-outs. The journey from a customer's click to a successful delivery is fraught with systemic inefficiencies that undermine the very promise of e-commerce.

Fragmented systems: A core dilemma

The primary and most pervasive challenge lies in the organisation's technological backbone. The data reveal that the organisation operates on a foundation of disconnected systems. The head office, distribution centres (DCs) and physical stores all run on standalone systems that do not communicate in real-time. Participant 4 starkly illustrated:

> '… the system says there is ten in stock, [*an online*] customer buys the ten, but at the same time there is a customer in store [*who*] also buys ten … now we are ten short.' (P4, male, regional inventory specialist)

This lack of integration is the root cause of a cascade of failures that creates predictable crises.

This problem is compounded by the absence of real-time system synchronisation. Instead of live updates, the organisation relies on an overnight batch-processing system. In the fast-paced world of online retail, where this delay is catastrophic:

> '… every second, every minute … customers click that button.' (P2, Female, Planner)

The stock levels customers see are a snapshot from the previous day that fails to account for a full day of in-store sales, online orders or even damaged goods. This lack of real-time synchronisation directly violates a core lean principle of providing accurate, value-added information to the customer.

Misinformation and mismanagement

The consequences of this fragmented system extend deeply into internal operations, particularly in information management and forecasting. When systems are not integrated, data become unreliable. Planners, who are responsible for allocating stock, find themselves making critical decisions in the dark. One participant explained:

> '… if the stock on hand, stock on order … are incorrect, I can't make a decision.' (P6, Female, Buyer)

TABLE 1: Example of the research objectives, main themes, and subthemes identified for the interviews.

Objectives	Main themes	Sub-themes	Direct quotes from participants
To investigate the factors that contribute to stock-outs	System challenges	Real-time system synchronisation	'Is a live system the fact that system X only updates overnight you know, already that causes you know because if you sold 2 units you don't know then you're gonna have to wait the next day and I mean online shopping it's every second, every minute you know customers click that button you know and now with our system taking so long to update I think that's one of our inefficiencies somehow.' (P1, xx, xx)
		System integration	'So for me the best that I could have think of is our ECC, which is what we use on a regular basis and for DC articles EWCM because sometimes they even misalignment between stock and ECC versus Stock on EWCM so is part of system X, or I think would make a difference if especially if it's direct to stores or even yeah more for direct to store members if there were some way that our system X was integrated with the suppliers stock system so that we could see immediately if there's an out of stock on the business side umm and I think that so just help us to have more visibility.' (P1)
	Information management	Accuracy of information sharing	'With the stock take the data integrity, if information is not correct, is not captured correct, it's not updated correctly it messes up the accuracy of the information in terms of your stock availability and also it affects the forecasts or on those lines because the demand is not really it won't forecast correctly because the updates are not correct.' (P5)
		Information sharing within the organisation	'So for us, we have recurring sessions with the OPS centre, merchandise teams every second week so recurring by weekly or biweekly sessions, then in between the sessions they still continuous engagement when you're at the offices over the phone and then defined like I said mentioned previously there were always off work so just having to find ways off works so that we know what specific power specific information should be shared so sometimes it's just a FYI but sometimes it's quite a collaboration session or workshop session so almost like a racy racy document you know who's responsible who's accountable who should just be informed all of that and then other than that we also have central if you just talk about information sharing it's either via e-mail and that we also have central drives on our company and G drive basically that we can we can share larger sets of data with.' (P6)
	Forecasting	Stock integrity	'You know we can't make accurate decisions and plan accurately if the stock integrity is not 100% correct but we have definitely not mastered that yet. Stock integrity is massive.' (P2)
		Inaccurate forecasting	'However, what we do find is the irregularities in shopping patterns. So, you might have 10 in stock, and that 10 much that the system does not order because it's a slow mover all of a sudden, the customer goes online, and he now buys nine of that. And then somebody comes in and wants another thing and all of a sudden, you're out of stock. But for 2 or 3 months you didn't move.' (P6)
	Delays	Internal delays	'Talking about DC to store deliveries if there's a delay from DC side it's also a massive concern for us because all this, all the planning side of things system wise might be in place, for example, you might already got your STO's in place; however, there's a lack from DC from receiving STO's and until stock actually gets to store. So sometimes the lead time from DC is too long so you have the stock, but your stock is not in the stores where you need it to be, is sitting in your DC.' (P5)
		External delays	'I think it's the delays in the background between us and the suppliers that ultimately lead to a delay in the customer.' (P1)
To explore how lean retail can reduce stock-outs in online shopping	Effective process in online shopping	Building the website	'I will refer to people, technology, information and product tolerance because that is where we need to start to define our online process in order to build up an effective system. Without all of these then you won't have an online platform.' (P5)
		E-commerce platform (third-party integration, minimising waste)	'To reduce stock-outs from the supply chain if they have to optimise the orders based on the rate of stock you know based on like she has mentioned per truck, per stock and we have those efficiencies in the system we've got system that can build that sort of like preload that for us. It will take care of lot of out-of-stock issues. OK it's just that maybe they don't need to do it for all the stores, so maybe take your top 10 stores you know and do that definitely they will be very different because in those stores, the volume that goes into those stores will or different beneficial.' (P2)
	Supply chain operations	Digitalising the supply chain (continuous improvement)	'I think that whenever always developing a way of working or having a defined process, it leaves less room for errors because there is a process that needs to be followed. So, there's nothing that gets skip if we have a way of working. I think that digitising supply chain it will ensure or assist that information can be distributed easier and quicker between departments at any time.' (P4)

This inaccuracy fuels a cycle of inaccurate forecasting, making it impossible to match supply with the unpredictable demand patterns of online shopping, especially for seasonal items.

Because online and in-store channels share the same pool of stock without live visibility, they are constantly competing for the same items. An online purchase and an in-store sale can happen simultaneously for the last unit, but the system will only catch the conflict hours later. This critical failure in stock integrity creates confusion for customers and staff alike and is a major contributor to stock-outs.

Delays and inefficient processes

The systemic flaws inevitably manifest as tangible delays. Internal delays are rampant, particularly within the supply chain. The process for stock transfer orders (STOs) between stores or from DCs to stores is described as administratively heavy, 'costly' and a distraction from serving the customer. Long lead times mean stock is often 'sitting in your DC' when it is desperately needed in a store, highlighting a severe lack of flow, a key concept in lean thinking:

> 'So, sometimes the lead time from DC is too long so you have the stock, but your stock is not in the stores where you need it to be, is sitting in your DC.' (P3, male, regional inventory specialist)

> 'The STO from store to store it becomes a bit counterproductive first thing, is costly to the company. Secondly, it's taking attention away from the customer in the sense that the operators need to do all this other extra administrative work which is start consuming and cost instead of serving the customer better.' (P9, male, regional inventory specialist)

Similarly, external delays with suppliers further strain the system. Without integrated systems, the organisation lacks visibility into its suppliers' operations, making it difficult to anticipate or react to disruptions. Participant 5 noted that

> '… delays in the background between us and the suppliers … ultimately lead to a delay for the customer.' (P5, Male, Replenishment analyst)

Using lean retail to overcome challenges

The investigation points towards clear, lean-oriented solutions to break this cycle. The first step is to address the effective processes or lack thereof. Participants indicated that stores are not optimally set up for e-commerce, with staff juggling online order fulfilment with in-store customer service, causing one or the other to suffer. One participant indicated:

> 'Online versus in stores all shares stock. So, we could be showing 80 units available now we're going to be selling online, but if we don't pick up packets faster when someone comes during the day and the store sells all 80 units. You then don't have stock.' (P4, male, regional inventory specialist)

A lean approach would involve defining the value stream for online orders and creating dedicated, efficient workflows to fulfil them without compromising other operations.

Central to this transformation is the need for supply chain digitisation and continuous improvement. The current, largely manual processes are prone to errors and delays. Participants envisioned that a digitised supply chain would 'leave less room for errors' One of the participants, flag issues like overdue STOs automatically, and ensure that:

> '… information can be distributed easier and quicker.' (P1, Male, Inventory specialist)

By leveraging real-time data, the organisation can move from reactive firefighting to proactive management, optimising stock levels and improving agility.

Furthermore, when exploring an e-commerce platform, third-party integration was highlighted as a way to minimise waste. Implementing a system that automatically optimises orders based on sales velocity could:

> '… take care of a lot of out-of-stock issues.' (P2, Female, Planner)

To mitigate risk and validate the process, a phased, lean rollout was suggested, beginning with a pilot in the 10 most critical stores to facilitate learning and adjustments before company-wide implementation.

Results

The data gathered from interviews and workplace observations clearly demonstrate that the organisation's online shopping operations are characterised by significant waste and inefficiency, as defined by Liker & Hoseus (2004) framework. The core issue is a fundamental misalignment between the dynamic nature of e-commerce and the organisation's rigid, siloed systems and processes.

A primary source of waste is the lack of real-time system synchronisation. The researcher's own experience, alongside observational and interview data, confirms that the online system frequently indicates stock is available when it is not. Stock-outs thus occur because 'System X' updates stock levels on an overnight batch cycle, rather than reflecting transactions as they happen, in real time. Consequently, a walk-in customer can physically purchase an item, while an online customer simultaneously buys the same now-unavailable stock. This buying of the same product using different platforms leads directly to customer disappointment and constitutes a major form of waste, specifically waiting and delays, as identified by Liker & Hoseus (2004). Customers are forced to wait, often for a full day, to be notified that their order cannot be fulfilled, undermining the core promise of convenience that online shopping is meant to offer, a critical failure in system integration.

The organisation's internal systems (for online sales, point-of-sale, distribution centres and inter-store transfers) operate in isolation. Furthermore, these systems are not integrated with those of key suppliers. This siloed

infrastructure, operational inefficiency (Liker & Hoseus 2004), means that data regarding sales, orders and stock movements cannot flow seamlessly. The result is a perpetual state of inaccurate inventory records that forces staff to engage in non-value-adding motion waste, such as physically calling other stores to locate products, rather than serving customers effectively.

This systemic failure has a direct and damaging impact on information management. As online customers cannot physically inspect products, they are entirely dependent on the accuracy of the information presented. Inaccurate stock levels, product details or delivery estimates erode trust and risk losing sales to competitors. The data suggest that, while the organisation has dedicated roles such as buyers, planners, and merchandise controllers to manage inventory, their efforts are undermined by the poor quality of the data they receive. Without integrated systems that provide a single source of truth, achieving accurate demand forecasting and effective inventory management becomes nearly impossible. The lack of integrated systems leads to a costly paradox: the organisation simultaneously suffers from stock-outs (a form of waste through lost sales) and potentially from excess inventory (another of Liker's wastes), as planners lack the reliable data needed to align stock with actual demand.

The manual and protracted nature of key processes, such as ordering stock from RDCs or executing inter-store transfers, creates further delays and administrative bottlenecks that shift staff's focus from value-adding customer service and contribute to a long turnaround time for online deliveries. In a market where competitors offer 24-h delivery, these delays represent a significant competitive disadvantage.

Ultimately, the organisation appears to be neglecting the principles of continuous improvement, as embodied by the PDCA cycle. The current state of the online platform suggests a reactive approach to problems, rather than a proactive, planned effort to enhance processes. Complaints are addressed on an ad-hoc basis, but there is no evidence of a systematic review of the entire end-to-end online shopping value stream to identify and eliminate the root causes of waste. For genuine improvement, the organisation must initiate a PDCA cycle, beginning with a comprehensive plan to integrate its systems, streamline its supply chain digitisation, and re-engineer its processes around the core lean principle of delivering maximum value to the customer with minimal waste.

Discussion

From a lean retail perspective, the entirety of these issues represents a fundamental deviation from its core philosophy of maximising customer value while minimising waste (muda). The current online shopping process is rife with waste. The organisation is not only suffering from the obvious waste of waiting (customer delays) and defects (incorrect orders), but also from the more insidious wastes of over-processing (manual administrative workarounds), motion (staff searching for stock), and most critically, the waste of unused talent (as staff are forced to fight systemic fires rather than contribute to improvement). The lack of real-time data creates a 'push' system based on flawed forecasts, rather than a customer-driven 'pull' system that responds to actual demand. A true lean approach would mandate a deep, value-stream mapping exercise to visualise this entire process, from customer order to delivery, and systematically eliminate every step that does not add value in the eyes of the customer, building a fluid, integrated and responsive system in its place.

The identified failures in real-time synchronisation and the resultant waste of waiting and customer dissatisfaction reveal the limitations of traditional, inventory-centric lean models in modern e-commerce. While improving internal data flow is a necessary first step, our findings suggest that a more profound application of lean thinking is required: the adoption of a dynamic fulfilment model. A dynamic fulfilment model is an agile logistics strategy that leverages real-time data and a networked ecosystem of fulfilment nodes to intelligently route customer orders to the optimal location, thereby enhancing service levels and operational resilience (Winkelhaus & Grosse 2020). This approach aligns with the concept of a physical internet and digital supply chain twins, where intelligent, real-time routing of customer demand is paramount (Ivanov 2023; Winkelhaus & Grosse 2020).

Instead of a stock-out representing a terminal failure in the value stream, a dynamic, pre-mapped network of alternatives, such as direct-to-customer shipping from a supplier or a peer-to-peer store transfer, can be instantly activated. This transforms a potential muda (waste) event into a continuous flow of value, ensuring the customer's need is met without delay. This resilience is a core tenet of modern supply chain strategy, moving beyond mere leanness to achieve agile resilience by designing for adaptability in the face of disruption (Dubey et al. 2023). Consequently, dynamic fulfilment emerges not merely as a technical solution, but as the logical evolution of lean principles integrated with digital capabilities, creating a system where value is preserved even in the face of inventory uncertainty.

While traditional lean retailing and conventional fulfilment models effectively target internal waste and improve forecast accuracy, they exhibit a critical limitation in the context of modern, volatile e-commerce: they are fundamentally designed to prevent stock-outs within a static, linear supply chain. When prevention fails, as it inevitably does due to sudden demand surges, supply disruptions or systemic data latency, these models offer no embedded, proactive mechanism to preserve the customer order. The result is a terminal service failure, manifesting as a cancellation, backorder or lost sale, which directly contravenes the lean principle of continuous value flow.

This study's findings reveal a pivotal gap between operational problem detection and resolution. The root cause of stock-outs was identified as systemic latency and information

fragmentation. Merely fixing this data delay, while a necessary foundational step, constitutes an incomplete solution. The extant literature and prevailing practice lack a prescriptive framework that leverages real-time data visibility not just for better internal planning, but for the dynamic, intelligent fulfilment across a network of available inventory nodes. This gap represents a missed opportunity to apply lean thinking holistically to the entire, extended value stream.

To bridge this gap, we propose a dynamic fulfilment framework that represents an evolution of lean principles, integrating them with the capabilities of digital supply networks. Its core innovation lies in shifting the operational paradigm from inventory-centric prevention to networked resilience. Unlike static models, this framework pre-maps and integrates alternative fulfilment pathways into a cohesive ecosystem. When a stock-out occurs at one node, the system does not default to failure; instead, it uses real-time data to instantly reroute the customer order to the optimal available inventory source within the network.

Consequently, the proposed framework differs from and improves upon current approaches in three significant ways. Firstly, it transforms a potential waste event (a stock-out) into a managed process, thereby upholding the lean mandate of continuous flow. Secondly, it extends lean value stream mapping beyond the organisation's boundaries to optimise the flow of goods and information across a multi-enterprise network. Finally, it elevates the strategic objective from mere operational efficiency to agile resilience, ensuring customer value is delivered despite localised disruptions. In essence, it moves beyond asking, 'How do we avoid running out of stock?' to answer the more critical question: 'How do we guarantee fulfilment even when we run out of stock in a primary location?'

The framework's core logic assumes that customer value is maximised by the seamless, uninterrupted fulfilment of demand. It posits that a stock-out in one network node need not cause a service failure if other nodes hold available inventory. This approach assumes the modern retail environment is inherently volatile, necessitating a design-for-resilience model. Successful implementation assumes the retailer possesses the internal coordination to manage a multi-node network. It requires key supply partners to have a basic level of digital connectivity and operational transparency. The framework is contingent upon technological readiness for real-time inventory synchronisation and intelligent order orchestration. It fundamentally depends on the availability of accurate, standardised, and timely data across the defined network. The model assumes the substantial initial cost of technology integration is justified by long-term gains in sales preservation. It also assumes network partners are willing to participate under mutually beneficial commercial terms. The framework is theoretically anchored in the core tenets of lean thinking. It represents an evolutionary application of lean principles to digitally connectable supply chain networks. The pull system principle dictates that replenishment should be triggered by actual consumption. In a digital network, a customer order can theoretically pull a product from the optimal available node across the entire ecosystem. Value stream mapping must be applied to the multi-path journey of a single order across organisational boundaries. This extended mapping identifies and eliminates waste in the hand-offs between network nodes, optimising for end-to-end flow. Lean's aim for perfect flow theoretically re-conceptualises discrete, static inventories into a fluid, shared network resource. A dynamic network transforms potential waste from lost sales into a managed process that maintains continuous value delivery. The transition to a networked ecosystem is therefore the contextual evolution of lean theory. It applies lean's fundamental axioms to the new reality of digitally connected supply chain actors.

The graphic framework in Figure 1 shows how lean thinking has developed in the context of e-commerce to solve the enduring issue of stock-outs. It starts with the discovery that stock-outs are the main problem in online retail, resulting in unhappy customers, lost sales and inefficient operations. The diagnosis, which is based on a lean-based root cause analysis, identifies systemic waste in the value stream, especially the waiting, correction, and flow failure

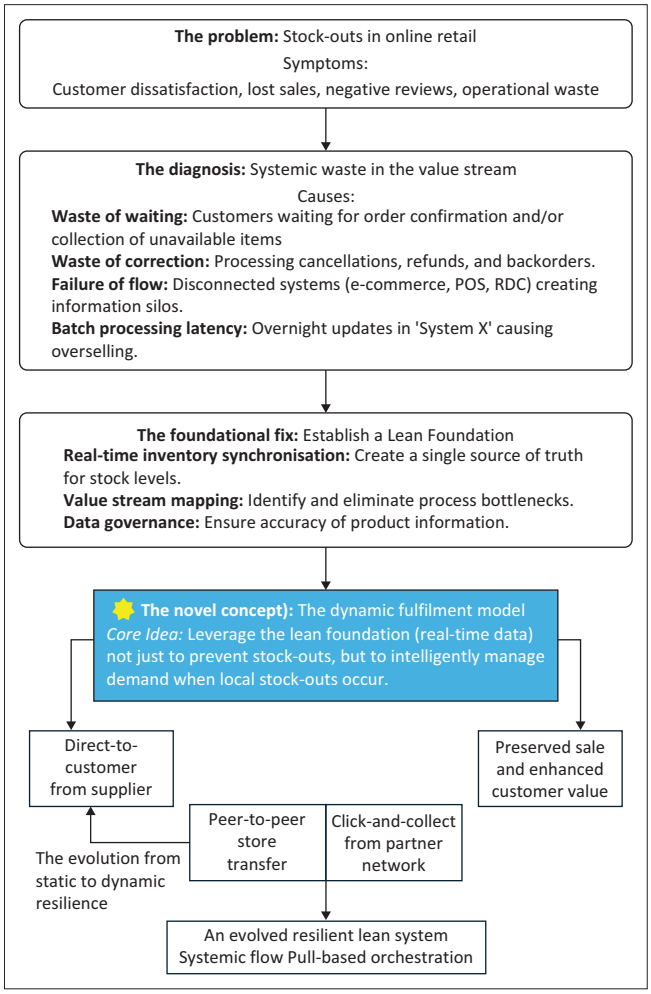

FIGURE 1: Evolving lean for e-commerce: A dynamic fulfilment framework to eliminate stockouts.

wastes, which are made worse by batch processing delays. To restore process efficiency, the fundamental lean solution suggests implementing value stream mapping, data governance and real-time inventory synchronisation. Building on this foundation, the framework presents the dynamic fulfilment model, a noteworthy innovation that employs real-time data to dynamically manage demand across a network of connected devices rather than just preventing stock-outs. This model enables fulfilment through direct supplier dispatch, peer-to-peer store transfer or partner click-and-collect, ensuring that sales are preserved and customer value is enhanced. Ultimately, the framework culminates in an evolved, resilient lean system characterised by seamless flow, pull-based orchestration and agile adaptability to disruption.

The utility and configuration of the dynamic fulfilment framework are contingent on specific product and retail characteristics. The framework offers strong utility for high-value, low-frequency goods like electronics, where the cost of a lost sale justifies network orchestration. It is highly beneficial for fashion and trend-driven retail, which suffer acutely from forecast errors and demand volatility. It is also effective for managing slow-moving or long-tail items, increasing assortment breadth without proportional inventory cost.

For fast-moving consumer goods, the benefit of complex dynamic routing may not offset its cost, although real-time visibility remains crucial. Perishable goods require a network designed with strict rules governing shelf-life and compliance. Very high-value-density goods may necessitate a more limited, tightly controlled network due to security and authentication requirements. The framework's core components are broadly applicable as a universal principle. Its specific instantiation, however, must be tailored to product characteristics such as value, variability, velocity and vulnerability.

Conclusion

This research confirms that stock-outs are a symptom of fragmented systems and batch-driven latency and argues that the ultimate solution lies not only in correcting these internal inefficiencies but also in architecting a fundamentally more resilient fulfilment model. Based on a lean perspective, this study identifies that stock-outs in online retail fundamentally represent a failure to deliver customer value and eliminate waste, primarily stemming from a lack of real-time system synchronisation. The key findings confirm that the core operational issue is the reliance on an overnight batch processing cycle within 'System X', which creates a critical lag. This latency allows in-store purchases to deplete inventory that remains listed as available online, leading directly to the dual sale of a single product and resulting in customer disappointment. This situation directly constitutes the lean wastes of waiting and unnecessary processing.

Furthermore, the accuracy of online product information is shown to be vital for value creation and closing sales; poor-quality information leads to abandoned purchases and demonstrates an incomplete implementation of lean principles. The underlying cause is that the organisation's internal and external systems operate in isolation, creating a fragmented rather than a cohesive, flowing supply chain. The proposed dynamic fulfilment framework addresses a specific shortfall in existing models, which treat the supply chain as a linear sequence with single points of failure. By contrast, our framework reconceptualises the supply chain as an agile, networked ecosystem. It fills the gap between real-time problem awareness and automated, multi-option resolution. This represents a significant departure from conventional lean applications focused on internal process refinement; here, lean thinking is leveraged to design and manage flow across a dynamic network, ensuring that the end-customer's value expectation of receiving the desired product is met with unprecedented consistency.

The managerial implications are severe, as these inefficiencies erode customer trust and brand equity by breaking the core promise of convenience, while also causing direct financial loss through cancelled orders and lost future sales. Strategically, this operational model leaves the organisation vulnerable to more agile competitors. To address this, practical recommendations include implementing a real-time inventory synchronisation platform to create one definitive and accurate record of all inventories. It is further advised to adopt a lean, iterative approach by piloting this system in a select group of top-performing stores before a wider rollout, allowing for refinement and validation. Finally, establishing a cross-functional data governance team is crucial for overseeing the quality and accuracy of all online product information.

The true evolution beyond a foundational fix lies in adopting a dynamic fulfilment model, which represents the next stage in the lean journey. This evolution entails a shift from simply creating an accurate, single source of truth for inventory to leveraging that data for building an agile, networked ecosystem. Within such an evolved model, a stock-out in one node no longer signifies a service failure; instead, intelligent systems instantly reroute demand to the optimal available inventory source across the network, whether a different warehouse, retail store or supplier. Such a capability transforms potential losses into preserved sales, thereby operationalising the lean principle of flow at a systemic level and creating unparalleled resilience against the inefficiencies of a fragmented supply chain. Therefore, this dynamic fulfilment framework does not merely seek to improve upon existing models incrementally; it proposes a paradigm shift towards a digitally enabled, lean-driven system where resilience is engineered into the very fabric of retail logistics, transforming inventory uncertainty from a liability into a manageable variable within a fluid network.

For future research, it is recommended to quantitatively investigate the return on investment of real-time integration

to build a stronger business case. Subsequent studies should also explore effective models for integrating key suppliers into the retailer's inventory management system to create an end-to-end supply chain. Further academic inquiry could productively examine the impact of advanced analytics and machine learning on enhancing lean retailing by moving from reactive problem-solving to proactive waste prevention and demand anticipation.

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The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

CRediT authorship contribution

Carol Mabunda: Conceptualisation, Formal analysis, Methodology, Writing – original draft. Anthea P. Amadi-Echendu: Conceptualisation, Funding acquisition, Supervision, Writing – review & editing. Nonceba Ntoyanto-Tyatyantsi: Writing – review & editing. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication and take responsibility for the integrity of its findings.

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Data availability

The data that support the study are available from the corresponding author, Anthea P. Amadi-Echendu, upon reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the authors and are the product of professional research. They do not necessarily reflect the official policy or position of any affiliated institution, funder, agency or that of the publisher. The authors are responsible for this article's findings and content.

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