Rethinking Inventory Intelligence: A Conceptual Model in Adopting AI-Based Demand Forecasting within Malaysian Retail Supply Chains

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ABSTRACT

Artificial Intelligence (AI) is increasingly transforming global supply chain practices, particularly in demand forecasting, where traditional methods often fall short in capturing dynamic market complexities. Despite growing awareness of AI's potential, many Malaysian retailers continue to rely on manual or historical trend-based forecasting methods. This often leads to inefficiencies, including stock imbalances, overstocking, and poor responsiveness to shifting consumer demand. Government-led initiatives such as the Malaysia Digital Economy Blueprint and the National AI Roadmap aim to close this digital gap, yet significant readiness barriers remain including lack of infrastructure, skill shortages, and limited strategic alignment. Thus, this conceptual study explores the integration of AI-based demand forecasting into inventory decision-making processes within Malaysian retail supply chains. Grounded in the Resource-Based View (RBV) and Technology–Organization–Environment (TOE) frameworks, the research aims to identify key enablers, practices, and expected impacts of AI adoption, while accounting for Malaysia's unique technological, organizational, and policy landscape. This study proposed a conceptual framework that highlights the interaction between critical stakeholders (e.g., retail managers, inventory analysts), enabling conditions (e.g., digital infrastructure, organizational culture), and core practices (e.g., automated demand forecasting, AI-driven replenishment planning). Expected outcomes include improved forecast accuracy, enhanced inventory responsiveness, and greater supply chain agility. As this study adopts a constructivist qualitative approach, it also remains open to the emergence of new themes during empirical investigation to ensure that context-specific insights and lived experiences are fully captured. Ultimately, this research contributes to the limited body of knowledge on AI adoption in Malaysian retail and provides a foundation for future empirical inquiry. By contextualizing global best practices within Malaysia's retail environment, it offers practical insights to guide policymakers, retail leaders, and technology adopters in building intelligent, resilient, and future-ready inventory systems.

Keywords: Artificial Intelligence (AI), Inventory Management, Demand Forecasting, Retail Supply Chain, Technology Adoption

INTRODUCTION

Artificial Intelligence (AI) is reshaping supply chain management, particularly in the domain of demand forecasting, where traditional techniques often fall short in today's dynamic and complex business environments. Conventional forecasting methods such as moving averages and exponential smoothing are largely reactive, rely on historical data, and fail to adapt effectively to real-time market fluctuations (Douaioui et al., 2024). This leads to inaccuracies in forecasting, causing downstream problems such as overstock, understock, and inefficient inventory turnover. In contrast, AI-based demand forecasting leverages machine

learning (ML) and deep learning (DL) models that process vast datasets, uncover nonlinear patterns, and continuously adapt to changing market signals (Choi, Wallace, & Wang, 2022). This allows organizations to make more accurate and timely inventory decisions, ultimately improving supply chain resilience and customer satisfaction (Jain et al., 2023).

AI's role in enabling intelligent, data-driven decisions marks a significant departure from traditional, judgment-based approaches. AI-powered forecasting can enhance organizational agility by reducing uncertainty, supporting scenario planning, and enabling proactive responses to market shifts. Moreover, the integration of AI facilitates coordination across the supply chain, contributing to leaner operations, reduced waste, and a stronger competitive advantage (Nair & Saenz, 2024). However, many businesses struggle with data silos, resistance to automation, and underinvestment in digital capabilities (Choi et al., 2022; Barenji et al., 2020). Despite these challenges, global interest in AI-enabled supply chain optimization continues to grow, driven by the need for greater adaptability in a volatile, interconnected world (Eyo-Udo al., 2024).

This shift is particularly relevant in the retail sector, which functions as the final link in the supply chain by delivering goods and services directly to end consumers. Retail operations span a diverse range of channels including physical stores, convenience outlets, and increasingly digital platforms such as e-commerce websites and mobile applications (Deloitte, 2023). Globally, the retail sector remains a critical economic driver, contributing approximately USD 29.3 trillion in 2023 (Capital One Shopping, 2025). In Malaysia, retail is an essential component of the national economy, embedded within the services sector that accounted for 59.2 per cent of the country's Gross Domestic Product (GDP) in 2023 (Department of Statistics Malaysia, 2024). The Malaysian retail market was valued at USD 89.35 billion in 2024 and is projected to grow to USD 126.75 billion by 2030, underscoring the need for efficient and adaptive supply chain strategies (Mordor Intelligence, 2024).

Background of the Study

In recent years, there has been a growing awareness of the potential of AI within the Malaysian retail ecosystem. Increasingly, companies are exploring pilot programs and adopting cloud-based AI tools that reduce the need for in-house technical expertise. This shift is further driven by the rise of omnichannel retailing, where customers engage with brands across multiple platforms necessitating faster, more flexible, and data-driven inventory strategies. AI supports these needs by enabling demand forecasting at granular levels, accounting for variations in consumer behaviour across regions and sales channels (Joned, 2024). Despite this growing interest, academic research in Malaysia has yet to keep pace, with limited conceptual studies addressing AI-based demand forecasting tailored to the nation's economic context, technological maturity, and policy landscape.

As Malaysia's retail landscape expands, so too does the complexity of managing inventory in the face of rapid urbanisation, shifting consumer preferences, and the accelerating pace of digital commerce. Traditionally, many Malaysian retailers have relied on manual, experience-based forecasting techniques. These outdated approaches lack the speed and accuracy required to navigate volatile demand cycles, resulting in frequent mismatches between supply and actual consumer demand. Such mismatches trigger the bullwhip effect, where small fluctuations in consumer purchases lead to disproportionately large swings in orders placed upstream in the supply chain (Lamzaouek, 2021; Çakır et al., 2025). The consequences include increased holding costs, stockouts, reduced customer satisfaction, and disruptions to manufacturing and distribution operations. Not only that, the major barrier to widespread AI adoption in Malaysian retail is also the uneven digital readiness across firms. This digital divide threatens to widen the performance gap between technologically advanced firms and traditional retailers. Recognising this, the Malaysian government introduced the Malaysia Digital Economy Blueprint and National AI Framework to promote AI adoption. Thrust 2 of the blueprint sets a national goal of enabling over 800,000 micro, small, and medium enterprises (MSMEs) to adopt digitalisation by 2025 (Economic Planning Unit, 2021). This aligns with the Sustainable Development Goal 9 (SDG 9), which advocates for inclusive and sustainable industrialization through the adoption of innovative technologies (Costa, 2024).

On a global scale, retailers have begun leveraging AI to improve forecast accuracy, minimize stockout risks, and stabilize inventory turnover (Amosu et al., 2024; Nguyen, 2023). With its ability to process real-time data, AI enables businesses to adapt rapidly to shifting market demands. However, in Malaysia, the adoption of AI in retail inventory management remains limited. Many companies continue to depend on manual, historical trend-based forecasting methods, which often lead to inaccurate procurement, inefficient replenishment, and supply chain bottlenecks (Joned, 2024; Ghazali et al., 2023). Although national efforts such as the Malaysia Digital Economy Blueprint and the PENJANA initiative have allocated RM700 million to support digital technology adoption, progress remains slow. Recent findings from Cisco's AI Readiness Index reveal that only 13 per cent of Malaysian organizations are adequately prepared to implement AI solutions (Cisco, 2023; MIDA, 2023). This gap between policy ambition and operational readiness underscores the urgent need to strengthen digital capabilities, infrastructure, and awareness among local retailers.

Successful implementation of AI-based forecasting relies heavily on several key enablers, including robust technological infrastructure, integrated data systems, and access to skilled human capital (Shahzadi et al., 2024; Khodri Harahap et al., 2025). However, many small and medium-sized enterprises (SMEs) in Malaysia continue to face significant barriers such as high upfront investment costs, limited digital proficiency, and a lack of understanding regarding the operational benefits of AI (Ghazali et al., 2023; Amosu et al., 2024). These constraints hinder efforts to optimize inventory visibility, set appropriate reorder points, and align stock levels with actual demand. In many cases, retailers still rely on spreadsheet-based forecasting methods, lacking real-time integration with point-of-sale data, supplier lead times, and warehouse inventory levels (Adetula & Akanbi, 2023). This limits their ability to make agile, informed decisions and undermines overall supply chain performance (Lee & Kim, 2021).

Although global studies have demonstrated that AI can enhance inventory turnover, reduce waste, and improve customer satisfaction by ensuring timely product availability (Kumar et al., 2024), its impact in the Malaysian retail context remains under-explored. Many retailers are still unaware of how AI can support smarter procurement planning, reduce excess inventory, and improve supply chain responsiveness (Joned, 2024). Consequently, this study aims to address the existing knowledge gap by developing a conceptual model that integrates AI-based demand forecasting into inventory decision making within Malaysian retail supply chains. By contextualizing global best practices within Malaysia's unique retail and digital landscape, this research deepens the understanding of key enablers, current practices, and the impact of enhancing inventory intelligence that will ultimately foster supply chain integration and supporting long-term business sustainability.

LITERATURE REVIEW

The Concept of AI-Based Demand Forecasting

AI-based demand forecasting harnesses machine learning algorithms to analyze vast datasets including historical sales, market trends, weather forecasts, and even social media activity to generate accurate, real-time predictions (Nweje & Taiwo, 2025). These intelligent systems uncover complex, non-linear relationships that traditional models fail to capture, resulting in significantly improved forecast accuracy and better inventory turnover (Gudavalli & Ayyagari, 2022). With continuous learning capabilities, AI models dynamically adjust replenishment schedules based on real-time demand signals, reducing both stockouts and surplus inventory (Verma, 2022). Furthermore, by automating the determination of reorder points and safety stock levels, AI enhances supply chain planning while minimizing manual workload for inventory managers.

The operational benefits of AI-driven forecasting are increasingly evident in the retail sector. Studies show that these tools can reduce forecasting errors by up to 50 per cent, leading to increased sales capture and higher customer satisfaction (Hasan et al, 2025). AI also contributes to leaner operations by reducing warehouse carrying costs and lowering labor needs through real-time replenishment and improved order fulfillment (Baharudin, 2023). Its demand sensing capability allows retailers to detect early signs of market shifts and seasonal trends, enhancing supply chain agility (Bai, 2023). Major global retailers like Walmart and Target exemplify this shift; Walmart uses regionally adaptive AI models to better align stock with localized demand,

while Target leverages AI across its network to optimize stock allocation and supplier coordination (Chen, 2021).

In the Malaysian context, the foundation for AI-based forecasting is being progressively developed. Government-led initiatives such as the establishment of the National AI Office and the introduction of cloud computing policies in 2024 aim to promote AI integration within supply chain operations (Reuters, 2024). The Malaysia Digital Economy Corporation (MDEC) has also supported the growth of over 140 AI companies, generating RM1 billion in revenue and enhancing AI readiness across both SMEs and larger retail players (Loheswar, 2024; The Star, 2024). However, readiness remains modest of less than 20 per cent of Malaysian organizations are fully equipped to implement AI solutions, hindered by inadequate digital infrastructure, talent shortages, and strategic gaps (Cisco, 2023). Despite these challenges, a growing number of retailers are beginning to adopt AI forecasting tools to improve inventory visibility, stock accuracy, and data-driven decision-making within increasingly competitive and volatile supply chains.

Understanding AI-Based Demand Forecasting for Enhanced Inventory Management

AI-based demand forecasting harnesses machine learning algorithms to analyze vast datasets including historical sales, market trends, weather forecasts, and even social media activity to generate accurate, real-time predictions (Paramesha et al., 2024). These intelligent systems uncover complex, non-linear relationships that traditional models fail to capture, resulting in significantly improved forecast accuracy and better inventory turnover (Gudavalli & Ayyagari, 2022). With continuous learning capabilities, AI models dynamically adjust replenishment schedules based on real-time demand signals, reducing both stockouts and surplus inventory (Verma, 2024). Furthermore, by automating the determination of reorder points and safety stock levels, AI enhances supply chain planning while minimizing manual workload for inventory managers.

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Inventory decision making refers to the strategic process of determining optimal stock levels and replenishment schedules to meet customer demand efficiently (Yellanki, 2023). This includes calculating reorder points, safety stock levels, and analyzing inventory turnover by considering the ratio of cost of goods sold to average inventory as key performance indicators (Tadayonrad & Ndiaye. 2023). A high turnover rate reflects strong inventory flow and sales alignment, while a low rate suggests overstock or sluggish demand (Addo, 2020). Effective inventory strategies also incorporate trade-off analyses between holding and stockout costs, and apply quantitative models such as Economic Order Quantity (EOQ) to determine optimal order sizes (Aro-Gordon & Gupte, 2016; Wu et al., 2023). These models, when integrated with AI systems, ensure data-driven accuracy that minimizes excess inventory while avoiding disruptions from stockouts.

In the context of modern retail supply chains, inventory decisions extend beyond replenishment. They include assortment planning, fulfillment strategies, and channel-specific stock allocations to balance physical and digital retail demands (RetailWire, 2023). Synchronization across multiple distribution centers is essential to maintain high service levels and accommodate regional demand variations. Additionally, inventory review systems either periodic or continuous play a critical role in decision timeliness. Continuous reviews are more responsive to sudden demand shifts, while periodic reviews require fewer resources but may introduce delays (Ghosh et al., 2023). Selecting the right review mechanism is essential for ensuring responsiveness, cost efficiency, and customer satisfaction in omnichannel environments (Gerea et al., 2021).

Malaysia's retail and logistics sectors are increasingly supported by national digitalization agendas that promote smarter inventory management. Initiatives such as the Malaysia Digital Economy Blueprint and the National eCommerce Strategic Roadmap encourage the adoption of predictive analytics and automation tools to improve inventory accuracy and supply chain efficiency (DOSM, 2023; MDEC, 2023). Agencies like MDEC and the World Bank provide digital infrastructure support, funding, and capacity-building programs to assist SMEs in modernizing their inventory systems. However, readiness gaps remain at less than 20 per cent of Malaysian businesses are fully equipped to deploy AI technologies due to infrastructure limitations, skills shortages, and strategic inertia (Cisco, 2023). Nevertheless, by aligning internal practices with these national initiatives, businesses can access incentives and build agile, tech-enabled inventory ecosystems that support Malaysia's broader ambition to become a regional logistics and e-commerce hub (World Bank, 2023).

Major Inventory Management Challenges in the Malaysian Retail Supply Chain

Inventory management plays a vital role in ensuring product availability, cost control, and customer satisfaction within Malaysian retail supply chains (Al Shukaili et al., 2023). Major retailers such as AEON, Mydin, Tesco (Lotus's), and 7-Eleven rely on integrated systems that combine point-of-sale (POS) data, warehouse management systems (WMS), and enterprise resource planning (ERP) platforms to achieve real-time inventory visibility and efficient replenishment (Wang & Ghauri, 2020). This digital synchronization supports just-in-time (JIT) inventory practices, which help minimize holding costs while meeting fluctuating consumer demands, particularly during promotional periods and festive seasons. Increasingly, retailers are turning to AI and predictive analytics to generate more precise demand forecasts using inputs such as historical sales, seasonal patterns, weather, and social media trends (Muthukalyani, 2023). These AI-powered tools optimize economic order quantities and safety stock calculations, facilitating more accurate and responsive inventory strategies (Bhavikatta, 2025).

Despite these advancements, several challenges continue to impede effective inventory management, particularly among small and medium-sized enterprises (SMEs). Many SMEs still rely on manual methods, including spreadsheets or paper-based logs, which lack real-time synchronization and increase the risk of errors. According to Malaysia Digital Economy Blueprint, these retailers, especially those in rural areas, also face digital infrastructure limitations, restricting access to advanced inventory management systems (Economic Planning Unit, 2021). Stock discrepancies due to data entry errors, theft, or system mismatches further reduce the reliability of inventory records (Kang & Gershwin, 2005; Best et al., 2022). Inventory shrinkage caused by internal theft, spoilage, and fraud remains a pervasive issue, affecting both profitability and operational accuracy (Hassan et al., 2016). Larger retail chains, in contrast, tend to benefit from more robust systems and better-trained staff, giving them a strategic advantage in inventory accuracy and responsiveness.

Operational inefficiencies are compounded by fragmented supply chain structures and inconsistent lead times from suppliers (Anthony et al., 2024). Retailers that source from multiple vendors frequently experience delivery delays, logistical bottlenecks, and unreliable schedules, which complicate inventory planning and reduce service reliability particularly for outlets in rural and remote areas (Czinkota, 2021). Seasonal fluctuations and rapid shifts in consumer behaviour, especially with the rise of e-commerce, further challenge inventory strategies. Retailers must now anticipate demand with greater precision and maintain balanced stock levels across both physical and digital channels (Niaz, 2022). Many still make inventory decisions based on intuition or past experience rather than data, which limits their ability to respond to dynamic market conditions effectively. This disconnects between front-end sales and back-end inventory data reduces operational agility and hinders timely procurement and replenishment (Yong et al., 2020).

To address these challenges, the Malaysian government has implemented strategic initiatives through the MyDIGITAL Blueprint 2021–2030 and related programs to enhance digital readiness in the retail sector (Economic Planning Unit, 2021). These initiatives aim to expand broadband access, build cloud infrastructure, and promote digital literacy, especially among SMEs. Grants such as the Smart Automation Grant offer financial support for the adoption of smart inventory technologies. These efforts, combined with growing e-commerce penetration and consumer expectations, are pushing retailers to invest in AI-powered inventory solutions. By leveraging predictive analytics, real-time inventory visibility, and automated replenishment tools,

retailers can transform their supply chain operations into agile, data-driven ecosystems capable of sustaining competitiveness in an evolving marketplace.

A Theoretical Integration in Exploring the Adoption of AI-Based Demand Forecasting within Malaysian Retail Supply Chains

The integration of the Resource-Based View (RBV) and the Technology-Organization-Environment (TOE) framework provides a robust theoretical foundation for understanding the adoption of AI-based forecasting technologies within Malaysian retail supply chains. RBV emphasizes the strategic role of internal resources such as data infrastructure, analytical capabilities, and organizational knowledge as drivers of competitive advantage. In contrast, the TOE framework offers a broader contextual lens, capturing technological attributes, organizational readiness, and environmental pressures that influence adoption behavior. Together, these frameworks offer a multidimensional perspective on how AI-driven forecasting impacts inventory decision-making and supply chain performance. Building on this theoretical base, the study proposes a conceptual framework that captures the dynamic interaction between stakeholders, enablers, practices, and outcomes. Key stakeholders including retail managers, IT or inventory analysts, and strategic decision-makers are central to driving adoption initiatives. Critical enablers include robust organizational capabilities and culture (RBV), as well as government support and digital infrastructure (TOE). These enablers support two primary AI-enabled practices: automated demand forecasting and AI-powered assortment and replenishment planning. When effectively aligned, these practices result in improved forecasting accuracy and enhanced supply chain agility. This integrated framework provides a structured pathway for achieving successful AI adoption, enabling Malaysian retailers to build data-driven, resilient, and competitive inventory management systems.

The Resource-Based View (RBV), as introduced by Barney (2005), posits that firms attain sustainable competitive advantage by developing and leveraging resources that are valuable, rare, inimitable, and non-substitutable (VRIN). Within the context of AI adoption in inventory forecasting, this theory highlights how internal technological capabilities—such as machine learning systems, big data analytics platforms, and data science expertise—can serve as strategic assets. These capabilities enable firms to make more informed, accurate, and agile inventory decisions, setting them apart from competitors. For Malaysian retailers, those that successfully embed these AI-driven resources into their operational routines can turn forecasting into a strategic function that enhances cost control, customer satisfaction, and responsiveness. RBV thus emphasizes the internal development of AI competencies as a pathway to transforming inventory forecasting into a source of long-term differentiation.

On the other hand, the Technology-Organization-Environment (TOE) Framework, provides a broader systems-oriented approach for analyzing innovation adoption (Baker, 2011). It considers three critical dimensions: the technological context, which includes the perceived relative advantage, compatibility, and complexity of AI tools; the organizational context, encompassing leadership commitment, financial resources, and workforce competency; and the environmental context, which captures competitive pressure, regulatory influence, and customer expectations. Within the Malaysian retail sector, the TOE framework helps to identify the external and internal conditions that influence whether firms adopt AI-based forecasting tools or not. For example, even when technological solutions are available, a lack of digital infrastructure or organizational support may hinder adoption. This framework is particularly valuable in the Malaysian context, where disparities in digital readiness among firms especially between large retail chains and SMEs can significantly affect adoption trajectories.

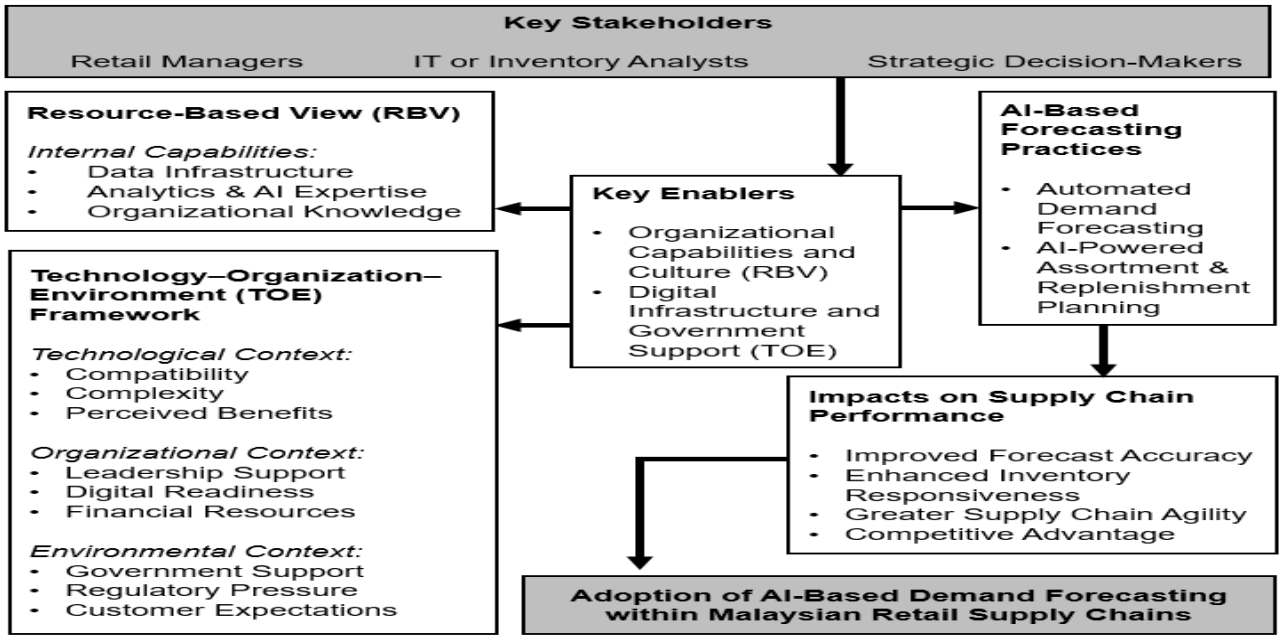

Figure 1: Theoretical integration of this study

Proposed Research Questions

Based on the theoretical integration discussed earlier, it is evident that both the Resource-Based View (RBV) and the Technology–Organization–Environment (TOE) framework contribute meaningfully to justifying each component of the proposed conceptual framework. As highlighted by Yin (2016), analytical generalization derived from a theoretical framework can result in either (1) the refinement, extension, or rejection of the initial theoretical foundation, or (2) the emergence of new concepts and insights upon completion of the study. In line with this, Creswell (2017) emphasize the importance of a clear research purpose and well-formulated research questions, as they guide the researcher in maintaining focus on the core phenomenon throughout data collection and analysis. Within the context of this study, the researcher is expected to critically explore each dimension of the framework including enablers, practices, stakeholders, and impacts and remain open to identifying new themes that may arise from the investigation. These findings will enhance understanding of the adoption process and validate the applicability of the integrated RBV and TOE frameworks in explaining how AI-based demand forecasting influences inventory decision-making and supply chain performance in the Malaysian retail industry. Accordingly, this study is guided by the following research questions, which are formulated to align with the theoretical underpinnings and objectives of the research:

Research Question 1: What are the key enablers for the successful adoption of AI-based forecasting in inventory management within Malaysia's retail industry?

Research Question 2: How are the practices of AI-based forecasting being applied in inventory decision making within Malaysia's retail sector?

Research Question 3: What are the impacts of AI-based forecasting on inventory accuracy, stock availability, and overall supply chain performance in Malaysian retail businesses?

SUMMARY OF FINDINGS AND CONCLUSION

This conceptual study aims to explore the adoption of AI-based demand forecasting within the inventory decision-making processes of Malaysian retail supply chains. Anchored in the Resource-Based View (RBV) and the Technology–Organization–Environment (TOE) frameworks, the research provides a comprehensive lens to examine both internal capabilities and external influences that shape AI integration. The proposed conceptual framework outlines the dynamic interactions between stakeholders, enabling factors, forecasting practices, and anticipated outcomes. It also offers a structured foundation for investigating how AI

technologies can enhance forecasting precision, inventory responsiveness, and overall supply chain performance in Malaysia's evolving retail landscape.

Drawing from the literature and theoretical constructs, the study anticipates that two core enablers such as government-led digital infrastructure and internal organizational readiness that will play a pivotal role in facilitating AI adoption. National initiatives, such as the Malaysia Artificial Intelligence Roadmap and major investments in cloud infrastructure, are expected to lower technological entry barriers and create a supportive ecosystem for AI adoption. Internally, organizational factors such as leadership commitment, cross-functional collaboration, and workforce digital literacy are predicted to be key differentiators. Firms that align AI initiatives with strategic objectives and foster a culture of innovation are more likely to realize successful integration and long-term impact.

In terms of practice, the study expects that retailers will adopt AI for two main purposes including automated demand forecasting and intelligent assortment and replenishment planning. These AI-driven applications are anticipated to improve decision-making by analyzing complex, real-time data, enabling retailers to anticipate demand shifts and optimize inventory levels with greater precision. For instance, tools that adjust replenishment quantities based on consumer behaviour, seasonal trends, and omnichannel data integration are likely to become standard features in modern retail inventory systems. As these practices mature, they are expected to contribute to improved stock availability, reduced waste, and increased operational efficiency across the retail value chain.

The anticipated outcomes of AI adoption include significant enhancements in both forecast accuracy and supply chain agility. Accurate demand predictions will likely reduce inventory imbalances, streamline procurement decisions, and minimize holding costs. In parallel, the ability of AI systems to provide real-time monitoring and scenario planning is expected to strengthen supply chain resilience, especially in times of market disruption or supply uncertainty. Importantly, as this research follows a constructivist qualitative approach, the researcher will remain open to emerging themes and patterns that may arise during fieldwork. This flexibility ensures that the lived experiences and insights of participants are fully captured, enriching the understanding of how AI is perceived, applied, and operationalized across diverse retail settings in Malaysia.

In conclusion, this study offers a theoretically grounded and contextually relevant exploration of AI-based demand forecasting in Malaysian retail supply chains. The integration of RBV and TOE frameworks enables a multi-dimensional analysis of adoption drivers, organizational practices, and expected impacts. While empirical data will be required to validate the conceptual model, this study serves as a foundation for future qualitative inquiry and practical application. As Malaysia progresses toward becoming a digital-first economy, AI technologies are poised to play a central role in transforming inventory decision making, enabling more intelligent, adaptive, and competitive supply chain strategies.

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