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Supply Chain E-Commerce Through Predictive Analytics: A Conceptual Review With Tokopedia As An Illustrative Case

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Abstract. The rapid expansion of Indonesia's e-commerce sector has intensified the need for supply chain systems that are more accurate, adaptive, and data-driven. As competition grows, companies increasingly rely on digital tools to manage uncertainty and support faster operational decisions. This conceptual paper examines how predictive analytics could influence Indonesia's e-commerce supply chain landscape, using Tokopedia only as a contextual reference. Drawing from a narrative review of recent literature on predictive analytics, digital supply chain transformation, and the Technology Acceptance Model (TAM), the study identifies several pathways through which data-driven prediction can strengthen operational performance. The review highlights that predictive analytics enhances demand forecasting accuracy, improves inventory synchronization, and supports more efficient logistics coordination. Insights from TAM further suggest that user acceptance of advanced analytics tools is influenced by perceived usefulness, perceived ease of use, and an organization's overall digital readiness. Methodologically, this paper synthesizes existing scholarly work published within the past five years to build a theoretical understanding without collecting primary data. The conceptual findings underline the potential of predictive analytics to support more resilient and responsive e-commerce operations. The paper concludes by outlining theoretical implications, proposing managerial considerations for digital adoption, and recommending future empirical studies to validate the conceptual propositions presented.

Keywords: Big Data Analytics; Digital Transformation; Predictive Supply Chain; Platform-Based Commerce; User Acceptance

INTRODUCTION

Indonesia's booming e-commerce industry has intensified the need for more sophisticated supply chain capabilities to manage fluctuating demand, regional disparities, and heightened competition. Predictive analytics powered by machine learning and data-driven modeling has surfaced as a key enabler for proactive, anticipatory decision-making (Nguyen et al., 2021). These analytical capabilities can significantly enhance accuracy and responsiveness in digital logistics environments (Ghosh & Shah, 2020). The rapid diffusion of digital platforms has reshaped consumer expectations in Indonesia, pushing e-commerce firms to operate with faster cycle times and greater service reliability. These shifts introduce new pressure on supply chain networks, particularly in coordinating last-mile logistics across geographically dispersed regions. As

uncertainties in demand patterns become increasingly volatile, the ability to anticipate operational fluctuations through data-driven forecasting becomes not just beneficial, but essential for sustaining competitive advantage in the sector. While global research acknowledges the strategic role of predictive analytics in strengthening supply chain competitiveness (Gunasekaran et al., 2021), dedicated conceptual studies focusing on its relevance to Indonesia remain limited. Additionally, although the Technology Acceptance Model (Davis, 1989) is widely applied to explain technology uptake, its application to predictive analytics adoption within Indonesian e-commerce contexts is still underdeveloped. Furthermore, the lack of integrated conceptual studies combining predictive analytics, digital supply chain frameworks, and technology adoption models highlights a significant theoretical gap. Existing scholarship tends to address these themes in isolation, limiting a holistic understanding of how analytical capabilities translate into practical improvements in emerging markets. A more synthesised perspective is therefore needed to clarify the mechanisms through which predictive analytics can be adopted and internalised within Indonesia's platform-based commerce environment. To further contextualize the importance of digital transformation in enabling modern supply chain capabilities, Figure 1 summarizes the key benefits that digital technologies contribute to efficiency, visibility, and resilience.



Why Does Digital Transformation Matter in Supply Chain Management?



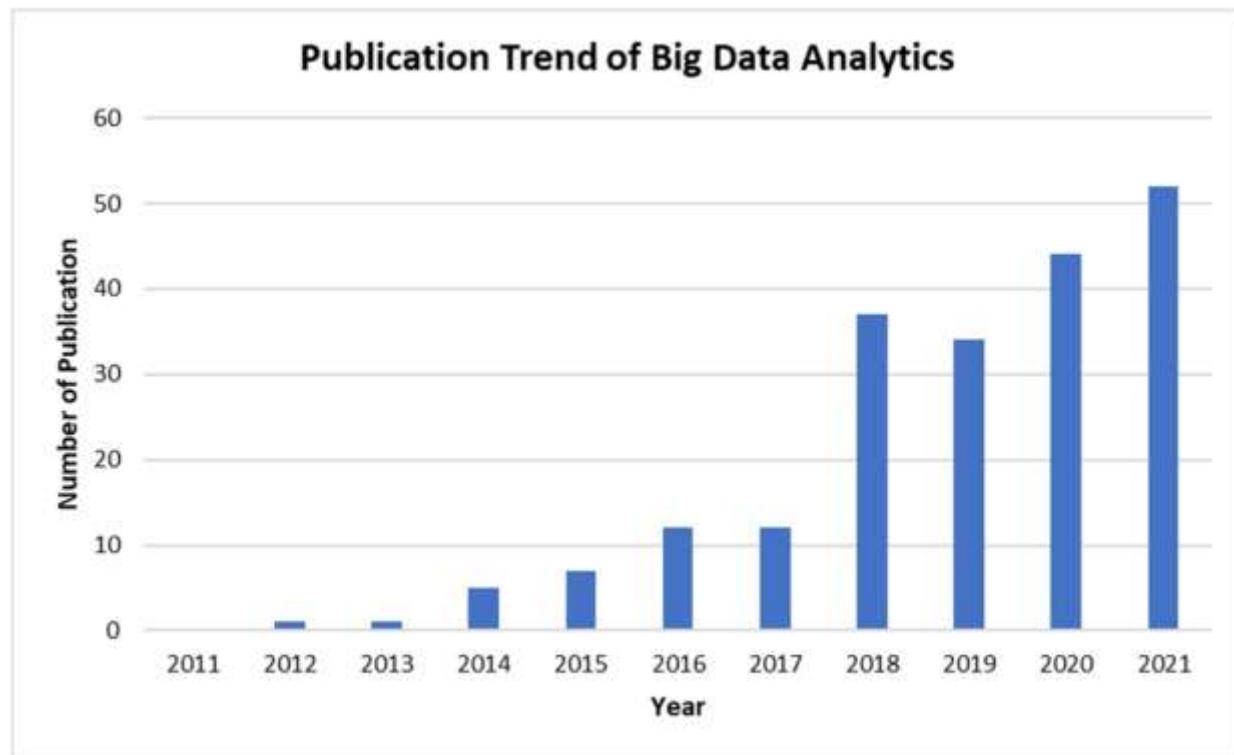
Source: Adapted from TechTarget (2023), <https://nextgeninvent.com/blogs/supply-chain-digital-transformation-matter/>

Figure 1. Key reasons why digital transformation matters in supply chain management.

Tokopedia often highlighted in industry analyses for its analytics-driven fulfillment initiatives (Tokopedia, 2023) provides a useful conceptual snapshot of how predictive analytics could be embedded in practice. Therefore, this article seeks to bridge existing conceptual gaps by integrating theories of predictive analytics, digital supply chains, and TAM, supplemented by Tokopedia as a literature-based illustration.

LITERATURE REVIEW

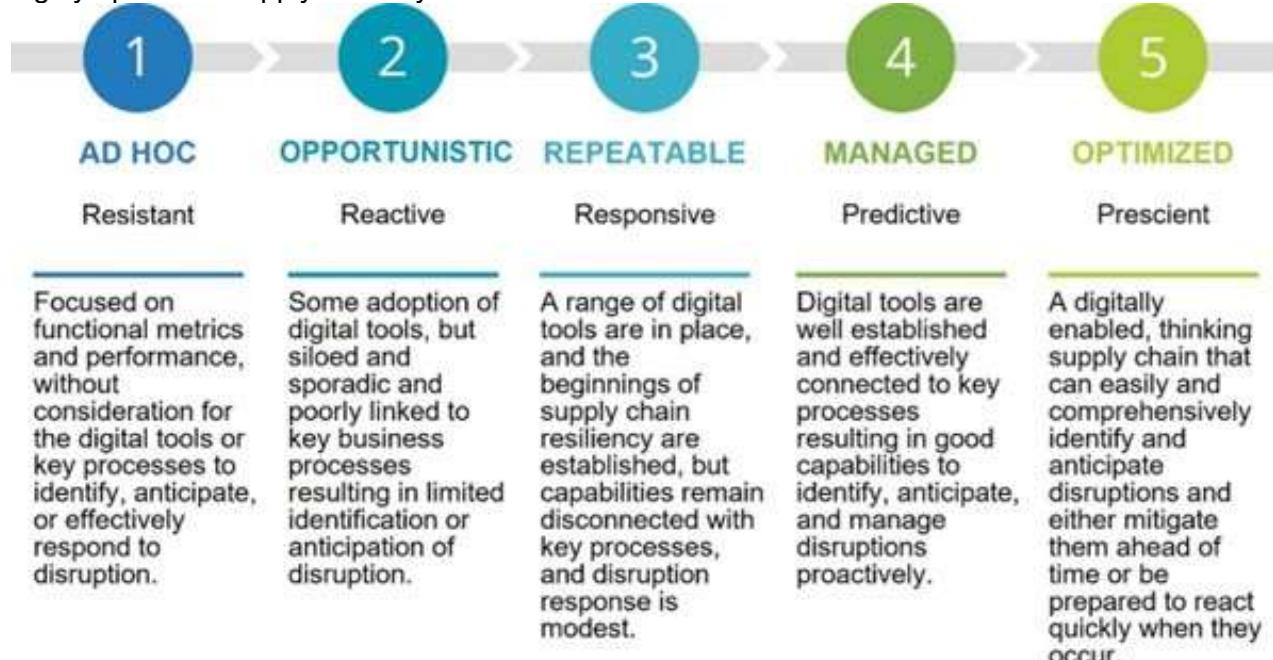
Predictive analytics involves the application of statistical modeling, machine learning techniques, and large-scale datasets to anticipate future patterns and support more informed operational planning (Nguyen et al., 2021). Within supply chain configurations, these analytical tools help organizations improve demand projections, decrease the likelihood of inventory imbalances, and reduce uncertainties that disrupt logistical flows (Ghosh & Shah, 2020). To highlight the rising scholarly attention surrounding data-driven decision support, Figure 2 visualizes the upward trend in big data analytics publications across the past decade.



Source: Adapted from BDCC (2022), <https://www.mdpi.com/2504-2289/6/1/17>
 Figure 2. Publication trend of big data analytics research from 2011 to 2021.

Figure 2 provides a clearer view of how scholarly attention toward big data analytics has expanded over the past decade. The gradual rise illustrated in the chart reflects a consistent increase in academic output, particularly after 2016, when digital transformation and data-driven decision-making began gaining stronger traction across supply chain disciplines. The upward pattern in publications signals a growing consensus that advanced analytics has become essential for addressing complexity, forecasting uncertainty, and improving the responsiveness of modern supply chains. This trend also reinforces the relevance of predictive analytics as a foundational component in contemporary research on e-commerce logistics. This progression makes clear that academic communities increasingly view big data analytics as a central component of modern supply chain design, reflecting a broader shift toward evidence-based operational management. To demonstrate how rapidly interest in data-driven supply chain research has expanded, the following figure presents the publication trend of big data analytics over the past decade. This upward trajectory indicates that predictive analytics has become a major focus within contemporary supply chain scholarship. The acceleration of digital supply chain transformation is largely fueled by technologies such as IoT sensors, advanced automation, and artificial intelligence. These tools provide real-time visibility, enhance the system's ability to withstand disruptions, and improve the speed and quality of decision-making (Ivanov & Dolgui, 2021). Organizations equipped with mature analytics infrastructures often exhibit stronger operational agility, dynamic response mechanisms, and superior coordination across supply chain nodes (Dubey et al., 2020).

To further clarify how firms progress along this transformation pathway, Figure 3 presents a maturity model illustrating the evolution from fragmented, reactive processes toward intelligent, highly optimized supply chain systems.



Source: Deloitte Digital Supply Chain Maturity Framework (2021), <https://blog-idceurope.com/manufacturers-supply-chain-resiliency-maturity/>

Figure 3. Digital supply chain maturity model from ad-hoc to optimized.

The Technology Acceptance Model (TAM), developed by Davis (1989), provides a theoretical basis for understanding why individuals and organizations choose to adopt or resist technological innovations. Contemporary adaptations of TAM show that it remains highly relevant in contexts involving artificial intelligence, predictive algorithms, and automated decision-support tools (Singh & Sharma, 2023). As companies transition toward digital-first operations, TAM offers valuable insight into behavioral factors shaping the adoption of analytics-driven systems. Tokopedia frequently appears in industry and academic discussions for its application of data-informed strategies across logistics, inventory coordination, and fulfillment operations (Tokopedia, 2023). While Tokopedia is not examined empirically in this study, its publicly reported innovations serve as a fitting conceptual illustration for understanding how predictive analytics may operate within Indonesia's e-commerce environment. Beyond these foundational concepts, scholars highlight that predictive analytics is increasingly intertwined with broader digital transformation strategies in supply chain networks. Recent studies emphasize that organizations no longer adopt analytics merely as a supportive tool but as an integrated capability that shapes long-term competitiveness (Wamba et al., 2022). Predictive models enable firms to move from descriptive assessments toward foresight-driven decision-making, which is critical for managing volatility in consumer demand, transportation delays, and multi-tier supplier dependencies. Another emerging thread in the literature concerns the democratization of data accessibility within organizations. Advances in cloud computing, API-based data integration, and user-friendly analytical dashboards have lowered technical barriers, enabling non-technical employees to engage with predictive insights (Kamble et al., 2023). This shift reinforces the argument that analytics maturity is not solely a technological challenge but also a matter of organizational culture, training, and cross-departmental alignment.

Researchers also note that predictive analytics plays a significant role in optimizing last-mile logistics—a critical bottleneck for e-commerce platforms in geographically diverse countries like Indonesia. Studies report improvements in route optimization, courier load balancing, delivery time prediction, and real-time exception handling, all of which contribute to a smoother fulfillment experience (Ramanathan et al., 2021). These findings suggest strong potential for Indonesia's e-

commerce players to reduce operational fragmentation by integrating predictive models into their logistics workflows. Additionally, literature focused on platform-based commerce reveals that data-driven supply chain innovation is particularly impactful for multi-vendor ecosystems such as Tokopedia. Predictive tools can help platforms create more accurate demand signals for sellers, improve warehouse slotting strategies, and optimize marketplace-wide inventory distribution (Shah & Sinha, 2022). This aligns with global trends where major platforms like Amazon, Alibaba, and Shopee increasingly rely on predictive intelligence to coordinate large networks of merchants.

Finally, several authors highlight the importance of examining behavioral and organizational readiness when adopting high-level analytics. Integrating predictive systems often requires structural adjustments, capability-building, and trust in algorithmic recommendations. TAM and its extensions therefore remain essential for explaining variations in adoption outcomes, especially in rapidly digitalizing environments where human–technology interaction becomes more complex (Al-Emran & Malik, 2023).

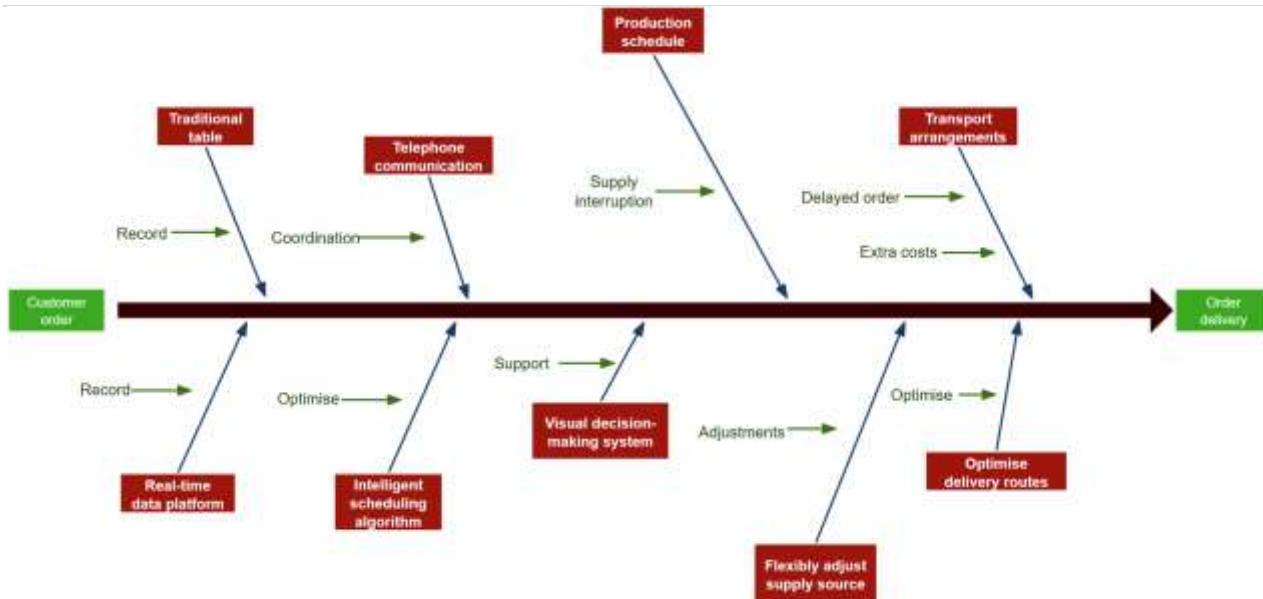
RESEARCH METHODS

This study adopts a narrative literature review approach to map and integrate theoretical perspectives on predictive analytics, digital supply chain transformation, and technology adoption models. The review draws primarily from peer-reviewed journal articles published between 2020 and 2024, complemented by reputable industry documents relevant to Indonesia's e-commerce and logistics environment. Tokopedia functions only as a conceptual illustration, with insights derived from publicly accessible secondary materials such as corporate publications, analyst reviews, and sectoral reports (Tokopedia, 2023). No primary data were gathered, as the objective of this paper is to construct a theoretical framework rather than conduct empirical validation. The analytical process involved identifying recurring themes, comparing conceptual positions across sources, and synthesizing implications for predictive analytics adoption within Indonesian e-commerce operations. Through this structured synthesis, the review establishes a conceptual foundation for understanding how predictive analytics may influence forecasting, inventory management, and fulfillment coordination in digital marketplace ecosystems.

RESULTS AND DISCUSSION

Technological Point of View

Existing studies consistently emphasize the value of predictive analytics in refining demand forecasts, improving decision-making accuracy, and enhancing inventory coordination (Nguyen et al., 2021). For Indonesia, with its diverse geography and unpredictable demand patterns, predictive analytics offers significant advantages in stock allocation and fulfillment planning (Gunasekaran et al., 2021). To better illustrate how predictive analytics enhances operational workflows, Figure 4 presents a simplified customer order-to-delivery process, showing how digital technologies enable faster coordination and more informed decision-making.



Source: Adapted from Smart Logistics Process Model (2023), <https://www.nature.com/articles/s41599-025-06011-3>

Figure 4. Customer order-to-delivery workflow in modern supply chain operations.

Digital supply chain technologies including digital twins, automated systems, and AI-supported optimization enable greater resilience and agility in navigating disruptions (Ivanov & Dolgui, 2021). These advancements are particularly relevant for e-commerce environments characterized by volatility and complex delivery networks. Industry publications indicate that Tokopedia has implemented various analytics-based tools to optimize warehouse distribution and improve fulfillment accuracy (Tokopedia, 2023). Although this article does not empirically assess Tokopedia's systems, these public insights demonstrate how predictive analytics may operate in practice within the Indonesian ecosystem. From a TAM perspective, adoption relies on whether employees perceive the system as beneficial and easy to use (Davis, 1989). Recent research supports that successful analytics adoption also depends on user-friendly interfaces, adequate training, and organizational readiness (Singh & Sharma, 2023). Moreover, digital capability and leadership support further influence the integration process (Khin & Ho, 2021). Overall, the synthesized literature suggests that predictive analytics can serve as a catalyst for Indonesia's logistics modernization, enabling platforms like Tokopedia to shift from reactive to predictive operational models.

Beyond operational forecasting, predictive analytics also reshapes how platforms coordinate multi-stakeholder ecosystems within e-commerce supply chains. In Indonesia, marketplaces rely on an extensive network of sellers, third-party logistics providers, and regional fulfillment centers, all of which produce fragmented and uneven data streams. Predictive models can help synchronize these distributed data inputs by identifying demand anomalies, regional order surges, and variations in courier capacity. Such visibility allows platforms like Tokopedia to anticipate congestion, adjust routing decisions, and allocate warehouse resources more strategically. This reinforces agility at both operational and strategic levels, enabling a shift away from last-minute, reactive adjustments toward more structured and anticipatory planning cycles. Another insight emerging from the literature is the potential of predictive analytics to facilitate more accurate last-mile delivery optimization. In dense urban regions such as Jabodetabek, delays are often caused by traffic volatility, courier shortages, and dynamic customer preferences. Predictive algorithms particularly those leveraging geospatial data and historical delivery performance can help simulate alternative routing patterns and approximate expected transit times with greater precision. These tools not only reduce failed deliveries but also improve customer satisfaction by narrowing delivery time windows. In rural or remote areas, predictive demand estimation can prevent stock-outs by enabling proactive inventory relocation before demand peaks occur.

Managerial Point of View

Predictive analytics also plays a pivotal role in supplier management and upstream procurement decisions. Prior studies note that e-commerce platforms increasingly rely on automated replenishment systems that evaluate supplier timelines, stock turnover rates, and material risk exposure (Khin & Ho, 2021). In the Indonesian context where supplier reliability varies across regions predictive tools can highlight early-warning indicators of supply disruptions, such as delayed restocking cycles or unusual order fluctuations. This capability supports more resilient procurement strategies by enabling stakeholders to adjust sourcing decisions or diversify supplier bases before operational performance is compromised. From a technology adoption standpoint, the integration of predictive analytics within e-commerce supply chains requires alignment between technological readiness and organizational culture. According to TAM-based insights, employee willingness to use analytics tools depends heavily on whether systems are intuitive, transparent, and clearly linked to performance improvements (Singh & Sharma, 2023). In organizations where digital literacy gaps remain substantial, employees may perceive analytics dashboards as complex or intrusive. As a result, proper onboarding, guided interpretation of analytics outputs, and strong managerial endorsement become essential foundations for ensuring successful adoption. These behavioral factors are particularly relevant for Indonesia, where many logistics partners operate with varying levels of digital maturity.

At the strategic level, predictive analytics can influence long-term planning by enabling scenario simulations and risk assessments. Literature in supply chain resilience emphasizes that predictive modeling can test multiple "what-if" scenarios such as sudden surges in online traffic, fuel price increases, courier disruptions, or natural disasters and assess their likely operational and financial impacts. For an e-commerce ecosystem as geographically dispersed as Indonesia's, these simulations provide platforms with the strategic capacity to allocate contingency budgets, strengthen infrastructure investment, and design more adaptive fulfillment networks. Over time, this reduces vulnerability to external shocks and strengthens national digital commerce competitiveness. For Tokopedia as an illustrative example, secondary reports suggest that the platform has progressively integrated data-driven features in demand prediction, warehouse slotting, and order batching. Although these insights are not empirically tested in this paper, they support the argument that predictive analytics is increasingly embedded within Indonesia's digital commerce infrastructure. What remains underexplored and therefore serves as an opportunity for future research is how deeply these models influence day-to-day operational behavior among employees, warehouse partners, and logistics intermediaries. Understanding this behavioral dimension is essential for evaluating the comprehensive impact of predictive analytics adoption.

Overall, the expanded discussion highlights that predictive analytics offers multidimensional benefits: operational optimization, improved last-mile logistics, enhanced supplier coordination, and more robust scenario-based decision-making. However, its implementation depends not only on technological capability but also on alignment across organizational, behavioral, and infrastructural factors. These findings suggest that Indonesia's e-commerce sector stands to gain significantly from analytics-driven transformation, although achieving its full potential will require sustained investment in both digital capability and workforce readiness.

Beyond the operational enhancements previously highlighted, predictive analytics also plays a strategic role in shaping long-term supply chain design within Indonesia's e-commerce landscape. As online retail platforms continue to scale, their logistics systems must increasingly account for rapidly changing consumption patterns, geographical fragmentation, and the growing complexity of multi-node distribution networks. Predictive models help organizations anticipate these structural challenges by identifying emergent demand clusters, forecasting market shifts, and estimating capacity needs across different regions. For platforms like Tokopedia, which operate across thousands of islands with varying degrees of infrastructure readiness, the ability to simulate future scenarios enables more adaptive and cost-efficient network planning. This strategic dimension underscores that predictive analytics is not only a tool for daily decision optimization but also a foundation for long-term supply chain resilience. A growing body of research further demonstrates that predictive analytics encourages firms to transition from a linear supply chain approach to a more integrated, ecosystem-driven model. In Indonesia, where e-commerce

platforms must coordinate with diverse stakeholders delivery partners, warehouse operators, MSMEs, and large brands predictive tools can help synchronize activities across actors that traditionally operate in silos. For example, demand-driven replenishment models can be shared across merchants to prevent simultaneous stockouts, while predictive lead-time estimation can help logistics partners allocate riders more efficiently in high-traffic areas. These forms of shared intelligence have been observed in global markets such as China and Singapore, and literature suggests that similar outcomes may be attainable in Indonesia given adequate data integration. Thus, predictive analytics supports ecosystem alignment, reducing inefficiencies that originate from fragmented supply chain interactions.

Predictive analytics also enhances risk management by equipping organizations with early-warning indicators for potential disruptions. Indonesia's logistics operations are frequently challenged by weather instability, natural hazards, congestion, and volatile fuel prices. Predictive models can analyze patterns in external risk indicators such as rainfall levels, seasonal holidays, or regional transportation bottlenecks to estimate their likelihood of affecting delivery performance. These insights allow firms to adjust dispatch schedules, reroute shipments, modify inventory buffers, or negotiate with logistics partners before disruptions escalate. Literature on supply chain resilience emphasizes that firms with strong predictive capabilities exhibit faster recovery after disruptions and lower overall volatility in service levels. For a high-volume platform like Tokopedia, this translates into fewer late deliveries, lower cost overruns, and more consistent consumer experience during high-traffic events such as Harbolnas or Ramadan. Another critical dimension emerging from the literature is the impact of predictive analytics on warehouse efficiency and inventory accuracy. Distribution centers remain central to Indonesia's e-commerce ecosystem, yet congested layouts, fluctuating inbound flows, and inconsistent picking processes often create bottlenecks. Predictive models, when integrated with warehouse management systems, can forecast inbound volume surges, anticipate SKU turnover rates, and predict stock aging, enabling more effective resource allocation. Studies of similar platforms in India and Brazil show that predictive analytics contributes to improved warehouse slotting, reduced picker travel time, and better replenishment planning. While Tokopedia's actual warehousing practices remain outside the scope of this conceptual paper, the theoretical evidence indicates that Indonesian platforms could experience comparable gains if predictive inventory systems were implemented at scale.

Furthermore, consumer behavior analytics such as browsing duration, cart abandonment patterns, and location-based preferences provides another layer of predictive intelligence that strengthens supply chain performance. By identifying which products are likely to trend in specific regions or demographics, platforms can position inventory closer to demand centers, reducing reliance on long-haul shipments. This aligns with recent literature on customer-centric supply chains, which posits that predictive modeling enables companies to shift from a product-push to a demand-pull strategy. Such alignment results not only in faster delivery times but also in reduced carbon footprints, which is increasingly relevant as Indonesia progresses toward more sustainable logistics practices. Predictive analytics thereby supports both efficiency and environmental objectives. From a managerial standpoint, predictive analytics can also influence organizational decision-making culture. Traditional supply chain operations in Indonesia often rely on intuition, past experience, or short-term performance indicators. The introduction of predictive tools encourages a more analytical mindset, prompting employees to ground decisions in data rather than assumptions. However, this shift requires adequate training, supportive leadership, and a clear communication of the value that predictive technologies can deliver. Several studies warn that analytics adoption often fails not because of the technology itself but because employees do not fully understand how to interpret or apply model outputs. Thus, human readiness becomes as crucial as technical capability, particularly in fast-growing digital marketplaces such as Tokopedia.

Acceptance Model Point of View

The Technology Acceptance Model (TAM) offers a useful lens for understanding these behavioral challenges. In predictive analytics adoption, perceived usefulness may relate to enhanced job performance, reduced workload, or increased forecasting accuracy. Perceived ease of use, on the other hand, is linked to the accessibility of dashboards, clarity of reports, and the

simplicity of interpreting predictive indicators. Literature indicates that when predictive systems are overly complex or poorly designed, employees are less likely to rely on them even if the potential benefits are substantial. This highlights the importance of designing user-friendly predictive interfaces and fostering a learning-oriented environment supported by continuous training. These behavioral factors ultimately influence how effectively predictive analytics is integrated into daily supply chain operations. On a broader scale, predictive analytics has implications for equity and inclusion in Indonesia's digital commerce ecosystem. Small merchants who form the backbone of platforms like Tokopedia often lack advanced operational systems and may struggle to engage with analytics-driven workflows. If designed inclusively, predictive models can offer MSMEs recommendations for stock replenishment, demand forecasting, and pricing strategies based on aggregate marketplace trends. This democratization of intelligence may help level the playing field between small sellers and larger enterprises, supporting more equitable market competition. However, achieving this requires that platforms ensure transparency in how predictive recommendations are generated, avoiding biases that may disadvantage certain merchant groups. Researchers have increasingly emphasized that algorithmic fairness must be considered in supply chain analytics, particularly in diverse economies like Indonesia.

Political and Ethic Point of View

Predictive analytics also carries potential policy implications. Indonesia's logistics performance is shaped not only by private-sector innovation but also by governmental regulations, infrastructure investments, and digital ecosystem readiness. Predictive analytics could support national logistics strategies by generating insights into freight movement patterns, regional bottlenecks, and future demand projections. Policymakers could incorporate these insights into infrastructure planning or regulatory adjustments aimed at improving logistics efficiency. As the government continues to promote digital transformation across sectors, there is significant opportunity to integrate predictive analytics research into national economic development initiatives. Ensuring a supportive regulatory environment may also encourage private platforms like Tokopedia to adopt more advanced predictive systems. Ethical considerations also form part of the broader discussion. As predictive analytics relies heavily on customer, merchant, and operational data, the risk of privacy violations or unintended data misuse must be carefully managed. While e-commerce platforms inherently collect large amounts of information, the use of predictive models intensifies concerns regarding data transparency, security, and consent. International literature highlights cases where poorly governed use of predictive models led to unintentional discrimination, inaccurate targeting, or exposure of sensitive data. For Indonesia, a robust data governance framework aligned with the Personal Data Protection Law is essential to ensure that predictive analytics is deployed responsibly. Such governance must balance innovation with consumer trust, ensuring that data used to optimize supply chain performance does not compromise user rights.

Finally, the broader academic conversation suggests that predictive analytics should not be viewed as a standalone solution but rather as part of a larger digital transformation journey. Its effectiveness depends on sustained investments in data quality, infrastructure, cross-organizational integration, and workforce capability. In Indonesia's rapidly expanding e-commerce sector, predictive analytics holds considerable potential to advance operational efficiency, reduce cost volatility, and enhance service-level reliability. Yet, realizing these benefits requires long-term coordination across technology vendors, logistics providers, platform operators, and regulators. Future empirical studies will be essential to validate the conceptual propositions outlined in this paper and to explore how predictive analytics performs when implemented in real-world Indonesian e-commerce settings.

CONCLUSION

This conceptual review concludes that predictive analytics holds strong potential to transform Indonesia's e-commerce supply chains by improving forecasting accuracy, optimizing inventory management, and strengthening operational responsiveness. Tokopedia's documented initiatives highlight how such technologies can be embedded within digital logistics systems. Theoretically, this study contributes by weaving together predictive analytics, digital supply chain

transformation, and TAM within a developing-market context. Practically, organizations are encouraged to invest in analytical tools, upskill their workforce, and ensure adequate digital infrastructure to support adoption. Future researchers are encouraged to conduct empirical investigations such as surveys, case studies, or operational data analyses to validate and extend the conceptual perspectives presented in this paper.

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