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Logistics Ecosystem Turbulence and Digital Logistics Agility: Evidence from Indonesian Third-Party Logistics Firms

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Abstract

The logistics industry is increasingly operating within highly dynamic and uncertain environments driven by regulatory changes, rapid technological developments, market volatility, and global supply chain disruptions. These conditions have transformed logistics ecosystems into complex networks, particularly for third-party logistics (3PL) firms that must develop adaptive capabilities to remain competitive. This study examines the effect of *Logistics Ecosystem Turbulence (LET)* on *Digital Logistics Agility (DLA)* among third-party logistics (3PL) firms in West Java, Indonesia. Using a quantitative approach, this study applies partial least squares structural equation modeling (PLS-SEM) with SmartPLS 4. The results indicate that *LET* has a positive and highly significant effect on *DLA* ($\beta = 0.847$, $p < 0.001$), with strong explanatory power ($R^2 = 0.717$; $f^2 = 2.533$). These findings demonstrate that environmental turbulence acts as a critical driver of digital logistics agility. The study contributes to the logistics and digital transformation literature by positioning ecosystem turbulence as a foundational antecedent of digital agility in emerging economies.

INTRODUCTION

The logistics industry is increasingly operating within highly dynamic and uncertain environments driven by regulatory changes, rapid technological developments, market volatility, and recurring global supply chain disruptions. These conditions have transformed logistics ecosystems into complex, interdependent networks, particularly for third-party logistics (3PL) firms that rely on coordination across multiple actors (Magro-Montero et al., 2025; Vlachos & Polichronidou, 2024). Rather than representing temporary disturbances, such environmental dynamics have become a structural characteristic of contemporary logistics systems, challenging traditional efficiency-oriented operational models.

In response to these challenges, digital transformation has emerged as a central strategic agenda in the logistics sector. Logistics firms increasingly adopt digital technologies such as real-time tracking systems, integrated logistics platforms, data analytics, and automation to enhance visibility, coordination, and responsiveness. However, prior studies indicate that digital adoption alone does not automatically result in organizational agility. Firms operating under similar technological conditions often exhibit different levels of responsiveness and flexibility, suggesting that the development of digital logistics agility is influenced by factors beyond internal technological readiness.

Several previous studies have examined the relationship between environmental turbulence and organizational capabilities. Jaworski and Kohli (1993) and Miller (1993)

conceptualized environmental turbulence as a structural condition that continuously reshapes organizational decision-making and operational configurations. In the logistics context, Christopher (2016) emphasized that high levels of ecosystem turbulence intensify coordination complexity and increase the need for adaptive responses across interconnected supply chain actors. From a dynamic capabilities perspective, Teece (2018) argued that turbulent environments act as critical triggers that stimulate firms to develop adaptive capabilities through sensing, seizing, and reconfiguring processes. Overby et al. (2006) and Vial (2021) further elaborated that digital technologies enable organizational agility by facilitating real-time sensing and rapid operational reconfiguration. More recently, Liu et al. (2013) examined the relationship between IT capabilities and supply chain agility, finding that information technology plays a mediating role in enhancing organizational responsiveness to environmental changes. Similarly, Zhang et al. (2015) investigated supply chain agility and performance, demonstrating that firms with higher agility levels achieve better operational outcomes under conditions of uncertainty.

Despite the growing body of research on environmental turbulence and organizational agility, a significant gap remains in understanding how logistics ecosystem turbulence specifically influences the development of digital logistics agility in the context of third-party logistics firms operating in emerging economies. Most existing studies have been conducted in developed-country contexts with different institutional and technological environments, limiting the applicability of their findings to settings such as Indonesia. Furthermore, previous research has predominantly focused on either environmental turbulence or digital capabilities separately, with limited empirical investigation of the direct relationship between logistics ecosystem turbulence and digital logistics agility as a distinct organizational capability. Additionally, while the dynamic capabilities perspective theoretically positions environmental turbulence as a trigger for capability development, empirical evidence examining this mechanism in the logistics sector remains scarce.

The novelty of this research lies in its conceptual and contextual contributions. Conceptually, this study integrates contingency theory and the dynamic capabilities perspective to position logistics ecosystem turbulence as a fundamental antecedent of digital logistics agility. By conceptualizing LET as a multidimensional construct encompassing regulatory uncertainty, technological turbulence, market volatility, competitive intensity, global supply disruption, and environmental pressure, the study offers a comprehensive framework for understanding how environmental conditions shape digital capability development in logistics firms. Methodologically, the study employs second-order construct modeling using PLS-SEM to capture the multidimensional nature of both LET and DLA, providing a more nuanced understanding of their relationship. Contextually, the research contributes to the limited body of empirical evidence on digital logistics agility in emerging economies by specifically examining third-party logistics firms in West Java, Indonesia—a rapidly developing region with distinct institutional and market characteristics.

This study therefore aims to examine the effect of Logistics Ecosystem Turbulence on Digital Logistics Agility among third-party logistics firms operating in West Java, Indonesia. The specific objectives are to conceptualize and measure Logistics Ecosystem Turbulence as a multidimensional construct, to conceptualize and measure Digital Logistics Agility as a

second-order capability, and to empirically test the structural relationship between these two constructs. The benefits of this study include providing empirical evidence for logistics managers regarding the strategic importance of developing digital agility in response to environmental turbulence, offering insights for policymakers seeking to enhance the resilience and competitiveness of the logistics sector, and contributing to the theoretical advancement of logistics and supply chain management literature by demonstrating how environmental conditions drive digital capability development in emerging-economy contexts.

From a theoretical perspective, logistics and supply chain research has predominantly focused on the performance outcomes of digitalization or on internal technological capabilities as antecedents of agility. Comparatively, less attention has been given to environmental conditions as structural drivers shaping the development of digital agility. Drawing on contingency theory and the dynamic capabilities perspective, this study argues that logistics ecosystem turbulence constitutes a fundamental antecedent of digital logistics agility. Accordingly, this study examines the effect of Logistics Ecosystem Turbulence on Digital Logistics Agility among third-party logistics firms.

METHOD

This study adopted a quantitative, explanatory research design using a cross-sectional survey approach to examine the structural relationship between Logistics Ecosystem Turbulence (LET) and Digital Logistics Agility (DLA). Data were collected from managers of third-party logistics (3PL) firms operating in West Java, Indonesia. The data were analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM) with SmartPLS 4. A two-stage approach was employed to estimate and validate the second-order constructs, following established PLS-SEM guidelines.

RESULTS AND DISCUSSION

Measurement Model Assessment

The measurement model was evaluated to assess the reliability and validity of the constructs. The results indicate that all constructs satisfy the recommended criteria for convergent and discriminant validity. All second-order loadings exceed the minimum threshold of 0.70, indicating strong representation of the higher-order constructs by their respective dimensions. Composite reliability values are above 0.70, and average variance extracted (AVE) values exceed 0.50 for all constructs, confirming adequate internal consistency and convergent validity.

For the second-order constructs, the two-stage approach demonstrates that Logistics Ecosystem Turbulence (LET) is well represented by its dimensions, including regulatory uncertainty, technological turbulence, market volatility, competitive intensity, global supply disruption, and environmental pressure. Similarly, Digital Logistics Agility (DLA) is reliably captured by digital logistics capability and innovation agility. Discriminant validity was further confirmed using the HTMT criterion, with all values below the recommended threshold, indicating that the constructs are empirically distinct.

Table 1. Outer Loading Second Order

	DLA	LET
DLA.DC	0.957	
DLA.IA	0.962	
LET.CI		0.855
LET.EP		0.875
LET.GSD		0.8
LET.MV		0.858
LET.RU		0.896
LET.TT		0.753

Source: Processed primary data from PLS-SEM analysis (2025)

Table 2. CR, and AVE

	Composite reliability (rho_c)	Average variance extracted (AVE)
DLA	0.958	0.92
LET	0.935	0.707

Source: Processed primary data from PLS-SEM analysis (2025)

Structural Model Results

The structural model was evaluated to test the proposed hypothesis and assess the explanatory power of the model. The results of the PLS-SEM analysis indicate that Logistics Ecosystem Turbulence has a positive and statistically significant effect on Digital Logistics Agility. The path coefficient from LET to DLA is strong and highly significant ($\beta = 0.847$, $t = 37.997$, $p < 0.001$), providing empirical support for the proposed relationship.

The coefficient of determination indicates that Logistics Ecosystem Turbulence explains a substantial proportion of the variance in Digital Logistics Agility, with an R^2 value of 0.717. This suggests that approximately 71.7% of the variance in DLA is accounted for by LET. Furthermore, the effect size analysis reveals a very large effect ($f^2 = 2.533$), indicating that Logistics Ecosystem Turbulence is a dominant driver of Digital Logistics Agility. These results collectively confirm the strong explanatory power of the model and support **H1**.

Table 3. Structure Model Results

Hypothesis	Path	β	t-value	p-value	R^2	f^2
H1	LET → DLA	0.847	37.997	< 0.001	0.717	2.533

Source: Processed primary data from PLS-SEM analysis (2025)

Discussion

The results of this study demonstrate that Logistics Ecosystem Turbulence has a strong and positive effect on Digital Logistics Agility among third-party logistics firms. The significant path coefficient and substantial explanatory power indicate that environmental turbulence is not merely a contextual challenge but a key driver that stimulates the development of digital agility in logistics operations. These findings suggest that logistics firms operating in highly turbulent ecosystems are compelled to enhance their responsiveness and flexibility through digitally enabled mechanisms.

From a theoretical perspective, this finding reinforces the core propositions of contingency theory, which emphasize that organizational effectiveness depends on the alignment between environmental conditions and internal capabilities. In highly turbulent logistics environments, traditional efficiency-oriented structures become insufficient, requiring firms to develop more adaptive and flexible capabilities. Digital logistics agility thus emerges as a structural response that enables firms to cope with regulatory uncertainty, technological change, and market volatility.

Furthermore, the results support the dynamic capabilities perspective by highlighting the role of environmental turbulence as a trigger for capability development. High levels of logistics ecosystem turbulence activate sensing, seizing, and reconfiguring processes that are increasingly facilitated by digital technologies. Digital logistics agility allows firms to sense environmental changes through real-time data, rapidly seize opportunities or mitigate disruptions, and reconfigure logistics processes accordingly. This underscores the strategic role of digital technologies in transforming environmental pressure into adaptive organizational capabilities.

From a managerial standpoint, the findings imply that investments in digital technologies should be viewed not only as efficiency-enhancing tools but also as strategic enablers of agility in turbulent environments. Logistics managers operating in volatile ecosystems should proactively align their digital transformation initiatives with environmental dynamics, focusing on enhancing sensing capabilities, real-time decision-making, and operational flexibility. Firms that fail to develop digital logistics agility may struggle to respond effectively to increasing ecosystem turbulence.

Overall, this study extends the logistics and supply chain literature by empirically positioning Logistics Ecosystem Turbulence as a fundamental antecedent of Digital Logistics Agility. By emphasizing the role of environmental turbulence in shaping digital capability development, the study contributes to a more nuanced understanding of how logistics firms adapt to uncertainty within complex ecosystems.

CONCLUSION

This study demonstrates that Logistics Ecosystem Turbulence significantly and positively influences the development of Digital Logistics Agility among third-party logistics firms, highlighting environmental turbulence—such as regulatory uncertainty, technological change, market volatility, and global supply chain disruptions—as a critical driver of digitally enabled adaptive capabilities. Theoretically, the findings contribute to logistics and supply chain literature by positioning logistics ecosystem turbulence as a key antecedent of digital logistics agility, reinforcing contingency theory and extending the dynamic capabilities perspective by identifying turbulence as a trigger for sensing, seizing, and reconfiguring processes. Managerially, the study suggests that firms should approach digital transformation as a strategic response to environmental uncertainty, aligning digital investments with the need for enhanced responsiveness, coordination, and flexibility. Future research is recommended to incorporate additional organizational and ecosystem-level variables, adopt longitudinal designs

to capture dynamic effects over time, and examine how digital logistics agility influences broader firm performance outcomes across different contexts.

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