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Determinants of Logistics Distribution Efficiency: A Case Study in Alor District, East Nusa Tenggara

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ABSTRACT: Indonesia's remote regions face persistent logistical challenges due to geographic fragmentation, infrastructure deficits, and limited digital adoption. This study examines the determinants of logistics distribution efficiency in Alor District, East Nusa Tenggara, using survey data from 150 respondents including logistics operators, government officials, and recipients. Descriptive and inferential analyses, including correlation and multiple linear regression, reveal that logistics information technology is the most influential factor ($r = 0.71$; $\beta = 0.35$), followed by infrastructure quality ($r = 0.62$; $\beta = 0.28$) and supply chain coordination ($r = 0.55$; $\beta = 0.22$), all significant at $p < 0.05$. These findings highlight the critical role of digital transformation in improving distribution efficiency in archipelagic regions. Practical recommendations include expanding internet connectivity in rural islands, providing digital literacy training for logistics actors, and developing integrated coordination platforms at the district level. Limitations of this study include reliance on self-reported data, potential non-response bias, and the focus on a single district, which may affect generalizability. Future research should incorporate longitudinal data and cross-district comparisons to strengthen evidence on logistics innovation in remote areas.

Keywords: Logistics Efficiency, Remote Areas, Digital Transformation, Infrastructure, Supply Chain Coordination.

INTRODUCTION

sport networks, eastern regions such as Nusa Tenggara Timur (NTT) rely on irregular and costly maritime routes, creating significant logistical inequities (1,2).

In response, the Indonesian government has initiated several interventions, including the Tol Laut (Sea Toll) program, the development of integrated regional logistics hubs, and the provision of freight subsidies. The Tol Laut initiative, in particular, has shown potential in improving inter-island connectivity and reducing transportation delays (3). However, its implementation has faced limitations. A 2021 report by the Ministry of Transportation indicated that only 62% of Sea Toll cargo was delivered on time, with the rest delayed or deemed cost-ineffective (4).

In addition to logistical policies, technological innovations have been introduced to enhance logistics performance. These include the adoption of regional logistics information systems (SILD), Geographic Information Systems (GIS) for route planning, and digital tracking tools. Despite these advances, the uptake of such technologies in remote regions remains low due to limited digital literacy, inadequate internet access, and insufficient training for local logistics actors (5,6). The resulting digital divide hampers inclusive logistics transformation across the archipelago.

To address these challenges systematically, there is a growing need for data-driven approaches to map actual logistics conditions in remote areas, identify the most influential factors on distribution efficiency, and assess the impact of current strategies. Quantitative data enable the analysis of inter-variable relationships, such as infrastructure conditions, information technology use, and human resource capacity, with output indicators like delivery time and logistics costs (7).

This study adopts a quantitative methodology to examine the relationship between logistics infrastructure, the application of logistics information technologies, and supply chain coordination in determining distribution efficiency. The research focuses on Alor District in East Nusa Tenggara (NTT), a representative case of a remote archipelagic region facing unique logistical challenges. Primary data are collected through surveys of logistics operators, local government officials, and beneficiaries (consumers), followed by statistical analysis to test the hypotheses.

The main objective of this research is to identify the key determinants of logistics distribution efficiency in remote areas and to develop evidence-based optimization strategies. By doing so, the study aims to generate practical recommendations for policymakers at both national and local levels, supporting the implementation of logistics innovations that are adaptable to Indonesia's geographic realities. Ultimately, this research contributes to promoting equitable logistics access and reducing inter-regional disparities, aligning with broader goals of inclusive development and regional equity (8,9).

METHOD

This study employs a quantitative descriptive-associative design to assess logistics distribution efficiency in remote regions and analyze the influence of logistics infrastructure, information technology adoption, and supply chain coordination. This approach supports statistical testing of inter-variable relationships while maintaining objectivity and replicability (10,11).

The research was conducted in Alor District, East Nusa Tenggara (NTT), Indonesia, between July and September 2025. This timeframe was selected to minimize seasonal variation in distribution activities.

The study population included logistics actors in Alor District, comprising local logistics operators (MSMEs), officials from the Department of Transportation and Trade, and retailers. The total population was approximately 250 individuals. A stratified random sampling method was employed to ensure proportional representation of each stakeholder group, resulting in a final

sample of 150 respondents. While stratified sampling increases representativeness, potential non-response bias remains a limitation, as some respondents declined participation (10).

The study involved three independent variables and one dependent variable:

- **X1: Logistics Infrastructure Quality** (road access, port facilities, storage facilities)
- **X2: Utilization of Logistics Information Technology** (tracking apps, GIS, distribution management systems)
- **X3: Supply Chain Coordination** (interaction among logistics actors, local government engagement)
- **Y: Logistics Distribution Efficiency** (distribution costs, timeliness, frequency of delays)

A structured questionnaire was developed to measure each variable using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The instrument was designed based on previously validated indicators (Fatimah et al., 2022; Rizky & Nurhaliza, 2021). A pilot test was conducted with 30 initial respondents to assess instrument reliability using Cronbach's alpha, ensuring internal consistency and construct validity (11,12).

Primary data were collected through both direct distribution of questionnaires and online forms. Additionally, 10 key informant interviews were conducted with logistics operators and government officials to triangulate findings and provide contextual depth. Interview transcripts were thematically coded to identify recurring patterns, which complemented the quantitative data. Secondary data were obtained from BPS statistics and government reports (1,4,11).

Data analysis involved descriptive statistics to summarize respondents' characteristics and variable means, followed by Pearson correlation and multiple linear regression to test hypotheses. Classical assumption tests (normality, multicollinearity, and heteroscedasticity) were performed to ensure model validity. Model fit was further evaluated using R^2 and the F-statistic. Statistical analyses were conducted using SPSS 26 and STATA with a 5% significance level ($\alpha = 0.05$).

Research ethics were strictly observed. All respondents provided informed consent prior to participation. Confidentiality of responses was guaranteed, and no personal identifiers were disclosed in reporting. The study adhered to ethical standards for social science research as recommended by the Indonesian National Research and Innovation Agency (BRIN).

RESULT AND DISCUSSION

Descriptive Analysis of Respondent Perceptions

Data from 150 respondents in Alor District, encompassing logistics operators, retailers, and local government representatives, were analyzed to assess perceptions of key logistics variables. Table 1 presents the average scores for each variable. Respondents rated the use of Logistics Information Technology (X2) the highest (mean = 3.6), followed by Distribution Efficiency (Y) at 3.4,

Infrastructure (X1) at 3.2, and Supply Chain Coordination (X3) at 3.1. These values suggest that stakeholders perceive digital tools as the most impactful component of logistics performance, while infrastructure and coordination are viewed as moderately developed. Standard deviations ranged from 0.6 to 0.9, indicating consistent and moderately dispersed responses across groups.

Table 1. Average Respondents' Scores on Research Variables

No	Variable	Mean Score (1–5)	Standard Deviation
1	Logistics Infrastructure (X1)	3.2	0.8
2	Logistics Information Technology (X2)	3.6	0.7
3	Supply Chain Coordination (X3)	3.1	0.9
4	Distribution Efficiency (Y)	3.4	0.6

These findings are supported by graphical analysis, which shows the highest bar for technology utilization, confirming the positive trend of digital adaptation despite geographic barriers. The results align with Dungey et al. (2016) and Mufadhol et al. (2022), who emphasize stakeholder perception as a crucial metric in assessing system usability and performance (4,10).

Correlation Analysis Between Variables

Correlation analysis using Pearson's coefficient reveals strong and positive relationships among all variables. Table 2 summarizes the inter-variable correlations, with the highest recorded between Information Technology (X2) and Distribution Efficiency (Y) at $r = 0.71$. This is followed by Infrastructure (X1) and Y at $r = 0.62$, and Coordination (X3) and Y at $r = 0.55$. These coefficients suggest that improvements in digital logistics capabilities have the most substantial impact on enhancing efficiency.

Table 2. Correlation Matrix among Variables

Variable	X1 – Infrastructure	X2 – Technology	X3 – Coordination	Y – Efficiency	Variable
X1 – Infrastructure	1.00	0.58	0.61	0.62	X1 – Infrastructure
X2 – Technology	0.58	1.00	0.64	0.71	X2 – Technology
X3 – Coordination	0.61	0.64	1.00	0.55	X3 – Coordination
Y – Efficiency	0.62	0.71	0.55	1.00	Y – Efficiency

The analysis further shows high interdependence among independent variables ($r > 0.60$), indicating that infrastructure, technology, and coordination function collectively rather than in isolation. These findings are consistent with prior literature emphasizing the integrative nature of modern logistics systems (1,8).

Multiple Linear Regression Findings

Multiple linear regression analysis was employed to determine the impact of the three independent variables on distribution efficiency. The resulting regression equation is:

$$Y = 1.10 + 0.28X1 + 0.35X2 + 0.22X3$$

The regression coefficients and their significance values are displayed in Table 3. All three predictors were statistically significant at $p < 0.05$, confirming their empirical contribution to efficiency outcomes. Among them, Information Technology (X2) had the highest coefficient at 0.35, followed by Infrastructure (X1) at 0.28, and Coordination (X3) at 0.22. The constant term was 1.10, indicating the baseline efficiency when all predictors are at zero.

Table 3. Multiple Linear Regression Results

Variable	Coefficient	t-Statistic	Significance (p-value)
Constant	1.10	4.50	0.000
X1 – Infrastructure	0.28	3.20	0.002
X2 – Information Technology	0.35	4.10	0.000
X3 – Supply Chain Coordination	0.22	2.85	0.005

These results highlight the dominant role of technology adoption in enhancing logistics performance, supporting prior studies that advocate for digital transformation in remote supply chains (4,11). The model confirms that while infrastructure and coordination also contribute, they do so to a lesser extent. Visual representation of these coefficients further validates the primacy of digital tools in driving distribution efficiency in geographically challenged areas like Alor.

In summary, the empirical evidence underscores that targeted investments in digital infrastructure, supported by physical logistics development and collaborative frameworks, are key to overcoming distribution inefficiencies in remote Indonesia. These insights inform strategic planning for equitable and sustainable logistics advancement.

The findings of this study demonstrate that logistics infrastructure, information technology, and supply chain coordination significantly affect distribution efficiency in Alor District. While the regression analysis confirmed all three as positive predictors, the strength of influence varied, with digital technology adoption emerging as the most dominant factor.

The role of infrastructure ($\beta = 0.28$; $r = 0.62$) highlights the importance of physical connectivity such as roads, ports, and storage facilities. In the context of Alor, however, infrastructure development faces unique geographic constraints due to its archipelagic nature and mountainous terrain. Even moderate improvements in micro-port facilities or inter-island ferries could directly reduce delivery delays and costs. This supports previous studies emphasizing infrastructure as a foundation for logistics equity in remote areas (13).

Technology adoption emerged as the most influential factor, with the highest regression coefficient (0.35) and correlation (r = 0.71). This suggests that digital tools are pivotal in transforming logistics efficiency, particularly in rural or island regions. The findings validate Setiawan & Lestari (2020), who observed up to 25% time savings in coastal logistics through GIS-based systems (14). In Alor, growing acceptance of digital tracking systems, mobile apps, and GIS reflects the broader potential of smart logistics. Nevertheless, barriers persist in the form of uneven internet access and low digital literacy among logistics personnel. As supported by Mufadhol et al. (2022) and Mukti et al. (2022), targeted interventions such as training programs, incentives for digital adoption, and rural internet expansion (e.g., Desa Digital initiatives) are necessary to fully harness this potential (4,6).

Supply chain coordination also showed a statistically significant but relatively lower influence (coefficient = 0.22, r = 0.55). This dimension refers to interaction among logistics actors, government agencies, transport service providers, and beneficiary communities. In Alor, logistical inefficiencies stem partly from unaligned shipping schedules, mismatch in cargo volumes, and poor communication networks. Respondents noted the absence of integrated forums or shared communication systems, which often resulted in shipment redundancies or stock shortages. These results highlight the relevance of collaborative logistics models like Logistics Clusters, which are proven effective in disaster response and adaptable for regular use in remote settings (3,15).

From a theoretical perspective, the interdependence among variables ($r > 0.60$) confirms that digital, physical, and organizational dimensions must co-evolve for optimal outcomes. This supports digital supply chain frameworks emphasizing integration and resilience in geographically challenged environments (1,8). Furthermore, the intercorrelation among independent variables ($r > 0.60$) demonstrates their interdependent nature, where infrastructure, digital tools, and coordination must co-evolve to yield optimal outcomes.

Despite these insights, this study has limitations. First, reliance on self-reported survey data introduces the possibility of response bias. Second, the focus on a single district restricts the generalizability of findings across other remote regions. Third, the cross-sectional design captures relationships at one point in time but does not assess long-term causal dynamics. Addressing these limitations in future research will require comparative multi-district studies and longitudinal designs.

In terms of policy implications, more concrete actions are required beyond general recommendations. For Alor, three priority strategies are suggested: (1) expand rural internet coverage through collaboration between the Ministry of Communication and local governments; (2) establish targeted digital literacy training for logistics operators and small traders; and (3) develop an integrated logistics coordination forum at the district level involving government, private actors, and community groups. These locally grounded interventions can significantly enhance distribution efficiency and reduce disparities between remote and urban regions.

CONCLUSION

This study confirms that logistics efficiency in remote regions is shaped by three interrelated factors: infrastructure, information technology, and supply chain coordination. Among these,

digital technology adoption emerged as the strongest determinant, underscoring its transformative role in overcoming geographic barriers. The findings provide new empirical evidence from Alor District, East Nusa Tenggara, demonstrating that digital tools can drive efficiency even in archipelagic contexts with limited infrastructure. Theoretically, this research contributes by integrating digital supply chain models with archipelagic logistics, highlighting the need to consider technological, physical, and organizational dimensions simultaneously.

Nevertheless, this study has several limitations. The reliance on self-reported data introduces potential response bias, and the single-district focus constrains generalizability across Indonesia's diverse remote regions. Future research should therefore employ longitudinal and comparative designs across multiple districts to validate these findings. Expanding the scope to include socio-cultural and institutional dimensions would also strengthen understanding of logistics performance in peripheral contexts. By addressing these gaps, subsequent studies can build on this research to inform more robust policies and scalable solutions for equitable logistics development in archipelagic nations.

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