

DIGITAL TRANSFORMATION AND ECO LEADERSHIP'S ROLE IN MODERATING THE RELATIONSHIP BETWEEN GREEN TRANSPORTATION AND COMPETITIVE ADVANTAGE

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ABSTRACT

Technology adaptation and green transportation implementation are related to achieving competitive advantage. This study aims to explore the relationship between green transportation and competitive advantage with the moderating role of digital transformation and ecological leadership. The research objects are several stevedoring companies operating in Jakarta. Data collection was conducted through the distribution of online questionnaires and then analyzed using the Generalized Structured Component Analysis (GSCA) tool. The results of the study indicate that the implementation of green transportation has a significant effect on competitive advantage, both in terms of company age and management position. Adaptation of digital transformation strengthens the commitment to implement green transportation in achieving competitive advantage. Furthermore, the factors of company age and management position further strengthen the role of digitalization in moderating the influence of green transportation on competitive advantage. Ecological leadership with the factor of company age strengthens the commitment to implement green transportation. These results have theoretical implications in the empirical enrichment of the concept of green transportation and the theory of resource-based competitive advantage. These results have practical implications for the maritime industry where the implementation of green transportation can increase competitive advantage strengthened by the adaptation of digital transformation and ecological leadership.

Keywords: *Eco leadership, competitive advantage, stevedoring business, green transportation, digital transformation*

INTRODUCTION

The concept of green transportation has been increasingly promoted in the transportation world since the 2000s, in line with increasing environmental awareness and international commitments. Although data show that the land transportation sector is more frequently the topic of empirical studies related to efforts to mitigate the impact of pollution from transportation exhaust gases, the implementation of green transportation in the maritime sector has also become an important focus for stakeholders in the maritime industry.

The maritime industry has adopted the concept of green transportation in the form of several concepts, such as the implementation of the green port concept by port business actors and the green shipping concept by shipping companies. Business actors in the maritime industry implement the concept of green transportation and its derivatives, such as green ports and green shipping, primarily aimed at responding to the fulfilment of legal or regulatory provisions set by the International Maritime Organisation (IMO). Compliance with these provisions is mandatory for all maritime industry players, both globally, regionally and locally. The implementation of green transportation in the maritime industry is not only fulfilling

obligations for regulatory compliance but also beneficial in achieving business sustainability and competitiveness. Numerous empirical studies have demonstrated that the implementation of green transportation is related to performance (Agyabeng-Mensah and Tang, 2021; Alzoubi, 2021; Samad et al., 2021), customer satisfaction (Siregar et al., 2024; Li et al., 2021), and competitive advantage (Larina et al., 2021; Fallahi et al., 2024).

The rapid development of technology has impacted businesses in the maritime industry. While some technological developments have had a positive impact on maritime business processes, others have had a negative impact. Negative impacts include the replacement of business processes by technological devices, resulting in a decrease in human resource utilisation and the need for investment capital. However, in the development of business processes in the maritime industry, companies that successfully adapt technology to their business processes can contribute to their competitiveness. Conversely, businesses that have not yet adapted technology to their business processes will face negative impacts and struggle to compete. Numerous empirical studies have shown that technological adaptation or digital transformation by companies improves

company performance. (Zhai et al., 2022; Al-Kharbush et al., 2023; Mutambik, 2024), and also increasing customer satisfaction (Iriqat and Jaradat, 2021; Abdel-Hamid et al., 2022; Miguel et al., 2022).

In addition to the digital transformation undertaken by companies that are hardware components in the maritime industry, the presence of corporate leaders who manage the companies is also important to highlight. Corporate managers whose leadership style displays a commitment to the environment, sustainability, and balance are believed to contribute to improved company performance, and become agents of change in corporate culture. This leadership style that emphasises environmental concerns, sustainability, and balance is a form of eco leadership, also known as environmental leadership. Numerous empirical studies have shown that eco leadership contributes to business practices that support the implementation of green transportation, increasing competitiveness. (Abdullah et al, 2025), improving company performance (Novita et al., 2022).

Stevedoring companies, as business entities specifically established to handle the loading and unloading of cargo to and from ships at ports, operate transportation equipment such as mobile cranes, trucks, and other types. All of these types of transportation equipment rely on fossil fuels as their primary driving force, which contributes to increasing pollution and greenhouse gas emissions in port environments. Furthermore, stevedoring companies still rely on stevedoring workers with an average level of competency in carrying out their port operations. Demands to meet customer needs and desires and be able to adapt to technological developments are increasingly pressing for every stevedoring business actor at ports if they are to exist. Likewise, port management partners emphasise that one of the requirements in partnership agreements for stevedoring companies working in port areas is to apply green transportation principles and adapt to technology in their business processes. The background of these conditions requires stevedoring companies to transform their business processes in accordance with technological developments in their business processes. Furthermore, the demand for improved skills and competencies among stevedoring company managers and workers with environmental and sustainability backgrounds, as mandated by international maritime regulations, is a necessity for every stevedoring company. The need to adapt to technology in business processes and be managed by environmentally conscious human resources when implementing green transportation

ultimately leads to high performance for stevedoring companies. Achieving good performance and meeting customer satisfaction and partnership requirements with port operator is a key indicator of competitiveness for stevedoring companies.

The theoretical basis of competitive advantage based on resources (resource-based view- RBV) explains that companies that manage resources that are rare, unique, valuable and difficult to imitate by competitors will have a competitive advantage. Stevedoring companies in their business processes rely on the empowerment of resources both tangible and intangible so that one of the challenges to the success of stevedoring companies is implementing the concept of green transportation in the company's business processes that can be a form of competitive advantage for the company as long as it is managed in a valuable, unique, and cannot be imitated by competitors. Several empirical studies show that green transportation has a positive association with competitive advantage in the logistics industry (Larina et al., 2021; Fallahi et al., 2024); however, this still requires empirical studies on stevedoring companies. The implementation of green transportation for stevedoring companies will have implications for changes in business processes and loading and unloading equipment that have so far relied on fossil fuels to be converted into environmentally friendly ones. Changes in these business processes will have an impact on the achievement of company performance, which is indirectly related to the competitiveness of stevedoring companies. Thus, the implementation of green transportation still requires Empirical evidence to establish a competitive advantage for stevedoring companies. This empirical study also addresses the assumption that stevedoring companies remain competitive despite relying on a labour-intensive workforce in their business processes. It also addresses the assumption that competitive advantage can be achieved as long as they comply with existing regulations in the maritime industry.

When a stevedoring company fulfills customer expectations by adopting digital transformation in its business processes, it will impact its performance, experiencing significant changes in its ability to generate financial and operational performance. Based on competitive advantage RBV theory, taking steps or breakthroughs in digital transformation in business processes represents a potential avenue for achieving competitive advantage for a company. Numerous empirical studies have shown that digital transformation significantly impacts customer

satisfaction and company performance. The role of digital transformation in generating competitive advantage for companies implementing green transportation concepts requires further study. Given that both digital transformation and green transportation implementation play a role as factors influencing competitive advantage, the role of digital transformation in achieving competitive advantage through green transportation implementation can be positioned as a supporting factor. Therefore, the role of digital transformation can be tested as a moderating factor in the relationship between green transportation and competitive advantage, which still requires empirical evidence.

Stevedoring companies implementing green transportation to achieve a competitive advantage require a work environment characterized by environmental concerns. Empirical studies in other industries, such as SMEs, show that an ecological leadership style influences competitive advantage (Novita et al., 2022; Abdullah et al., 2025). The role of green leadership in achieving competitive advantage for companies implementing green transportation can be positioned as a supporting factor. Therefore, the role of ecological leadership as a moderating factor in the relationship between green transportation and competitive advantage still requires empirical evidence. Furthermore, how stevedoring companies, from the perspective of company age, such as new and established companies, adapt to technology to achieve a competitive advantage when implementing green transportation. Furthermore, how stevedoring companies, from the perspective of company management positions with an ecological leadership style, achieve competitive advantage when implementing green transportation.

Based on the concept of green transportation and the competitive advantage RBV theory, as well as on several studies that have proven the relationship between green transportation and competitive advantage, this study aims to explore the implementation of green transportation in stevedoring companies that adapt to technological developments and incorporate ecological leadership to achieve competitive advantage. Digital transformation and ecological leadership function as moderating factors. Furthermore, this exploratory study will examine the age of the company and the position of management in adapting to technology. This research will also address the assumption that stevedoring companies remain competitive despite relying on labor-intensive labor in their business processes and that competitive advantage can still be achieved as long

as they comply with existing regulations in the maritime industry.

Literature Review and Hypothesis Development

a. Green Transportation and Competitive Advantage

Green transportation is a mode of transportation designed to minimise negative impacts on the environment, reduce or eliminate greenhouse gas emissions, and increase competitiveness (Avriani et al., 2025). The maritime industry has implemented green transportation concepts in the form of green ports, green shipping, and green environments around ports by business actors within port operations. However, the main challenges lie in initial investment costs and limited infrastructure. The implementation of green ports, which leads to port competitiveness, is achieved through steps to allocate port resources, encourage port technology innovation, and improve port environmental management (Li et al., 2024). In the shipping sector, efforts undertaken by shipping companies to achieve a competitive advantage include introducing green shipping through innovative fuel costs that meet the requirements of an ecologically oriented shipping environment (Cemehob, 2024). Other empirical research shows that implementing green logistics as part of green transportation significantly improves social performance, financial performance, and green competitiveness for companies (Agyabeng-Mensah and Tang, 2021). Stevedoring companies, as part of port business operators, can achieve competitiveness through their ability to adapt to changes. This implies that implementing green transportation as a form of regulatory compliance will also have a significant impact on logistics operational efficiency (Nitsenko et al., 2024). Stevedoring companies that implement green transportation concepts will generate competitiveness for their companies as long as they can adapt. Therefore, the following hypothesis can be developed: H_1 :

Implementation of green transportation has a significant effect on achieving a competitive advantage

Company competitiveness is related to the company's experience and age. Start-up companies require greater effort in adapting to change to achieve a competitive advantage because it is related to the quality of the company's sustainability (Campos et al., 2023; Kusuma, 2025). Companies with more experience in this area, along with their age, will perform better than start-ups in achieving a competitive advantage. Therefore, the following hypothesis can be formulated:

H_{1a}: The implementation of green transportation by established stevedoring companies has a more significant effect on competitive advantage compared to newly established companies

Similarly, the maturity of company management is linked to its position of responsibility within the company. Company competitiveness is related to the maturity and experience of company management, where position is correlated with knowledge and skills (Tianqi et al., 2023). Another study showed no statistically significant difference in the competitiveness of logistics companies between career seniority and different job positions (Van Thu et al., 2023). Stevedoring companies that implement green transportation, when viewed from the perspective of job position within the company, will accelerate the achievement of competitive advantage. Therefore, the following hypothesis can be formulated:

H_{1b}: The implementation of green transportation when viewed from the perspective of higher level job position has a more significant effect on achieving competitive advantage compared to lower job position.

b. Green Transportation, Competitive Advantage, and Digital Transformation

The unloading and loading of goods onto and off ships at ports implementing the green port or green transportation concept is related to customer satisfaction. Empirical studies show that, in addition to complete port facilities, service quality, professional stevedoring personnel, and corporate image and social responsibility, the implementation of green ports or green transportation also increases customer satisfaction (Febriani, 2025). Strategic green port initiatives in developing countries aim to support sustainable maritime transportation. These initiatives will guide port operators in implementing strategic frameworks that encourage green port development (Turbaningsih et al., 2022).

Empirical studies have shown that technological adaptation in the transportation industry through digital transformation can reduce carbon intensity, particularly for those relying on domestic digital sources. For segmented digitalisation, carbon intensity reductions from digital infrastructure are more significant. Therefore, technological advancement is a primary channel for digital transformation in the transportation industry in reducing carbon intensity (Huang et al., 2023). Factors influencing digital transformation in the maritime transportation sector include organisation, technology, and the environment.

With the digital transformation, businesses in the maritime transportation sector are experiencing significant changes in their business models, generating additional revenue from new sources, providing new services, and introducing new sales channels (Jovic et al., 2022).

The implications or impact of technological adaptation in the maritime industry will ultimately lead to the ability of companies in the maritime transportation sector to produce superior products and services in the eyes of customers. Several studies have shown that technological adaptation will generate competitive advantages in the manufacturing sector. These advantages include increased productivity, increased research and development intensity, and improved human resources (Sui et al., 2024). This, in turn, enhances their overall competitiveness. Competitiveness from digitalisation is manifested in improvements in the quality of human resources, including positive attitudes supporting digital transformation, initiatives to deepen technology, and a corporate culture that supports digital transformation (Molosevic et al., 2024). The competitive advantages resulting from digital transformation in the service sector have also been shown to have a significant impact (Shehadeh et al., 2023). Digital transformation impacts company competitiveness, particularly in innovation, efficiency, and cost reduction. It also impacts the global value chain in terms of specialisation, geographic coverage, governance, and increases the company's standing (Leão & da Silva, 2021). Digital transformation in service companies, such as stevedoring companies operating at ports, when implementing green transportation, will generate a competitive advantage for the company. Therefore, the following hypothesis can be developed:

H₂: The role of digital transformation in moderating the influence of digital transformation has a significant effect on competitive advantage

Regarding technology adaptation for companies, empirical studies show that larger companies are more likely to adapt technology more quickly and easily as a means of achieving competitive advantage (Buer et al., 2021). Considering the age of the company in the digital transformation process, the company's ability to adapt indicates that newly established companies have less capacity than established companies. When viewed from the age of the company, when implementing green transportation by adapting digital transformation, start-up companies' ability to achieve a competitive advantage will be lower than that of established companies. Therefore, the hypothesis that can be developed regarding company age is:

H_{2a}: The moderating role of digital transformation in established companies strengthens the influence of green transportation on achieving competitive advantage compared to newly companies

Company management, when viewed from the position within the company, will influence the company's ability to implement transportation by adapting technology to achieve a competitive advantage. The role of company leaders at the director level plays a crucial role in ensuring the success of digital transformation when implementing green transportation. Empirical studies show that the role of top management is more significant in setting company goals, visions, and targets than in managing information flow during the digital transformation process (Li et al., 2023).

Stevedoring operating at ports, managed by company leaders and managers, will influence the company's ability to adapt technology when implementing green transportation at the port. Therefore, the following hypothesis can be developed:

H_{2b}: The moderating role of digital transformation led by top management strengthens the influence of green transportation on achieving competitive advantage compared to those led by general managers

c. Green Transportation, Competitive Advantage, and Eco Leadership

Company managers are increasingly required to participate in the digital transition process demanded by the industry. On the other hand, sustainability and environmental issues must be incorporated into company operational strategies, requiring company managers, especially leaders, to adopt an eco leadership style. Eco leadership requires the ability to explore development opportunities amidst the challenges and opportunities of the digital era. Empirical studies show that in responding to ecosystem disruptions created by the digital revolution, eco leadership requires the development of eco leadership skills to address the challenges posed by the development and training of leaders aligned with sustainability principles (Justino Alves et al., 2024).

Companies, faced with adapting to technology while simultaneously being required to implement green transportation to achieve a competitive advantage, face a dilemma: technological developments in the industrialisation process, on the one hand, also impact environmental degradation. Empirical studies show that environmentally friendly innovative initiatives have a significant positive impact on sustainable competitive advantage. On the other hand,

industrialisation and globalisation, while positively impacting company growth, are also suspected of contributing to environmental violations, requiring companies to focus on environmentally friendly concepts to achieve a competitive advantage. The touch of eco leadership will contribute to maintaining a company's competitive advantage through the creation of environmentally friendly innovation values (Suparna et al., 2021).

Stevedoring companies, in their port activities, must comply with regulatory requirements related to the principles of the green port concept and green transportation. Eco leadership is essential for company management, both at the board of directors and managerial levels. By implementing green transportation in their business processes, stevedoring companies have the opportunity to achieve a competitive advantage. Furthermore, when companies are led by leaders with eco leadership styles, their ability to achieve a competitive advantage increases. Therefore, the following hypothesis can be developed:

H₃: The moderating role of eco leadership will strengthen the influence of green transportation on achieving competitive advantage for stevedoring companies.

Companies managed by leaders with eco leadership styles when implementing green transportation in established companies are not directly related to the company's age. Startups, such as small and medium enterprises (SMEs), also face a similar dilemma. Empirical studies in startups and small and medium enterprises (SMEs) show that shifting from traditional transformational leadership to green transformational leadership can be a key initiative towards environmental sustainability (Ismail, 2025). On the other hand, leading companies, namely established companies, have achieved significant progress in environmental technology innovation, which can be an asset in achieving competitive advantage (Yu et al., 2024).

Stevedoring companies, most of whom are already established, are faced with the challenge of adapting to the demands of implementing green transportation. Even though companies are well-established, adopting an eco leadership style can significantly increase their competitive advantage. Therefore, the following hypothesis can be formulated:

H_{3a}: The moderating role of eco leadership in established stevedoring companies significantly strengthens the influence of green transportation on achieving competitive advantage compared to newly companies.

Companies led by top management at the director level with an eco leadership style will significantly improve the company's ability to implement green transportation (Huang, 2025). Stevedoring companies led by directors with an eco leadership style significantly differed from those led by senior managers in implementing green transportation in achieving competitive advantage, with director-level leadership being more significant in achieving competitive

advantage. Therefore, the following hypothesis can be developed:

H_{3b}: The moderating role of eco leadership at the director level, compared to senior manager-level leadership, strengthens the influence of green transportation on competitive advantage.

Based on the above series of hypotheses developed and supported by several previous empirical studies in analysing the relationships between variables, the following model can be reconstructed as shown on Figure 1.

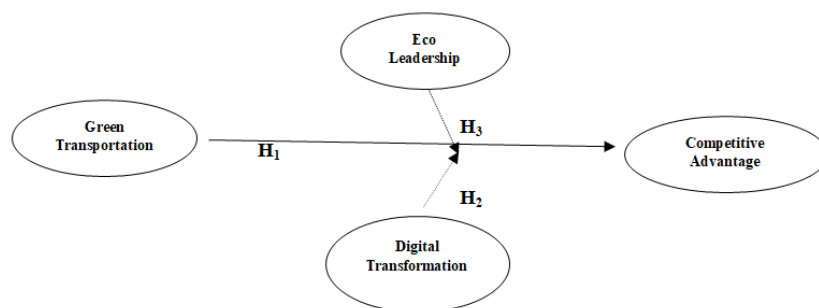


Figure 1. Research Model

RESEARCH METHODS

This study used a quantitative method approach and was conducted over three months (February to April 2025) with port stevedoring service companies as the research subjects. Stevedoring companies are service companies that unload and load goods onto and off ships at the dock, as well as delivering or receiving them from the owners. The research population is several stevedoring companies operating in 3 three) commercial port areas in Jakarta (Tanjung Priok, Sunda Kelapa and Marunda). The determination of the number of samples uses the Slovin formula, namely, the minimum number of samples of 110 companies with a population of 150 companies.

The sampling technique was by random drawing. The data collection technique was carried out by distributing an online questionnaire using Google Form in the form of respondents' perceptions using a 5-point Likert scale, namely strongly agree, agree, neutral, disagree and strongly disagree. The collected data were then analysed statistically, both descriptive analysis and inferential analysis using the GSCA (General Structural Component Analysis). There are 4 variables in this study, namely green transportation as the independent variable, the competitive advantage variable as the dependent variable, the ecological leadership variable and the digital transformation variable as moderating variables. The green transportation variable, also known as environmentally friendly transportation or sustainable transportation, is a transportation system approach designed to minimise negative

impacts on the environment. This variable is reflected in 5 items adapted from Felicio et al (2021), including: compliance with maritime regulations at ports, meeting customer demands, improving the company's image, contributing to the company's operational efficiency, and improving the quality of the company's culture. The competitive advantage variable is the company's ability to perform better than its competitors, which can be obtained from superior product/service quality, operational efficiency, innovation, or exceptional customer service. This variable is reflected in 6 items adapted from Sigalas dan Papadakis (2018), including: using efficient business processes, making breakthrough innovations that cannot be imitated, superior service products, initiating new products, impressive after-sales service, and access to complete and affordable networks. The eco leadership variable is a leadership style that views the organisation as part of a larger living system, emphasising connectivity, sustainability, and environmental responsibility, which does not only focus on profits. This variable is reflected in 5 items adapted from Al-Zawahreh et al (2019), including: implementing open systems, focusing on sustainability, building networks, thinking holistically, and creating success oriented towards the welfare of the ecosystem. The digital transformation variable is a fundamental process for integrating digital technology into a company's business processes that transforms company operations, delivers value to customers, and meets market demands. This variable is reflected by six

items adapted from Saldanha et al. (2017), including: improving the quality of business processes, improving the quality of service products, increasing company efficiency and productivity, fulfilling customer desires, complying with port authority regulations, and improving the quality of corporate culture.

RESEARCH RESULT

3.1 Respondent Description

Stevedoring companies operating at the port are managed by competent human resources in the port industry. The human resources employed by stevedoring companies must comply with the regulations imposed by regulators, port authorities, and even partners of port business entities. The respondent profile, as shown in Table 1, shows that in terms of company age, 23 companies (20.9%) are less than 5 years old, and 87 companies (79.1%) are more than 5 years old. Based on this profile, only 23 companies are newly established, and the respondents are dominated by established companies, with 38.18% of respondents aged 6-10 years, 23/63% aged 11-15 years, and 17.29% aged 15 years or more. The next profile, based on company size, shows that 73 companies (66.36%) have a maximum of 60 employees, while the remaining 37 companies have over 60 employees (33.64%). When viewed from the perspective of decision-making level, the respondent profile shows that 54 companies (49.09%) are represented by directors, and 56 companies (50.91%) are represented by general managers.

3.2. Variable Description

The variable descriptions from the data processing, as shown in Table 2, show that the mean value for the four variables is 4.48 for the

green transportation variable, which is the same as the mean for the eco leadership variable. Meanwhile, the mean value for the digital transformation variable is lower, at 3.98, and the mean value for competitive advantage is among the lowest, at 3.73. These values indicate that respondents or stevedoring companies place a high value on the implementation of green transportation and eco leadership, while those related to digital transformation and competitive advantage place a moderate value.

3.3. Outer Model Testing

The outer model testing aims to determine the level of correlation between variables and the indicators or items they reflect. The outer model testing aims to determine the validity, reliability, and feasibility of the model. Convergent validity testing is assessed by examining the loading factor values for each item reflecting the variable, as shown in Table 3. The loading factors for all items, without multi-group analysis, were above 0.6. This result indicates that all items met validity criteria. When conducting multi-group analysis with the control variable of company age, three items had loading factor values below 0.6, but still above 0.5. For the newly established companies category, these items still met the validity criteria. Meanwhile, for the established companies category, all items met the validity criteria. Similarly, for the job position category, both director and general manager, all items reflecting the four variables met the validity criteria. Validity testing for each variable, as shown in Table 4, also met validity requirements. Each variable had an AVE value above 0.5, concluding that all four variables met validity criteria.

Table 1. Respondent Description

Company Profile		Company Numbers	Percentage (%)
Company Age	1-5 years	23	20.90%
	6-10 years	42	38.18%
	11-15 Years	26	23.63%
	>15 years	19	17.29%
	Total	110	
Company Size (total of employee)	1-20 employee	15	13.64%
	21-40 employee	23	20.90%
	41-60 employee	35	31.82%
	61-80 employee	21	19.09%
	81-100 employee	9	8.18%
	>100 employee	7	6.37%
	Total	110	
Job Position	Director	54	49.09%
	General Manager	56	50.91%
	Total	110	

Sources : Data Internal Process, 2025

Table 2. Variable Description

Variable	Item	Mean	Median	Min	Max	Standar of Deviation
Green Transportation (GT)	GT ₁	4.64	5.0	4.0	5.0	0.479
	GT ₂	4.48	4.5	3.0	5.0	0.534
	GT ₃	4.61	5.0	4.0	5.0	0.488
	GT ₄	4.43	4.0	3.0	5.0	0.593
	GT ₅	4.25	4.0	2.0	5.0	0.575
Competitive Advantage (CA)	CA ₁	3.93	4.0	3.0	5.0	0.651
	CA ₂	3.88	4.0	3.0	5.0	0.656
	CA ₃	3.57	4.0	2.0	5.0	0.776
	CA ₄	3.54	4.0	2.0	5.0	0.886
	CA ₅	3.80	4.0	3.0	5.0	0.440
	CA ₆	3.70	4.0	2.0	5.0	0.595
Eco Leadership (EL)	EL ₁	4.64	5.0	3.0	5.0	0.706
	EL ₂	4.53	5.0	4.0	5.0	0.479
	EL ₃	4.71	5.0	3.0	5.0	0.654
	EL ₄	4.64	5.0	4.0	5.0	0.452
	EL ₅	3.88	5.0	3.0	5.0	0.639
Digitan Transformation (DT)	DT ₁	3.86	4.0	2.0	5.0	0.733
	DT ₂	4.11	4.0	1.0	5.0	1.042
	DT ₃	3.71	4.0	3.0	5.0	0.488
	DT ₄	4.11	4.0	2.0	5.0	0.725
	DT ₅	4.21	4.0	3.0	5.0	0.524
	DT ₆	3.93	4.0	2.0	5.0	0.700

Sources : Data Process Internal, 2025

Table 3. Item Loading factor of each variable Variable	Item	Loading Factor with out MGA	Loading Factor with MGA		Job Position	
			Company Age New Company	Esstablished Company	General Manager	Director
Green Transportation (GT)	GT ₁	0.651	0.740	0.635	0.604	0.717
	GT ₂	0.764	0.806	0.760	0.798	0.704
	GT ₃	0.740	0.804	0.729	0.791	0.669
	GT ₄	0.724	0.520	0.760	0.740	0.741
	GT ₅	0.699	0.500	0.730	0.663	0.763
Eco Leadership (EL)	EL ₁	0.748	0.679	0.768	0.855	0.678
	EL ₂	0.655	0.596	0.679	0.730	0.605
	EL ₃	0.863	0.858	0.867	0.879	0.856
	EL ₄	0.765	0.905	0.726	0.765	0.761
	EL ₅	0.846	0.865	0.841	0.856	0.851
Digital Transformation (DT)	DT ₁	0.804	0.884	0.787	0.807	0.796
	DT ₂	0.624	0.553	0.611	0.605	0.612
	DT ₃	0.794	0.829	0.785	0.813	0.782
	DT ₄	0.855	0.861	0.854	0.856	0.853
	DT ₅	0.786	0.789	0.789	0.743	0.847
	DT ₆	0.815	0.634	0.849	0.861	0.779
Competitive Advantage (CA)	CA ₁	0.756	0.796	0.748	0.777	0.731
	CA ₂	0.820	0.863	0.809	0.815	0.819
	CA ₃	0.792	0.875	0.773	0.816	0.776
	CA ₄	0.837	0.834	0.837	0.812	0.855
	CA ₅	0.724	0.626	0.746	0.772	0.645
	CA ₆	0.724	0.670	0.748	0.751	0.678

Sourcess : Data Internal Process, 2025

Table 4. Variable reliability and AVE Value

Variable	Criteria Cronbach Alpha	Composite Reliability	AVE Value
Green Transportation (GT)	0.762	0.840	0.514
Eco Leadership (EL)	0.835	0.884	0.607
Digital Transformation (DT)	0.844	0.888	0.579
Competitive Advantage (CA)	0.868	0.901	0.603

Sourcess : Data Internal Process, 2025

The next outer model test is an examination of the model's reliability by looking at the Cronbach alpha and composite reliability values, as shown in Table 4. According to the provisions, if the Cronbach Alpha value is above 0.6 and the Composite reliability value is above 0.7, then a variable meets the reliability requirements. Based on the test results as shown in Table 4, the four variables have Cronbach alpha values above 0.6 and Composite reliability values above 0.7, so it can be concluded that the four variables in this research model meet the reliability requirements. Thus, the research model can be used in this study. The next model test is the R-squared and Q-squared measurements, which show the diversity of endogenous constructs that can be explained by the diversity of exogenous constructs. The results of the structural model test show the R coefficient value for the research model shown in

Table 5, where the R-squared value is 0.206. This value indicates that 20.6% of the competitive advantage variable can be explained by green transportation, while the remaining 79.4% is explained by factors outside the research model such as firm size, operational capability, market orientation, relationship capital, regulatory pressure, or service quality—that may contribute to competitive advantage.

Before proceeding to the inner model testing, which examines the relationships between variables, it is necessary to conduct a feasibility and model fit test. The model fit test is assessed using the model fit criteria and quality indices, as shown in Table 6. Based on the test results, all model fit and quality indices meet the criteria with good and ideal explanations. Therefore, the reconstructed research model meets the fit criteria and is suitable for use as a research model.

Table 5. Test of the model R squared and Q-squared

Variable	Competitive Advantage (CA)	
	R-squared	Q-squared
Green Transportation (GT)	0.206	0.226

Sourcess : Data Internal Process

Table 6. Model Fit and Quality Indices

No	Model FIT and Quality Indices	Fit Criteria	Result	Description
1	FIT	0 – 1	0.0609032	Good
2	AFIT	0 – 1	0.0394699	Good
3	FITs	0 – 1	0.395871	Good
4	FITm	0 – 1	0.284752	Good
5	GFI	sample <100, GFI >0.890;	0.9329498	Good
6	SRMR	sample >100, GFI >0.930, SRMR < 0.08	0.0410165	Good

Sourcess : Data Internal Process

3.4. Inner Model Testing

Based on the research model used, the relationship between the variables tested is between green transportation and competitive

advantage, with ecological leadership and digital transformation acting as moderating variables. The results of the test of the relationship between the variables, as shown in Table 7

Table 7. Variable Inter relationship Examination (Inner Model) Variable Inter relationship	Hypothesis	Multi Group Analysis (MGA) or without MGA	Path Koefisien	p - alue	Description	
GT → CA	H ₁	w/o MGA	0.372	< 0.001	H ₁ accepted New Company	
	H _{1a}	MGA (company age)	0.367	< 0.001	Established Company General Manager	H _{1a} accepted
	H _{1b}	MGA (job position)	0.379	<0.001	Director	H _{1b} accepted
	H ₂	w/o MGA	0.036	0.352	Moderation role Strengthen New Company	H ₂ accepted
GT → CA With DT Moderation	H _{2a}	MGA (company age)	0.137	0.093	Moderation role Strengthen Established Company	H _{2a} accepted
			0.375	0.018	Moderation role Strengthen General Manager	
			-0.169	0.092	Moderation role Weakend	H _{2b} rejected
	H _{2b}	MGA (job position)	0.277	0.014	Director Moderation role Strengthen Moderation role	H _{2b} accepted
GT → CA With EL Moderation	H ₃	w/o MGA	0.170	0.033	Moderation role Strengthen	H ₃ accepted
			0.072	0.249	New Company Moderation roe Strengthen Established Company	H _{3a} accepted
	H _{3a}	MGA (company age)	0.005	0.490	Moderation role Strengthen General Manager	
			0.100	0.221	Moderation role Strengthen Director	H _{3b} accepted
	H _{3b}	MGA (job position)	-0.042	0.377	Moderation role Weakend	H _{3b} rejected

Sourcess : Data Internal Process

DISCUSSION

Testing the relationship between the two variables and the role of the moderating variable also takes into account the control variables,

namely, company age and the position of company management. The use of the control variable, company age, aims to determine the extent to which newly established companies implement

green transportation to achieve a competitive advantage compared to established companies. Similarly, the control variable, company management's position, is used in implementing green transportation to achieve a competitive advantage. The results of the test of the relationship between the variables, as shown in Table 7, indicate that the implementation of green transportation in stevedoring companies has a significant positive effect on achieving competitive advantage thus, the hypothesis H_1 is accepted. The relatively low path coefficient of 0.372 indicates that green transportation implementation has a moderate effect on achieving competitive advantage. This relatively moderate path coefficient is reflected in the R-squared value of 0.206, indicating that only 20.6% of the competitive advantage factor can be explained by the green transportation variable, while the remaining 79.4% is explained by factors outside the research model such as firm size, operational capability, market orientation, relationship capital, regulatory pressure, or service quality—that may contribute to competitive advantage. As explained in previous empirical studies, implementing green transportation in port areas not only improves performance but also aims to comply with international and regional maritime regulations. In implementing green transportation, stevedoring companies operating in port areas are primarily focused on complying with regulations set by the International Maritime Organisation (IMO). The results of this study are also in line with previous empirical studies with the object of research on ports and logistics, where green transportation has a significant effect on achieving competitive advantage (Li et al., 2024; Agyabeng-Mensah and Tang, 2021). Therefore this results does not support the concept of green transportation because companies implementing green transportation prioritize fulfilling requirements

Testing the relationship between the two variables when further exploration is carried out in terms of company age and company management positions. The implementation of green transportation in established companies has increased influence, with a higher path coefficient compared to start-up companies. The results of the test with a review of company age are in line with previous empirical studies by Campos et al. (2023) and Kusuma (2025). Thus, the hypothesis H_{1a} is accepted, namely, the implementation of green transportation in established loading and unloading companies has a more significant effect on competitive advantage compared to newly established companies.

Testing the relationship between the two variables when viewed from the position of company management between the positions of director and general manager shows that the path coefficient value increases when managed by a director compared to the position of general manager, as shown in Table 7. These results are in line with previous empirical studies (Tianqi et al., 2023), where company managers have broader and greater authority and have more experience and knowledge. High levels of commitment will support the achievement of a competitive advantage from the implementation of green transportation. Thus, hypothesis H_{1b} is accepted, namely that the implementation of green transportation by loading and unloading companies, when viewed from the aspect of higher job positions, has a more significant influence on the achievement of competitive advantage compared to lower job positions.

Testing the relationship between green transportation and competitive advantage, when digital transformation plays a role, shows that digitalization strengthens the influence of green transportation on competitive advantage, thus accepting H_2 . Port-based stevedoring companies adapt technology in their business processes to meet customer demands and partnership requirements with port businesses and port authorities. Furthermore, this also contributes to the company's competitive advantage, enabling it to meet customer expectations. These test results align with previous empirical studies (Molosevic et al., 2024 and Shehadeh et al., 2023).

The presence of digital transformation in stevedoring companies, when measured by company age, indicates that established companies significantly achieve competitive advantage compared to start-ups, thus accepting hypothesis H_{2a} . This is because established companies have the experience to adapt to changes in business processes, relying on their experience. These results align with previous empirical studies (Buer et al., 2021).

Technology adaptation for companies, when managed at the general manager level, actually weakens the impact of green transportation implementation on achieving competitive advantage. Conversely, results indicate that when led by a director, it strengthens the impact of green transportation implementation on achieving competitive advantage. These results suggest that the general manager's position is not strong enough to control the adaptation process, thus rejecting hypothesis H_{2b} . This finding aligns with previous empirical evidence (Li et al., 2023), which confirmed that a more strategic position

significantly impacts the company's goals, vision, and targets.

Leaders with an environmentally friendly leadership style emphasise sustainability in the implementation of green transportation within a company. The knowledge and experience of leaders with an eco leadership style support the realisation of green transportation implementation in achieving competitive advantage. Test results of the presence of an eco leadership style in a stevedoring company indicate a significant moderating effect on the relationship between green transportation and competitive advantage, thus accepting hypothesis H_3 . This result aligns with previous empirical evidence (Suparna et al., 2021), which found that eco leadership can contribute to maintaining a company's competitive advantage through the creation of environmentally friendly innovation values.

Leaders with an eco leadership style, when managing established companies, will further strengthen the influence of green transportation implementation on competitive advantage. Test results show that both established companies and start-ups with an eco leadership style equally strengthen the influence of green transportation implementation on competitive advantage. However, the effect is less significant for start-ups. This may occur because start-ups are more easily able to adapt their corporate culture compared to established companies, thus accepting hypothesis H_{3a} . This test result is inconsistent with previous empirical evidence (Yu et al., 2024), which found that established, leading companies have achieved significant progress in environmental technology innovation, which can be a key asset in achieving competitive advantage.

Leaders with an eco leadership style, holding a director-level position, will significantly influence the company's implementation of green transportation to achieve a competitive advantage. However, test results show the opposite, where the director position weakens the influence of green transportation on competitive advantage. Conversely, the general manager position strengthens the influence of green transportation implementation on competitive advantage, thus rejecting hypothesis H_{3b} . This result can occur when the director's capacity to implement green transportation is not supportive, especially when it comes to influencing the company's principles and culture. Conversely, the general manager position can be more effective when collaborating with the team to implement green transportation to achieve a competitive advantage. These test results align with previous empirical research (Huang, 2025), which found that companies led by top executives

at the director level with an ecological leadership style significantly increased the company's ability to implement green transportation.

Limitation of the research

Based on the results of the hypothesis testing, two hypotheses were rejected. This requires further analysis by expanding the assumptions used. This is also a limitation of this study, namely, related to eco leadership. Therefore, individual and organizational behavioral factors are important factors to include in exploring aspects of eco leadership. Similarly, the sustainability aspect was not included in this study. This is crucial when discussing green transportation, which is synonymous with partisanship and sustainability. Therefore, this factor is a limitation of this study, open to further study in subsequent empirical testing.

Implications of the Research Findings

The results of this study, which explore how green transportation implementation contributes to achieving competitive advantage, and are enriched by the moderating role of digital transformation and eco leadership, provide empirical evidence for the concept of green transportation and the theory of competitive advantage. Stevedoring companies, classified as service companies with minimal assets, implement green transportation not only to comply with regulations but also to significantly contribute to achieving a competitive advantage. Thus, the results of this study also contribute implications for the technical level of business operations, recommending that the implementation of green transportation be further strengthened by the moderation of digital transformation and the inclusion of an eco leadership style to achieve competitive advantage.

CONCLUSION

Stevedoring companies operating at ports are inextricably linked to compliance with maritime regulations from the International Maritime Organization (IMO) and national regulations. The results of this study, which explores the implementation of green transportation in the business processes of stevedoring companies in achieving competitive advantage, indicate that green transportation implementation has a significant impact on achieving competitive advantage primarily aimed at fulfilling administrative requirements related to IMO provisions.

When companies adapt technology in the form of digital transformation into their stevedoring business processes, the research indicates that digital transformation strengthens the impact of digital transportation implementation on

competitive advantage. Digital transformation is more significant for established companies in moderating the impact of green transportation on competitive advantage compared to start-up companies. Similarly, the association between director-level positions in the company strengthens the role of digitalization in moderating the impact of green transportation on competitive advantage.

Company managers with an eco leadership style are associated with green transportation. The test results indicate that green leadership strengthens the influence of green transportation on competitive advantage. Likewise, when leaders with an eco leadership style are in established or start-up companies, the role of eco leadership equally strengthens the influence of green transportation on competitive advantage. However, a review of leaders with an eco leadership style, with a review of job positions between directors and general managers, shows that the higher the position, the weaker the role of eco leadership in moderating the influence of green transportation on competitive advantage.

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