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Digital technology adoption and institutionalization in Thai maritime industry: An exploratory study of the Thai shipowners

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ABSTRACT

This exploratory study delves into the factors influencing digital technology adoption and the dynamics of its institutionalization within the Thai maritime industry, a key sector underpinning Thailand's economic expansion. Data was collected through semi-structured interviews with executive leaders from seven Thai shipowners, utilizing a snowball sampling method. The study reveals that digital technology adoption is driven by a complex interplay of factors including reliable IT infrastructure, perceived technological benefits, organizational culture, top management support, IT skills and support, legal, regulatory, and policy requirements, social pressure influence, and varying degrees of government support. Additionally, the institutionalization of such technologies within the maritime sector is heavily reliant on well-defined organizational rules and the establishment of trust in technological advancements. These findings not only enrich the theoretical landscape regarding digital adoption but also offer practical insights for industry stakeholders, paving the way for more nuanced interventions and policy formulations aimed at enhancing digital integration in this traditionally conservative sector.

1. Introduction

Transforming business models by embracing and employing digital technologies creates an environment where new opportunities are facilitated and value is generated (Tijan et al., 2021). The adoption of new technologies can lead to significant changes in organizational structures, processes, and practices, necessitating the development of new policies and procedures to support their integration. In this context, technology adoption acts as a catalyst for institutionalization, as organizations must embed new technologies into their daily operations to ensure successful integration and sustained use (Bajpai, 2021).

Given the heightened competition in today's business landscape, swift and efficient services are essential, prompting enterprises to innovate to secure long-term viability. This is particularly relevant for the maritime industry, where integrating digital processes can redefine operations and unlock additional prospects (Gabrielsen & Leptos-Bourgi, 2017).

With more than four-fifths of global merchandise trade (in terms of volume) occurring through maritime routes, maritime transportation plays a fundamental role in supporting global trade and the manufacturing supply chain. For long distances, the maritime industry

offers the most economical and dependable means of transportation (UNCTAD United Nations Conference on Trade and Development, 2019).

According to the National Economic and Social Development Council (NESDC Office of the National Economic and Social Development Council, 2022), Thailand is one of the largest maritime nations in Southeast Asia, with a coastline of over 3200 kilometers and a strategic location in the heart of the region. The country has a strong tradition of seafaring and a long history of maritime trade, which has contributed significantly to its economic growth and development. Today, Thailand is home to a large and diverse fleet of ships, owned by both domestic and international companies. According to the Thailand Board of Investment (BOI), there were 1239 Thai-owned ships registered with the country's Marine Department as of 2020. These ships had a combined gross tonnage of 7.63 million and a total value of 269 billion baht (approximately 8.5 billion USD). Of these ships, 592 were engaged in domestic trade, while the remaining 647 were involved in international trade.

According to the National Economic and Social Development Council (NESDC Office of the National Economic and Social Development Council, 2022), water freight transport shows a rising trend. In 2021, domestic water freight volumes are 111,852 thousand tons rising

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from 103,271 thousand tons in 2020, or equivalent to a 8.31 % increase, owing to import-export restrictions reduction of the trading partners and product demand increase shows in Fig. 1.

Thai shipowners are active in a wide range of sectors, including container shipping, dry bulk shipping, tanker shipping, and offshore services. In recent years, the country has seen significant growth in its offshore oil and gas industry, which has led to an increase in demand for specialized vessels such as offshore support vessels and drilling rigs. Thai shipowners have responded to this demand by investing in new vessels and upgrading their existing fleets (NESDC Office of the National Economic and Social Development Council, 2022).

According to Hellenic Shipping News Worldwide (2020), despite the challenges posed by the COVID-19 pandemic, the shipping industry has remained resilient and continues to play a vital role in the country's economy. With the ongoing digital transformation of the industry, Thai shipowners are poised to take advantage of new opportunities and enhance their competitiveness in the global marketplace (NESDC Office of the National Economic and Social Development Council, 2022; Tunnicliffe, 2020).

The maritime industry is generally considered conservative, although the degree of conservatism varies depending on the specific sector, organization size, and business culture (Wang, 2010). The industry has been somewhat resistant to change, especially in terms of technology adoption and sustainability practices. This could be attributed to slow regulatory changes and the influence of traditional business values. However, there are also examples of companies and organizations in the industry that are embracing innovation and sustainability and are modernizing their operations and adopting new technologies (Sullivan et al., 2020). These forward-thinking organizations may have an advantage in competing in the rapidly changing and highly competitive global maritime industry (Yang, 2019; Ikpogu, 2021; Gavalas, 2020; Gabrielsen & Leptos-Bourgi, 2017).

It is crucial for Thai shipowners to overcome this conservatism and embrace digital technology for several reasons:

- A. Enhanced operational efficiency: Adopting digital technology enables Thai shipowners to streamline and automate various processes, leading to increased operational efficiency. Technologies such as data analytics, automation, and Internet of Things (IoT) devices can optimize vessel performance, reduce fuel consumption, and improve maintenance planning (Sullivan et al., 2020).
- B. Competitive advantage: Embracing digital technology offers Thai shipowners a competitive edge in the global maritime industry. Companies that successfully adopt digital solutions can differentiate

themselves from competitors, attract new customers, and enhance their reputation as forward-thinking and innovative organizations.

- C. Regulation: The International Maritime Organization (IMO) plays a critical role in driving digital technology adoption among Thai shipowners. As the regulatory body for the global maritime industry, IMO sets guidelines and standards that influence strategies and initiatives of Thai shipowners. Compliance with IMO regulations is not only necessary but also strategically important for Thai shipowners to ensure operational excellence and competitiveness.
- D. Sustainability and environmental responsibility: Digital technology plays a crucial role in achieving sustainability goals in the maritime industry. By adopting technologies that enable efficient energy management, emission reduction, and environmentally friendly practices, Thai shipowners can contribute to a greener and more sustainable future (Gavalas, 2020).

Considering these factors, it is evident that the adoption of digital technology is necessary for Thai shipowners to thrive in a rapidly changing and highly competitive industry. By embracing technological advancements, shipowners can unlock numerous benefits, including operational efficiency, improved decision-making, a competitive advantage, and a commitment to sustainability.

Through this research, we aim to explore the factors influencing digital technology adoption in Thai shipowners and investigate the processes required for the institutionalization of technology within their operations. By understanding these factors, we can provide valuable insights and recommendations to support Thai shipowners in their digital transformation journey.

Despite various studies exploring the adoption of digital technology, a comprehensive investigation into digital technology adoption and its sustained implementation is lacking, particularly within the confined context of Thai shipowners. In order to address this gap, this study is among the first to blend the digital technology adoption and institutionalization framework within the maritime industry.

The structure of this paper is as follows: the next section discusses the literature review including an overview of digital technology adoption and institutionalization in the maritime industry, as well as the theoretical foundations applied to the research. The research methodology and data analysis are presented in the third and fourth sections. The next part presents the interview findings, followed by a discussion on the implications of digital technology adoption and institutionalization in Thai shipowners. Finally, a summary of the study and a discussion about future research concludes the paper.

2. Literature review

2.1. Overview of digital technology adoption and institutionalization in the maritime industry

The maritime industry has traditionally been viewed as a conservative sector, slow to embrace new technologies and changes. However, the industry is beginning to realize the potential benefits of digital technologies in enhancing efficiency, improving safety, and reducing costs (Wang, 2010; Gavalas, 2020). Despite these benefits, the adoption of digital technologies faces several challenges, including resistance to change, lack of awareness and knowledge, and regulatory barriers. Institutionalization, the process by which new technologies become integrated into organizational practices and culture, presents another major challenge (Yang, 2019; Ikpogu, 2021; Gavalas, 2020; Gabrielsen & Leptos-Bourgi, 2017).

The maritime sector faces several challenges in adopting digital technology. Firstly, there is often a lack of leadership, as management tends to take a conservative approach and resources are limited. Although technologies like Blockchain and autonomous shipping can foster digital technology adoption, many employees and managers are resistant to change and lack awareness of how digital technology can



Fig. 1. Domestic water freight volume (Thousand Tons).

positively affect the business (Bajpai, 2021; Yang, 2019; Tijan et al., 2021).

Secondly, the challenge lies in handling data utilization and ownership. Maintaining data confidentiality has gained significance, especially for functions like predictive maintenance, usage tracking, route planning, and resource management (Gavalas, 2020). However, multiple parties might have motives to withhold specific information from other business participants, leading to disputes over data ownership.

Thirdly, cyber-security is a major concern. IT-intensive activities create new security zones when plates, containers, and other items are linked. Enhanced cybersecurity measures are introduced to shield against unauthorized third-party access to crucial sensors and controllers through existing interfaces and network connections. Implementing cybersecurity measures can be intricate due to existing safety and security prerequisites and updates to pertinent regulations (Gavalas, 2020; Tijan et al., 2021).

Regulatory challenges emerge as a fourth concern. Unlike sectors such as manufacturing or retail, maritime transport operations are intertwined with global economics and politics. Furthermore, the industry's activities are governed by both national and international legislation (Zeng et al., 2020; Ikpogu, 2021).

Fifthly, International laws and conventions such as UNCLOS, SOLAS, COLREG, and MARPOL may affect the permissibility of certain technologies, particularly those used on uncrewed vehicles (Ikpogu, 2021; Tijan et al., 2021).

Finally, the lack of digital skills and a qualified labor force in the maritime transport sector. This problem is expected to worsen as new technologies require the development of new skill sets and technological expertise. To address this challenge, cooperation between universities and the corporate sector is needed, including investment in knowledge, new study and training programs, and other measures (Gavalas, 2020; Tijan et al., 2021).

Thai shipowners in the maritime industry face various challenges that affect their operations and competitiveness. These challenges include the high costs associated with vessel acquisition and maintenance, which can be a significant barrier for smaller shipowners. The shortage of skilled personnel, particularly in technology and innovation, further hampers their ability to adopt modern technology and remain competitive. Regulatory changes, such as environmental and safety standards, add to their operational costs, and failure to comply can lead to penalties. Additionally, intense competition from countries like China and Japan, with larger fleets, advanced technology, and lower labor costs, presents a challenge for Thai shipowners. To address these challenges, Thai shipowners need to invest in modern technology, develop the necessary skills, ensure compliance with regulations, and establish collaborations and partnerships within the industry (NESDC Office of the National Economic and Social Development Council, 2017; NESDC Office of the National Economic and Social Development Council, 2021; NESDC Office of the National Economic and Social Development Council, 2022).

2.2. Theoretical frameworks

2.2.1. Technology, organization, and environment (TOE) framework

The TOE framework is instrumental in examining technology adoption at the organizational level. Developed by Tornatzky and Fleischer (1990), this framework encompasses three aspects: technological context, organizational context, and environmental context.

Technological Context refers to the internal and external technologies relevant to the firm, including existing technologies and those that can be adopted.

Organizational Context involves descriptive measures about the organization, such as scope, size, and managerial structure, which can influence technology adoption decisions.

Environmental Context consists of the industry characteristics,

trading environments, regulatory framework, and government support that can impact the organization's decision-making processes.

In applying the TOE framework to the Thai maritime industry, this study focuses on how these three contexts influence the propensity of Thai shipowners to adopt digital technologies. For instance, the organizational readiness in terms of organization culture and the management's innovative orientation are scrutinized, alongside environmental factors such as maritime regulations and competitive pressures.

2.2.2. Institutional theory

Institutional Theory complements the TOE framework by offering insights into the broader social and regulatory dynamics that influence organizational behavior. According to DiMaggio and Powell (1983), organizations conform to their institutional environments through processes such as mimetic, coercive, and normative pressures, which help them gain legitimacy and increase their survival prospects.

Mimetic Pressure arises when organizations mimic the practices of other organizations, particularly those that are perceived as successful or legitimate.

Coercive Pressure stems from formal and informal pressures exerted on organizations by other organizations upon which they are dependent, including government mandates (DiMaggio & Powell, 1983).

Normative Pressure involves pressures associated with professional standards and practices that emerge from networks of professional relationships (DiMaggio & Powell, 1983).

Integrating the TOE framework with Institutional Theory allows this study to adopt a holistic view of digital technology adoption, considering both the internal capabilities and external pressures. This dual-framework approach enables an in-depth analysis of the drivers and barriers to technology adoption specific to the Thai maritime context, where traditional practices often clash with modernizing impulses dictated by global standards and competitive dynamics.

2.2.3. Model for institutionalization change

The Change institutionalization framework by Armenakis et al. (1999) is a model that describes the process of institutionalizing change in organization. It consists of three stages:

Initiation stage: In this stage, the need for change is identified, and a plan is developed for implementing the change. The key factors that influence this stage include the readiness of the organization for change, the availability of resources, and the level of support from key stakeholders (Armenakis et al., 1999; Choi, 2011).

Implementation stage: This stage involves the actual implementation of the change. Key factors that influence this stage include the level of involvement and commitment of employees, the effectiveness of communication channels, and the availability of training and development programs (Kleppe & Nortvedt, 2020).

Institutionalization stage: In this stage, the change is integrated into the organization's culture and practices. Key factors that influence this stage include the level of acceptance of the change by employees, the alignment of the change with the organization's values and goals, and the establishment of new systems and processes to support the change (Armenakis et al., 1999).

To address these challenges, the maritime industry needs to develop a strategic roadmap for digital transformation, build awareness and knowledge about the potential benefits of digital technologies, and work with regulators to overcome barriers to adoption. Organizational culture and leadership also play a key role in the institutionalization of digital technologies (Gavalas, 2020; Ikpogu, 2021; Tijan et al., 2021).

Technology adoption and institutionalization are two concepts that are closely related in the context of organizations. Technology adoption refers to the process of integrating new technologies into the organization, while institutionalization refers to the process of establishing new practices or policies as standard procedures within the organization.

The adoption of new technologies can lead to changes in the organizational structure, processes, and practices, and may require the

development of new policies and procedures to support the integration of the new technology. In this sense, technology adoption can be seen as a catalyst for institutionalization, as the organization must institutionalize the new technology to ensure its successful integration and use (Jacobs & Osman-Gani, 2004).

Once a new technology has been adopted, the organization may establish new procedures, policies, or norms to support its use and ensure its sustainability. This process of institutionalization is crucial to the successful adoption and integration of new technologies, as it helps to ensure that the new technology becomes embedded within the organizational culture and practices (Jacobs & Osman-Gani, 2004; Conner & Patterson, 1982).

Institutionalization also helps to create a sense of continuity and stability within the organization, as the new technology becomes a part of the standard operating procedures. This can lead to improved efficiency, effectiveness, and innovation within the organization, as employees become more familiar and comfortable with the new technology over time (Jacobs & Osman-Gani, 2004).

In summary, the relationship between technology adoption and institutionalization is interdependent, as successful technology adoption requires institutionalization to ensure its integration and sustainability within the organization. The institutionalization of new technologies is essential to creating a culture of innovation and continuous improvement within the organization.

3. Methodology

This exploratory study employed a qualitative approach, allowing for an in-depth exploration and understanding of the experiences, perspectives, and behaviors of individuals and organizations related to digital technology adoption and institutionalization in the maritime industry. Using in-depth interviews provide rich and detailed data that can capture nuances, complexities, and contextual factors that may not be captured by quantitative method alone (Maxwell, 2013).

Additionally, as this research aims to explore and understand the social and cultural factors that influence digital technology adoption and institutionalization in the maritime industry, the qualitative method is well-suited for this purpose. It is particularly useful for investigating subjective experiences, attitudes, and perceptions, which are important factors in understanding why some firms are more successful in adopting and institutionalizing digital technologies than others.

3.1. Data collection

The data collection process was meticulously designed to gather comprehensive insights into the factors influencing digital technology adoption and institutionalization among Thai shipowners.

3.1.1. Selection of participant/company

Executives were chosen from seven Thai shipping companies based on their strategic roles and direct involvement in decision-making processes related to digital technology. These companies were selected to represent a diverse range of operational scales and scopes within the Thai maritime industry. The following are the highlighted strengths of each selected organization:

- Company A: Holds the largest market share in bulk carrier services in Thailand and operates internationally. It is the only company in the country to have implemented simulator vessel technology and ERP over 20 years ago.
- Company B: Ranked second in market share for crew boat services in Thailand, and recently launched the nation's first electronic crew boat vessel.
- Company C: Recently merged and needs to rapidly develop technological capabilities to stay competitive such as ERP system.

- Company D: A listed oil tanker company planning to expand its fleet from domestic to international operations.
- Company E: Dominates the market for oil tanker fleets in Thailand, with advanced technology integrated into its vessels and a control room for real-time monitoring, ERP system.
- Company F: The largest container fleet in Thailand which is expanding internationally; utilized BI and ERP systems to enhance operational efficiency.
- Company G: A local oil tanker and chemical carrier company currently in the first phase of implementing new technology.

From the Thai Ship Owners Association's total of 38 companies, this research sample included 7 companies, meticulously chosen to represent the broader industry distribution: oil tankers, which make up 22 companies or 58%; bulk carriers, 3 companies or 8%; crew & supply boats, also 3 companies or 8%; and container ships, 2 companies or 5%, and encompassing a diverse range of operational scopes from large international to smaller domestic operators, with key decision-makers like CFOs and Technical Managers making up the interviewees, thereby ensuring that the findings are comprehensive, authoritative, and addressing the research objectives effectively.

In Thailand, a significant majority of ships owned by Thai ship-owners fly the Thai flag. This regulatory framework is designed to promote national registration, which helps in ensuring compliance with local maritime safety and labor laws, and supports economic strategies aimed at bolstering the national shipping industry.

3.1.2. Justification for multiple interviewees per company

Interviewing multiple individuals from each company was a deliberate methodological choice aimed at enriching the data set. This approach allowed the study to capture diverse perspectives within the same organizational context, highlighting variations in perceptions and experiences that might not be apparent from a single interviewee.

3.1.3. Interview procedure

Each interview lasted approximately 60 min and was conducted using a semi-structured format that allowed participants to express their views freely while ensuring that all relevant topics were covered.

3.1.4. Confidentiality and data integrity

To ensure the reliability and confidentiality of the information, all interviews were recorded with the participants' consent and transcribed verbatim. Transcripts were then anonymized and reviewed by the interviewees for accuracy, providing an opportunity to clarify any ambiguities and confirm the precision of the responses.

Cross-Validation: Responses from multiple participants within the same company were cross-validated to identify common themes and discrepancies. This process not only reinforced the validity of the data but also provided a richer, more nuanced understanding of the institutionalization processes and the factors influencing technology adoption. This information also was cross-referenced with the company's annual report and website.

Based on these criteria, the researcher intends to select a diverse range of case studies that represent different aspects of technology adoption in the Thai shipowner industry. Additionally, the researcher will pay special attention to the size and scale of operations, specifically targeting companies with the largest fleet or the biggest container vessels, showcasing their expertise and experience in adopting advanced technologies. The demographic profiles of the companies are summarized in Table 1.

3.2. Data analysis

The analysis focused on the narratives of adoption. All managerial replies were transcribed the day following each interview. The most recurrently mentioned factors influencing adoption were determined

Table 1

The demographic profiles of the companies.

Company ID	Business Type	Size (No. of Vessels)	Trade Scope	Listed	Key Interviewees (Roles)	Flag
A	Bulk Carrier	Large (38)	International	Yes	Training Instructor Manager, Technical Manager	Thai
B	Crew and Supply Boat	Medium (13)	Domestic	No	CFO	Thai
C	Oil Tanker	Medium (13)	Domestic & Near Coastal	No	Technical Manager, SSHEQ Manager	Thai
D	Oil Tanker	Medium (12)	Domestic	Yes	Commercial Manager	Thai
E	Oil Tanker	Large (54)	Domestic & Near Coastal	Yes	Crewing Manager, Training & Fleet Development Manager	Thai
F	Container	Large (45)	International	Yes	Fleet Manager	Thai
G	Oil Tanker and Chemical Carrier	Small (5)	Domestic & Near Coastal	No	CTO, CEO	Thai

after consistently sorting comments. Detailed analysis within cases and across cases was carried out in an iterative manner. Data was juxtaposed with existing theories, allowing the data itself to guide the analysis. Participants' responses were analyzed and program NVivo 12 of QSR International 2022 was used as a tool for analyzing data to categorize, coding, and thematic analysis.

To provide a clearer and more detailed understanding of how digital technology adoption factors are perceived by different companies within the Thai maritime industry. It incorporates a scoring system reflecting the degree of emphasis and engagement that each company has regarding various adoption factors. The revised scoring is as follows:

"+++" (High Impact): Assigned when both interviewees from a company, or even just one, indicate that the factor strongly influences their decisions to implement digital technology. This level shows that the factor is critical and has led to substantial technological integration or is central to their planned technology strategy.

"++" (Moderate Impact): Used when the factor is recognized by both interviewees, or at least one, as influencing their technology plans, with the company in the initial stages of implementation. This level indicates that the factor is steering the planning or early implementation phases, though full integration has not yet been realized.

"+" (Limited Impact): Given when only one interviewee mentions the factor, and it has minimal influence on their company's current technology implementation efforts. This level suggests that while the factor is recognized, it is not a significant driver in their technology adoption strategy.

"blank" (No Impact): Used when none of the interviewees mention the factor. This absence indicates that the factor is either not applicable or not yet recognized as relevant by the companies interviewed. Highlighting these gaps is crucial for identifying potential areas for improvement and further research.

4. Findings on digital technology adoption and institutionalization in Thai shipowners

This paper presents the findings of a study on the factors influencing digital technology adoption and institutionalization in Thai shipowners. Specifically, this study focuses on the perspective of Thai shipowners, exploring their experiences with digital technology adoption, the challenges they face, and the factors that contribute to successful adoption and institutionalization.

The combined analysis from the literature review and semi-structured interviews revealed seven factors as influencing the digital technology adoption and two factors drive institutionalization of digital technology within organizations after its initial adoption in Thai shipowners which is shown in Table 2.

4.1. Factors influencing to digital technology adoption

4.1.1. Technological factors

The TOE framework emphasizes the importance of technological factors in facilitating technology adoption and implementation within organizations. In this context, reliable IT infrastructure and the benefits perceived by the adopting firms are the key factors driving organizations to embrace and leverage technology as part of their operations.

4.1.1.1. Reliable IT infrastructure. A universally important factor for all companies, ensuring robust IT infrastructure is critical. This includes everything from stable internet connectivity to advanced data processing capabilities, particularly vital for large international operators like Company A (Bulk Carrier) and Company F (Container).

Company A emphasized, "Our investment in securing our IT infrastructure has not only protected sensitive data but also bolstered overall reliable in our digital systems."

Table 2

Summary of the digital technology adoption and institutionalization.

Factors/Company	A	B	C	D	E	F	G
Technological Factors							
• Reliable IT Infrastructure	+++	++	++	+++	+++	+++	++
• Perceived Benefits of Digital Technology							
◆ Improved organizational efficacy	+++			++	+++	+++	++
◆ Reduced operational expenses	++	+++	++	+++	++	+	+++
◆ Plan maintenance monitoring & Unplanned situation	++		+		+++	+++	
◆ Documentation	+	++	+++	++			++
Organizational Factors							
• Organizational Culture	++	+	+	++	++	+++	++
• Top Management Support	+++	+++	+++	++	+++	+++	++
• IT Skills and Support	++	++		++	+++	+++	
External Environmental Factors							
• Legal, Regulatory, and Policy requirements	++	+++	+++	++	+++	+++	++
• Social Pressure Influence	++	+++	+	+	++	+++	++
• Government Support		+	+		+++	+	+++
Institutionalization Factors							
• Organizational Rules and Policies	+++	++			++	+++	++
• Technology Trust		+++	++	++	+++	++	++

Company F's Fleet Manager highlighted, "We use real-time monitoring systems for machinery, which, despite high costs, are crucial for minimizing human errors and ensuring operational efficiency".

Whereas smaller companies such as Company G focus on adjustable solutions that suit their more focused operational areas. "For us, flexibility in technology is crucial to adapt quickly to new routes and smaller markets."

Reliable IT Infrastructure is not merely a foundational element but a critical enabler in the maritime industry. Unlike in many terrestrial industries, the maritime sector's dependency on robust IT infrastructure is elevated by the need for continuous operations across vast and often remote areas. This infrastructure supports everything from basic communications to advanced navigational systems on board, making its reliability a non-negotiable aspect of maritime operations.

4.1.1.2. Perceived benefits of digital technology. The perceived benefits can influence users' attitudes and intentions to adopt digital technology, emphasizing the importance of improved organizational efficacy, reduced operational expenses, plan maintenance monitoring and unplanned situation, and documentation which emphasizing these benefits to promote technology acceptance and adoption within organizations.

- Improved organizational efficacy.

Particularly important for large companies (e.g., Companies A, E, F) that operate on an international scale and require efficient communication systems across global networks.

When being asked about the benefits of digital tools in large companies, Company E described, "The digital tools have streamlined our operations, reducing time spent on manual processes and significantly cutting costs."

The Training Instructor Manager of Company A noted, "Implementing digital technologies has streamlined our training processes, enhancing overall efficiency."

- Reduced operational expenses

Regardless of size, all companies acknowledge cost reductions. The CTO of Company G stated that investing in IT systems has significantly cut down operational costs, particularly in maintenance and unplanned downtime. Critical for medium-sized companies (e.g., Companies B, C, D), where cost efficiencies can significantly impact competitiveness.

Company D emphasized that "Every dollar saved through technology improves our competitive edge in domestic markets."

- Plan maintenance monitoring & unplanned situation

Emphasized by companies that operate complex logistics and need robust systems to manage maintenance schedules and handle unforeseen events effectively (e.g., Companies E, F).

Company F referred that "Real-time monitoring and planning reduce the risks of sea operations, crucial for areas where immediate service is not possible."

Plan maintenance monitoring and unplanned situations are of paramount importance in the maritime sector. In contrast to typical corporate settings where equipment failures might lead to operational delays, in the maritime industry, such failures can result in severe safety hazards and substantial financial losses. This necessity is compounded by the challenges of performing repairs mid-voyage, which underscores the critical role of predictive maintenance technologies that can forecast equipment malfunctions before they occur.

- Documentation

Several companies highlighted the move towards digital documentation for regulatory compliance and operational efficiency. For example, Company C noted the significance of digital documentation, "Digital documentation has not only improved compliance but also streamlined our operations."

4.1.2. Organizational factors

The results of this study identify key organizational factors influencing digital technology adoption, specifically organizational culture, top management support, and IT skills and support. These factors align with the organizational context in the TOE framework, which encompasses the characteristics and resources of the firm that influence its ability to adopt new technologies.

4.1.2.1. Organizational culture. The adoption and effectiveness of digital technology were strongly influenced by organizational culture. Companies with a culture that embraced change and innovation, such as Company F, integrated new technologies more seamlessly and effectively. In contrast, companies with more traditional cultures encountered resistance, requiring more substantial change management efforts to align technology adoption with existing practices.

Company D focused on open-minded changes in new technology. "The most important thing is that the people in the organization must be open-minded and receptive to the changes brought about by new technologies. In this (digital) era, you have to adapt and improve yourself, otherwise you will be left behind."

4.1.2.2. Top management support. Strong, visible support from top management was critical across all companies. This support facilitated strategic alignment and resource allocation essential for successful technology adoption.

When asked about the top management's role in technology adoption, Company B explained, "The decision to adopt technology starts from the top. Our CEO's vision is crucial for pushing these changes."

Company C stated, "Our shift towards digital operations was driven by top management who championed the adoption of advanced analytics platforms."

4.1.2.3. IT skills and support. Especially crucial for companies engaged in international trade and those with large fleets (e.g., Companies A, E, F), where the complexity of operations necessitates a higher level of technical expertise and support.

Company E's Crewing Manager highlighted the importance of ongoing IT training for staff to fully leverage the benefits of new technologies.

While there is some investment in IT skills, the scale is smaller, and often external IT support is relied upon for medium and small companies.

Company D also supported that IT has an important role at the beginning of the implementation of new technology. "When we first implemented the ERP system, The team from the ERP service provider firm was very important because we started from zero. ... The implementation team provided guidance to our staff throughout the process. As time passed, our staff became more familiar with the system and to adapted to the program (ERP)."

4.1.3. External environmental factors

By exploring the relationship between the external environment, TOE framework (specifically the external context), and Institutional Theory, this research aims to shed light on the factors that shape organizations' technology adoption. It seeks to understand how external pressures, such as legal, regulatory and policy requirements, and societal pressure influence, influence organizations' decisions regarding technology adoption.

4.1.3.1. Legal, regulatory, and policy requirements. Compliance with maritime safety and environmental regulations is crucial for all companies but particularly for those involved in international trade where regulatory scrutiny is more intense. Companies engaged in international trade adhere to stringent regulations from entities like the IMO and regional authorities.

Company F emphasized compliance with higher standards, *"These requirements we have to comply strictly. The regulations in Thailand are lower than Singapore's standards. We conform Singapore's. In addition, the IMO is frequently updated. We have to forecast 1 or 2 years in advance the forecast. So that we can plan for the changes."*

Furthermore, this type of business significantly impacts regulatory compliance. Company A remarked on the specific challenges faced by certain vessels: *"Ships such as Oil Tankers or Passenger ships are subject to more regulations than Bulk carriers due to the hazardous nature of their cargo, which poses significant environmental or human risks, and whose impacts are difficult to quantify."*

Company E highlighted the regulation gained through technology, *"We regularly update our technology usage policies to reflect new safety standards and efficiency metrics, ensuring our operations remain compliant and competitive"*.

Legal, regulatory, and policy requirements in the maritime industry are significantly more complex and stringent than in many other industries. The global nature of shipping operations, crossing multiple jurisdictions, necessitates a deep understanding and adherence to a labyrinth of international, regional, and local regulations. Our findings discover the role of digital technologies in facilitating compliance with these regulations, which can vary dramatically across different waters, making regulatory technology an indispensable tool in the maritime industry.

4.1.3.2. Social pressure influence. The need to maintain competitive advantage and adhere to industry standards drives companies to adopt new technologies. This is particularly notable in large international and domestic operators (e.g., Companies A, E, F) that face significant market and social expectations to demonstrate technological leadership.

Company F highlighted the competitive advantage gained through technology, *"The ability to monitor and manage our fleet in real-time across the globe provides us with a distinct competitive edge."*

Domestic-focused companies are also influenced by societal expectations, though the scale and impact may be less intense.

Company C discussed the customer focus with the technology, *"Customer requirements serve as a significant factor in decision-making processes. However, a notable barrier within the Thai context is the absence of explicit criteria or stipulations from customers concerning technology performance benchmarks that, if met, would result in an increase in freight charges. This lack of definitive guidelines contributes to a reluctance among companies to commit to investments."*

4.1.3.3. Government support. Government support is a critical external environmental factor that can significantly influence the adoption of digital technologies within the maritime industry. This support can take various forms, including subsidies, tax incentives, or emergency supports that encourage or mandate the use of modern technologies. However, the level of government support can vary greatly between countries, affecting the pace and extent of technology adoption.

In Thailand, despite the government's broad policy initiatives aimed at transitioning to Industry 4.0, which encourage businesses to modernize operations and embrace digital transformations, specific supports for the maritime sector have been limited. Insights from industry executives reveal a nuanced landscape of governmental involvement and support.

An executive from Company E highlighted the lack of direct financial support or subsidies from the government for digital technology integration in maritime operations, *"The primary agencies responsible for maritime business, the Ministry of Transport and the Marine Department, currently offer no budget or support for digital advancements. Instead, the focus seems to be on encouraging policy adherence rather than actual financial or technical assistance."*

Contrastingly, the experience in Singapore, as mentioned by an executive from Company G, demonstrates a more proactive governmental

stance. They described how the Singaporean government not only fosters an environment conducive to maritime business but also actively supports technological investment and innovation, ensuring that maritime companies can easily comply with regulations without the burden of upfront tax payments, *"The Singaporean government promotes investment in the maritime industry. You don't have to pay taxes upfront and then reclaim them. If you're promoted, you just report your tax number, and everything is handled by the government, making it easier for us to do business. Additionally, the government is ready to assist and resolve issues whenever our ships encounter unexpected incidents at sea, which is a stark contrast to the situation in Thailand."*

The disparity in government support between Thailand and its neighbors highlights a significant external barrier to digital technology adoption. Thai shipowners find themselves in a challenging position, needing to innovate without the substantial governmental backing their international peers might enjoy. This lack of support could slow the pace at which digital technologies are adopted and fully integrated into the Thai maritime sector.

4.2. Factors influencing the drive of digital technology institutionalization

4.2.1. Organizational rules and policies

Larger companies, such as Companies A, E, and F, have developed comprehensive policies and guidelines to support the sustained use of digital technologies. These policies cover aspects such as regular maintenance, user training, and compliance with international standards. For example, Company A has established detailed procedures for technology use and maintenance to ensure long-term benefits. *"Our detailed policies around technology use ensure that these systems are an integral part of our workflow, not just temporary fixes."*

Company F stated, *"Every 3 months, there is a management review to see what improvements has been done and finding the root cause of the problems."*

Medium and small companies are in the process of formalizing their policies related to digital technology use. These companies are focusing on creating frameworks that align with their specific operational needs.

Company B noted the importance of top management support and clear communication, *"Our company had a town hall meeting that discussed on how to move forward with technologies, what KPIs will be used, what changes are required and the expected outcomes."*

In contrast, policies becoming ineffectual if not regularly monitored. As highlighted by Company C, *"Executives establish policies that include both rewards and penalties; however, they infrequently monitor the implementation and effectiveness of these policies. As a result, when reviewed and found to be ineffective, these policies often require modification, a cycle that occurs frequently."*

4.2.2. Technology trust

Trust in technology is higher in oil tanker (Company C, D, E) and crew boat (Company B) which poses significant environmental or human risks, and whose impacts are difficult to quantify. in reliable and proven systems.

Company E's Crewing Manager highlighted the trust in technological systems, *"We have built a strong trust in our technological systems, which has been essential for achieving operational excellence"*.

The CFO of Company B explained the approach to building trust, *"We focus on demonstrating the reliability and benefits of new technologies to all passengers to gain their trust and support"*.

Company A holds a differing opinion regarding the trust of technology, *"I believe that the technology we adopt does not need to be flawless, especially in terms of cybersecurity vulnerabilities. Achieving such a level of perfection is not only unrealistic but also unnecessary. In terms of cybersecurity, it is incumbent upon the users to exercise caution. It is unrealistic to expect that the systems employed on ships will be without any flaws."*

Institutionalization refers to the integration and acceptance of technology within society, organizations, or specific sectors. When trust

and confidence in technology are established through effective data privacy and security policies, it becomes easier for technology to become an established and accepted part of institutional frameworks, regulations, and practices.

5. Discussion findings and implication

This study's findings have revealed technology adoption, challenges related to institutionalization, and opportunities for theoretical application. These insights are essential for improving industry performance, fostering economic growth, and promoting development. The significance of this study lies in its contribution to theory, as it sheds light on the adoption of technology among Thai shipowners. By addressing these findings, policymakers and industry stakeholders can enhance their understanding and take proactive measures to overcome the challenges and leverage technology for national sustainable development.

5.1. Theoretical implications

The study provides a theoretical contribution within the area of digital technology adoption and institutionalization by using insights from previous literature to enrich this emerging topic in the maritime industry.

Firstly, the study findings share the same view other which highlighted the importance factors to digital technology adoption in maritime industry (Gavalas, 2020; Ikpogu, 2021), likely technological infrastructure, organizational culture, regulatory requirements, IT skills and IT support which can positively influence willingness to digital technology adoption. In addition, top management needs to not only announce the policy but also consider its allocation of resources, the integration of services, and the restructuring of business processes (Al Shaar et al., 2015).

Secondly, the study contributes to the theory by adding more insights into the essential factors. The perceived benefits of reduced operational expenses, streamlined maintenance monitoring, and enhanced documentation are likely to positively influence users' attitudes toward digital technology. According to the TAM, a positive attitude toward technology adoption is a result of the perceived benefits associated with its use (Davis, 1989; Wiafe et al., 2019). Organizations that emphasize and communicate these benefits effectively can shape users' attitudes, leading to greater acceptance and adoption of digital technology (Davis, 1989).

Another contribution to the digital technology adoption concept in Thai shipowners is the finding of social pressure influence. This finding aligns with Institutional Theory and its mechanisms of mimetic, coercive, and normative pressures. The finding emphasizes that organizations are influenced by societal expectations and pressures to adopt digital technology, driven by the desire to enhance reputation and competitiveness. By understanding these pressures, organizations can navigate the social landscape and strategically adopt digital technology to conform to prevailing norms, gain legitimacy, and meet stakeholders' expectations.

Fourthly, the maritime regulatory and policy environment and government support places a high emphasis on ensuring the safety of crew members and cargo during maritime operations. This finding is consistent with the Nigeria maritime industry context (Ikpogu, 2021) that the policy changes have the potential to create a conducive environment for industry stakeholders to invest in technology, leading to improved industry performance and a more sustainable future. Contrastingly, lack of clear direction and support from the government are among the barriers to technology adoption.

Fifthly, trust plays a crucial role in encouraging continuous technology use. According to Lippert and Davis (2006), when users trust a technology or platform, they are more likely to engage with it over the long term, adopt new features, and share positive experiences with others. This paper proposed that trust minimizes uncertainties and fears

associated with data privacy and security onboard, making users feel more comfortable and confident in their interactions.

Moreover, the Commitment-Trust Theory, developed by David Gefen in 1997, focuses on the relationship between commitment and trust in the context of technology adoption. Applied to the domain of continuous change, this theory suggests that trust and commitment are closely linked. As individuals trust the change process and those leading it, they become more committed to adapting and contributing to the change effort. This commitment further enhances their trust, creating a positive feedback loop that encourages ongoing participation and adaptability in the face of change.

Finally, to our knowledge, this is the first study to investigate the factors of technology adoption and the drive for institutionalization, thus, it addresses a significant gap in the existing literature. By filling this void, our study provides valuable insights and a solid foundation for future research endeavors, paving the way for a deeper understanding of the complex dynamics involved in technology implementation within organizations.

5.2. Practical implications

Thailand's maritime industry, while growing and modernizing, may still be in the earlier stages of digital technology adoption compared to leading shipping nations like those in Scandinavia, Singapore, or South Korea. These countries often have high levels of technology integration, significant investments in research and development, and strong governmental support for digital innovation. Factors influencing these differences could include the level of technological infrastructure, regulatory environments, and the availability of skilled workforce trained in new technologies. Thailand might face unique challenges such as a need for more substantial investment in digital infrastructure or more proactive policies to encourage digital transformation in its maritime sector.

Reference to advanced technologies from developed markets, Thai shipowners should look towards companies in technologically advanced maritime nations, as discussed by Tijan et al. (2021), which have shown significant operational efficiencies and competitive advantages through digital transformation. For instance, leveraging case studies from countries like Singapore or the Netherlands could help Thai shipowners understand how integrated digital operations and data analytics have streamlined operations and reduced costs.

The study by Ikpogu et al. about Nigeria provides insights into overcoming barriers such as organizational inertia and the lack of technical skills. Thai shipowners can adopt change management frameworks and skills development initiatives that have been successful in similar contexts. Establishing training partnerships with technology providers or maritime academies to enhance the digital capabilities of their workforce is a strategic move.

Drawing from the findings of Gavalas et al. on the adoption of ICT technologies in Greece, Thai shipowners can evaluate the benefits of strategic ICT implementation that not only supports compliance with international regulations but also drives efficiency. Exploring technologies like IoT for fleet management or blockchain for secure and transparent supply chain operations, which have been successfully adopted in European maritime operations, could be beneficial.

By studying how companies in regions with stringent regulations handle compliance through technology, Thai shipowners can proactively adjust to upcoming international maritime laws. Following the European model, investing in environmental monitoring technologies could prepare Thai companies for stricter global emissions regulations ahead of enforcement.

Emphasizing the need for a cultural shift towards innovation and technology in the maritime sector, Thai shipowners can take cues from successful organizational transformations highlighted in these studies. Encouraging a culture that values continuous improvement and technological advancement can facilitate smoother adoption of new

technologies.

The maritime community must boost technology literacy, particularly for smaller operators, by providing affordable technological solutions and establishing mentorship programs with larger entities. Promoting a culture of innovation through community-driven technology hubs and organizing challenges and competitions will foster creative solutions and active participation in the industry's technological evolution.

Policymakers are urged to develop regulatory frameworks that not only update safety and environmental standards to accommodate new digital technologies but also provide fiscal incentives such as tax breaks and subsidies for maritime companies investing in digital advancements. Robust cybersecurity standards are essential to protect the industry against digital threats and ensure a secure transition to digital operations.

Digital technology adoption varies significantly with vessel size, which often dictates the technological, operational, and financial capacities of shipowners. Larger vessels, typically engaged in international trade, tend to have more robust IT infrastructure and a higher propensity to integrate advanced digital solutions such as IoT and AI for navigation and operational efficiency. Conversely, smaller vessels, often limited to domestic or near-coastal trade, face challenges due to limited resources and lesser exposure to competitive pressures. This highlights the need for customized digital transformation strategies tailored to the specific challenges and opportunities presented by the size and type of the fleet. In addition, the type of business—whether oil tanker, bulk carrier, or container ship—also significantly influences technology adoption. For example, oil tankers and passenger ships, which carry goods and passengers that pose significant environmental or human risks, face more stringent regulatory demands. This necessitates more sophisticated technological solutions to ensure compliance and safety, thereby accelerating technology adoption in these sectors. In contrast, bulk carriers might not face such intense regulatory scrutiny.

6. Conclusion

This exploratory study has significantly enriched our understanding of digital technology adoption and its institutionalization within the Thai maritime industry, which is pivotal to Thailand's economic stability and growth. By synthesizing qualitative insights from industry executives, this research delineates a comprehensive framework of technological, organizational, and external factors that shape digital technology adoption and institutionalization practices among Thai shipowners.

The study identified eight critical factors influencing digital technology adoption: reliable IT infrastructure, perceived benefits of digital technology, organizational culture, top management support, IT skills and support, the regulatory environment, social pressure, and government support. These factors underscore the intricate interplay between internal capabilities and external pressures, highlighting the necessity for a strategic approach to harness technology for organizational and operational optimization.

Moreover, the research highlights two pivotal factors essential for the institutionalization of digital technology: the establishment of organizational rules and policies, and the cultivation of technology trust.

For Thai shipowners and industry stakeholders, the study provides actionable recommendations to effectively navigate the landscape of digital transformation by adoption of technology tailored to scale, strategic leadership and innovation culture, enhancing IT capabilities, navigating regulatory compliance, and advocacy for government support.

This study provides foundational insights and opens several avenues for future research, including employing quantitative methods to test the relationships between identified factors and technology adoption rates across a broader maritime sample, expanding to include other stakeholders such as ports, logistics providers, and shipbuilding facilities

for a holistic view of digital transformation, and conducting longitudinal studies to evaluate the long-term impacts of digital technology adoption and institutionalization on sustainability and practice evolution.

In summary, the successful adoption and institutionalization of digital technology are imperative for enhancing the competitiveness and sustainability of the Thai maritime industry. This study not only enriches the existing body of knowledge but also provides practical frameworks and recommendations that can be implemented by Thai shipowners to navigate the complex dynamics of digital transformation effectively. By addressing the challenges and leveraging the opportunities identified, stakeholders can ensure that the maritime sector remains robust and responsive in the face of evolving technological landscapes, thereby contributing significantly to the national and global economy.

CRedit authorship contribution statement

Atcharaporn Janmethakulwat: Conceptualization, Data curation, Formal analysis, Project administration, Validation, Writing – original draft, Writing – review & editing. **Bundit Thanasopon:** Supervision, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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