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Extending the TOE Framework with Knowledge Transfer to Enhance Sustainable Supplier Performance in the Oman Maritime Logistics Sector

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Abstract. This research examined the relationships among digital transformation adoption (DTA), knowledge transfer, and sustainable supplier performance (SSP) in the Omani marine industry. The study evaluated organisational, technical, environmental, and regulatory competencies as essential for adopting digital transformation, recognising its growing importance for competitiveness. Data were collected via a structured survey, and both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to validate the study instrument. The EFA findings confirmed a clear factorial structure, with DTA statements distributed across four distinct dimensions, while knowledge transfer and SSP were assessed as single, cohesive constructs. High factor loadings and the total variance explained further supported the instrument's reliability. The CFA also affirmed construct, convergent, and discriminant validity, confirming consistent assessment of each variable. Composite reliability (CR) and average variance extracted (AVE) values exceeded the required thresholds, indicating robust dependability and consistency. Descriptive statistics showed modest response levels with high standard deviations, indicating varied opinions. The report highlights ongoing digital transformation and partnerships, but disparities remain across institutions. Results offer key insights for policymakers, regulators, and organisations aiming to improve digital integration, knowledge sharing, and supplier performance in the marine sector.

Keywords: Digital Transformation Adoption, Sustainable Supplier Performance, Exploratory Factor Analysis, Confirmatory Factor Analysis

1. Introduction

The global shipping sector has experienced a rapid transition due to technological advancements, competitive challenges, and environmental mandates (Mba, 2024; Melnyk et al., 2023). Digital transformation is essential for companies to maintain competitiveness in a more connected and unstable global economy (Suntsova, 2024). The Technology-Organisation-Environment (TOE) paradigm has become a prominent theoretical perspective for understanding how organisations acquire and use new technologies (Amini & Jahanbakhsh Javid, 2023). However, there is increasing recognition that knowledge transfer procedures are crucial in ascertaining if adoption initiatives result in measurable partnership performance. Oman's shipping industry, strategically situated along vital global maritime routes, has significantly invested in improving its ports, shipping infrastructure, and logistical capabilities to establish itself as a regional maritime center (Khalid & Al-Mamery, 2019; Sanni, 2025b, 2025c). Nevertheless, the nation's shipping industry is susceptible to the challenges posed by digital innovation and international competitiveness (Quitzau et al., 2018). Industry companies are increasingly required to use sophisticated digital technologies, including blockchain logistics platforms, artificial intelligence in vessel management, cloud-based documentation systems, and predictive analytics for supply chain optimisation (Iqbal et al., 2025; Wong et al., 2021). However, this adoption presents several obstacles, including organisational preparedness, financial frameworks, environmental legislation, and institutional backing (Islam et al., 2023; Owusu-Berko, 2025). In this context, both local and international collaborations have become essential mechanisms for improving competitiveness and maintaining development (Lusha, 2024). Strategic alliances help Omani shipping companies access new markets, distribute risks, and use technical proficiency that may be lacking domestically (Sanni, 2025a). The effectiveness of these collaborations is largely contingent upon the efficient adoption and integration of digital transformation inside organisational processes. Figure 1 depicts the conceptual framework illustrating how TOE elements influence the adoption of digital transformation in Oman's shipping sector, with knowledge transfer mitigating their effect on partnership performance. Technological considerations, including infrastructure, compatibility, and complexity, affect adoption readiness. Organisational elements, including leadership endorsement, resources, and culture, influence internal capabilities, whilst environmental variables such as rules, market pressures, and competition serve as external motivators. The transmission of knowledge via sharing, absorption, and application improves the efficacy of these elements, guaranteeing that implemented technologies are successfully used within strategic partnerships. Ultimately, effective integration results in enhanced partnership performance, shown by efficiency improvements, value co-creation, and long-term sustainability. This approach emphasizes that digital adoption is inadequate without robust knowledge transfer systems.

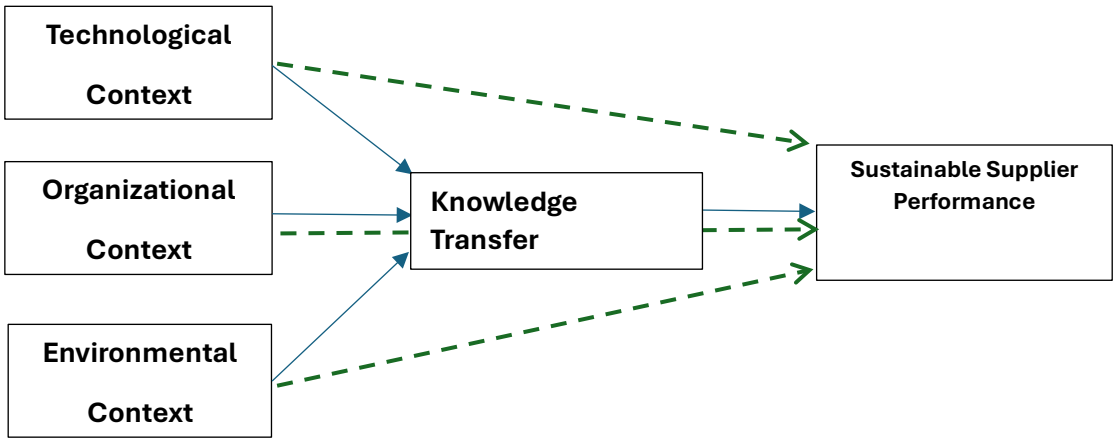

Fig.1: Conceptual Framework: Extending the TOE Framework with Knowledge Transfer for Partnership Performance in Oman's Shipping Industry

The TOE framework provides a systematic approach to analysing digital adoption across three fundamental dimensions: technological competence, organisational preparedness, and environmental pressure (Al Hadwer et al., 2021; Satyro et al., 2024). Each of these factors is particularly pertinent to the Omani maritime sector. Technological competence refers to a firm's ability to integrate modern technology into current operations, supported by adequate infrastructure and experience (Lei, 2000; Pérez-López & Alegre, 2012). Organisational preparedness emphasises leadership commitment, human capital, and financial resources, all of which influence adoption (Niguse et al., 2025; Nordin, 2012). Environmental pressure highlights the influence of regulatory frameworks, competitive intensity, and international shipping standards. The interplay among digital transformation, partnership efficacy, and knowledge transfer is especially significant for Oman, given the nation's aspirations to diversify its economy beyond oil dependence (Al-Hajri et al., 2024; Al Zuheimi, 2025). Maritime logistics and shipping are recognised as pivotal areas for promoting diversification, attracting foreign investment, and enhancing regional connectivity (Liang & Liu, 2020). The efficacy of these initiatives will depend on enterprises' ability to establish robust transactional and knowledge-based relationships (Alguezaui & Filieri, 2014). This research seeks to enhance the TOE framework by including knowledge transfer as a moderating variable, offering practical insights for policymakers, industry leaders, and stakeholders aiming to maximise digital transformation efforts in the shipping industry.

The literature on supply chain logistics increasingly emphasises resilience as a strategic capability for withstanding and recovering from disruptions. Prior studies have examined buffers, redundancy, flexibility, and collaboration as key resilience levers in logistics networks. Building on this, Al-Qasimi et al. (2024a) review mitigation strategies across a wide range of logistics settings and categorise resilience practices into risk identification, disruption mitigation, and recovery enhancement. Their findings show that digital technologies and information-sharing platforms are central enablers of visibility, coordination, and rapid response in resilient logistics systems, yet empirical evidence remains limited in specific sectors, such as maritime logistics in emerging economies. Rising costs associated with digital adoption in Oman's shipping industry require organisations to demonstrate performance outcomes. The growing importance of international cooperation in marine logistics requires mutual confidence and the exchange of expertise. Regulatory challenges concerning environmental sustainability, safety, and digital compliance also demand swift change. Knowledge transfer is a crucial moderating element, enabling Omani enterprises to overcome hurdles and achieve enhanced partnership outcomes (Al-Qasimi et al., 2024b). Partnership performance involves the capacity of organisations to generate value, increase efficiency, and maintain competitiveness. Digital transformation, facilitated by efficient information transfer, is expected to enhance these outcomes by enabling real-time communication, cohesive decision-making, and data-driven innovation. The incorporation of knowledge transfer within the TOE framework signifies a theoretical progression and a practical need for the Omani maritime sector. The study highlights the transformational potential of digital adoption in Oman's strategic economic objectives, particularly when integrated with effective knowledge transfer methods. The research aims to elucidate how shipping companies in Oman can manage digital transformation and partnership administration within a global, knowledge-driven sector. This perspective enhances scholarly discussions and offers practical suggestions for industry executives aiming to boost the competitiveness of Oman's shipping industry in the digital age.

2. Methodology

2.1. Research Design

This study used a descriptive research approach, deemed appropriate for examining and assessing existing occurrences within their natural setting. According to (Darwish, 2018), descriptive research focuses on analysing a phenomenon inside a specified group, in a specific place, and at a certain moment in time (Nassaji, 2015). This method does not seek to change variables; instead, it prioritizes methodical

observation, interpretation, and analysis to attain explicit goals. This strategy enabled the research to provide a comprehensive and precise grasp of the investigated topics while preserving a robust connection between theory and empirical data. The research used two key kinds of data sources to guarantee the correctness and reliability of its findings: primary and secondary data.

Principal Sources: The primary instrument for collecting primary data was the questionnaire, meticulously crafted to elicit participants' perspectives, attitudes, and experiences (Alordiah & Ossai, 2023; Waghmare et al., 2024). This instrument provided the researcher with the means to get original data directly from respondents, so assuring alignment with the study aims (Oben, 2021). Furthermore, using a questionnaire facilitated the validation of replies by systematic and uniform inquiries, resulting in more accurate findings. This kind of data gathering is especially beneficial in descriptive research, since it offers new information based on the actual experiences of participants. Secondary Sources: In addition to main data, the research extensively used secondary sources to reinforce its theoretical framework. These included published books, scholarly publications in Arabic and English, official academic rules, and prior research works pertinent to the issue. Emphasis was placed on using reputable and current sources to substantiate the discussion's legitimacy. Additionally, dependable electronic databases and digital resources were used, providing a comprehensive viewpoint and facilitating the triangulation of results. The combination of these two sources resulted in a balanced and thorough research strategy that effectively addressed the research challenge with depth and rigour.

2.2. Study Population and Sampling

The target demographic of this research comprises all personnel engaged in logistics institutions in the Sultanate of Oman. This group was selected since it embodies the essential workforce directly involved in the activities, operations, and decision-making processes that influence the logistics industry. The research emphasizes personnel at all organizational levels to ensure its conclusions capture the many viewpoints, experiences, and difficulties present in this crucial business. The research used a two-stage sampling process to ensure reliability and validity. Pilot Investigation (Mukhopadhyay, 2005): Prior to administering the questionnaire to the primary sample, a pilot test was conducted with a cohort of thirty (30) persons from the research population. This step aimed to evaluate the clarity, accuracy, and relevance of the instrument, ensuring its capability to properly measure the required variables. Statistical analyses were conducted to validate the tool's dependability. Cronbach’s alpha coefficient was computed to evaluate the internal consistency of the questionnaire questions, confirming that they yielded consistent and coherent replies (Hajjar, 2018; Izah et al., 2023; Vaske et al., 2017). The Pearson correlation coefficient was used to assess the link between individual claims and the theoretical aspects they were intended to represent. The studies' findings validated that the instrument exhibited satisfactory levels of validity and reliability for use in the primary research (Cook & Beckman, 2006; Markus & Borsboom, 2024).

Sampling Frame and Method: Upon validating the appropriateness of the instrument, the questionnaire was disseminated to the main research sample (Gunawan et al., 2021). The sample frame consisted of personnel from logistics institutions who fulfilled the requirements for inclusion in the study population. A simple random sampling technique was used to choose participants. This methodology was used to reduce bias, provide equitable selection opportunities for all population members, and improve the generalizability of the findings. The study sample was meticulously crafted to provide robust, reliable, and representative data, facilitating the researcher in achieving the specified goals and efficiently addressing the research questions.

2.3. Unit of Analysis

The unit of analysis in this study comprises persons, since the researcher gathered data directly from those with pertinent information and expertise about the research issue (Moser & Korstjens, 2018). The survey aims to gather participants' perspectives, attitudes, and insights about strategic alliances,

knowledge transfer, and digital transformation inside enterprises. The technique yields analyses that closely align with first-hand viewpoints, which were further generalised to draw overarching conclusions about organisational practices and outcomes.

2.4. Data Collection

To align with the study's objectives, which aimed to investigate the adoption of digital transformation and its effects on the performance of strategic partnerships in the maritime transport sector of the Sultanate of Oman, the researcher developed a structured questionnaire as the primary data collection instrument. The selection of a questionnaire was justified after a thorough examination of theoretical literature and prior empirical research concerning digital transformation, strategic alliances, and the Technology Organisation–Environment (TOE) framework. This approach was deemed the most appropriate since it facilitates the systematic gathering of measurable data from a wide proportion of the research population, hence assuring objectivity, uniformity, and efficiency. The development of the questionnaire adhered to a meticulous procedure. Utilizing pertinent academic sources and prior studies, the researcher delineated the principal dimensions and axes that correspond with the TOE framework and the setting of the marine transport sector. Each axis denoted a main construct of the research, including technology preparedness, organizational capacities, environmental challenges, and partnership performance. In these areas, specific sentences were crafted to encapsulate respondents' beliefs, attitudes, and behaviors about digital transformation. Efforts were made to guarantee that each statement was clear, succinct, and devoid of ambiguity, thus enabling precise replies.

Upon finalization of the dimensions and their respective statements, the questionnaire was divided into coherent parts. Each part started with overarching guidelines and preliminary comments to assist responders in delivering accurate and truthful responses. A five-point Likert scale was used to assess the level of agreement or disagreement with each statement, facilitating a detailed examination of the data. The instrument's organized design facilitated statistical analysis and comparison of answers, yielding substantial data to address the study concerns. The methodical design made the questionnaire a credible and valid instrument for gathering significant data to evaluate the correlation between digital transformation and strategic partnership success in Oman’s marine transport industry.

3. Result and Discussion

3.1. Descriptive Statistics for Study Variables (Digital Transformation)

To assess the degree of digital transformation in the marine transport industry, the means and standard deviations of the respondents' views were computed for each dimension of the first axis, Digital Transformation (Table 1). The research offers significant insights into the prioritization and perception of several elements of digital transformation among workers in logistics organizations (Purwanto et al., 2023). The findings reveal that the mean score for the aspects of digital transformation was 2.78, with a standard deviation of 1.118, indicating a modest level of reaction. This study indicates that, while digital transformation methods exist to a degree, they have not yet reached a sophisticated or highly integrated level across the sector. Adoption remains incomplete, with differing levels of focus on the many variables being examined (Jardak & Ben Hamad, 2022). Of the four dimensions, the Regulation’s Competence achieved the highest ranking, with an arithmetic mean of 2.95 and a standard deviation of 1.311, categorising it inside the moderate response range (Figure 2). This result underscores the significance of legal frameworks in facilitating or hindering digital change. Employees acknowledge that robust and proficient laws are essential in influencing the speed and efficacy of digital adoption, especially in heavily regulated sectors like marine transport.

Table 1: Arithmetic means and standard deviations of sample members' responses to the dimensions of the first axis: Digital Transformation.

Ser.	Dimensions of the first axis	Arithmetic means	standard deviation	Rank	Response degree
1	First Dimension: Technological Competence	2.71	1.324	3	Moderate
2	Second Dimension: Organizational Competence	2.73	1.513	2	Moderate
3	Third Dimension: Environmental Competence	2.71	1.399	4	Moderate
4	Fourth Dimension: Regulation's Competence	2.95	1.311	1	Moderate
	Overall average	2.78	1.118	-----	Moderate

The Organizational Competence component subsequently recorded a mean score of 2.73 and a standard deviation of 1.513. This signifies that firms are advancing in cultivating internal capabilities, including skills, infrastructure, and leadership dedication to support digital projects. The intermediate score indicates that significant improvements in organizational preparedness are necessary for complete digital integration (Kyongo, 2016; Magolama, 2024). The Technological Competence dimension was placed third, with an arithmetic mean of 2.71 and a standard deviation of 1.324 (Figure 2). This outcome indicates that while technology resources exist, their implementation and efficient use are still constrained (Wedege, 2000). Obstacles such as expense, technical expertise, and system integration may influence this moderate assessment. The Environmental Competence component was ranked the lowest, with a mean of 2.71 and a standard deviation of 1.399, categorized as moderate. This suggests that external issues, including market preparedness, industry competitiveness, and stakeholder pressure, are seen as less significant or less advanced relative to the other dimensions. The findings indicate that digital transformation within the marine transport industry is advancing, but at a measured rate. Regulatory frameworks seem to be the predominant catalyst, although organizational, technical, and environmental elements want considerable enhancement to attain elevated levels of digital maturity.

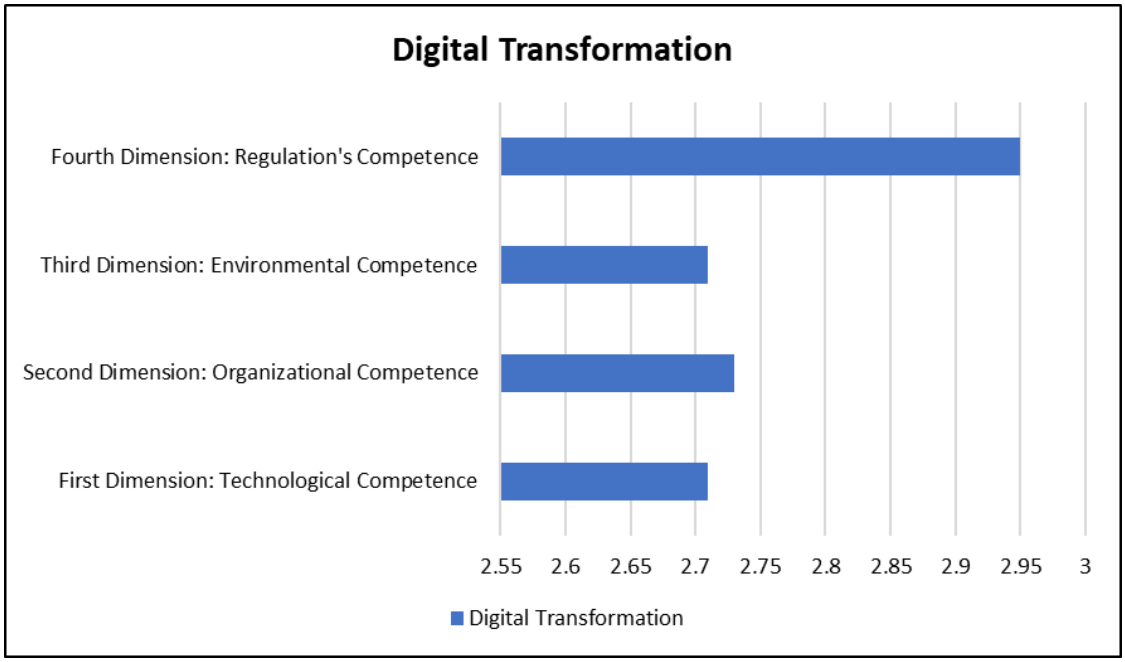

Fig.2: The arithmetic means of the sample members' responses regarding Digital Transformation.

3.2. Technological Competence

The findings presented in Table 2 and Figure 3 provide a clear view of how the study sample perceives the level of technological competence within the organization, particularly in the area of maritime transport and shipping operations. The overall arithmetic means of the first dimension, Technological Competence, was reported as 2.71 with a standard deviation of 1.324, reflecting a moderate response score. This suggests that the organization demonstrates a reasonable level of reliance on technology, but that the current systems and practices fall short of being perceived as highly advanced or strongly aligned with best practices in technological adoption. Table 2 highlights the ranking of individual statements within the first dimension, offering insight into which technological practices are relatively more emphasized, and which remain weaker. The leading item, Statement No. (6), "The organization relies on reliable technologies in managing maritime transport and shipping operations," achieved the highest mean (2.85) with a standard deviation of (1.449). Although this is the strongest statement in the dimension, the score still falls within the "moderate" range, implying that while technologies are considered reliable to some extent, they may not fully meet the demands of modern maritime logistics and operational complexity.

Statement No. (5), which addressed the maintenance and updating of hardware and software, ranked second with a mean of 2.78 and a higher standard deviation (1.530). This result indicates that, although maintenance practices are somewhat evident, they may not be systematic or consistent across the organization. The wide spread of responses also suggests varied experiences among respondents, perhaps due to differences in departmental practices or unequal access to technological support.

Table 2: Frequencies, percentages, arithmetic means, and standard deviations of sample members' responses to the first dimension: Technological Competence

Ser.	Statements	**Response score**						**Means**	**SD**	**Rank**	**Response Degree**
			Strongly agree	**agree**	**neutral**	**disagree**	**Strongly agree**				
1	The organization has the technical infrastructure necessary to support digital transformation.	F	65	69	38	104	94	2.75	1.459	3	Moderate
		%	17.6	18.6	10.3	28.1	25.4				
2	The digital systems used in the organization are in line with technological developments.	F	49	61	41	88	131	2.48	1.445	6	Low
		%	13.2	16.5	11.1	23.8	35.4				
3	The organization provides specialized technical support to ensure the	F	63	68	37	91	111	2.68	1.488	5	Moderate
		%	17.0	18.4	10.0	24.6	30.0				

	continuity of digital systems.										
4	The organization has the ability to integrate modern technologies such as artificial intelligence into operational processes.	F	68	67	41	79	115	2.71	1.516	4	Moderate
		%	18.4	18.1	11.1	21.4	31.1				
5	Hardware and software are regularly maintained and updated to support operational efficiency.	F	75	67	37	83	108	2.78	1.530	2	Moderate
		%	20.3	18.1	10.0	22.4	29.2				
6	The organization relies on reliable technologies in managing maritime transport and shipping operations.	F	69	75	37	108	81	2.85	1.449	1	Moderate
		%	18.6	20.3	10.0	29.2	21.9				
Overall average								2.71	1.324	Moderate	

The weakest performance was seen in Statement No. (2), which examined the alignment of the organization's digital systems with contemporary technological advancements. This statement had the lowest mean score of 2.48, with a standard deviation of 1.445, indicating a "low" reaction rating. This study highlights a significant deficiency: the organization's technology infrastructure is not seen as advancing in alignment with the fast progress in marine digitalization, including automation, artificial intelligence, and blockchain-based solutions that are progressively transforming the industry. The standard deviations for the assertions varied from 1.445 to 1.530, indicating somewhat high values. This statistical distribution underscores notable disparities in opinion across the sample, indicating that some respondents may get greater amounts of technical help than their counterparts. This variety may be ascribed to organizational silos, disparities in regional infrastructure, or uneven use of digital technologies. Figure 3, which visualizes the arithmetic means of the sample responses, reinforces the results displayed in Table 2. The graphical representation allows for a clearer comparison of how each statement stands relative to the overall average. The moderate clustering of means around the overall score of 2.71 reflects a consistent but lukewarm perception of technological competence. The figure also visually underscores the notable underperformance of Statement No. (2), highlighting the concern that technological upgrades and alignment with external developments lag.

The findings include several implications. The modest overall mean suggests that the organization operates with a fundamental but inadequate level of technical assistance. In sectors like sea transport,

where efficiency, safety, and competitiveness are significantly dependent on technological technology, a modest score may indicate susceptibility to operational inefficiencies or competitive disadvantages. The variation in replies indicates inconsistent access to or use of technology throughout the firm, perhaps resulting in internal inefficiencies and employee discontent.

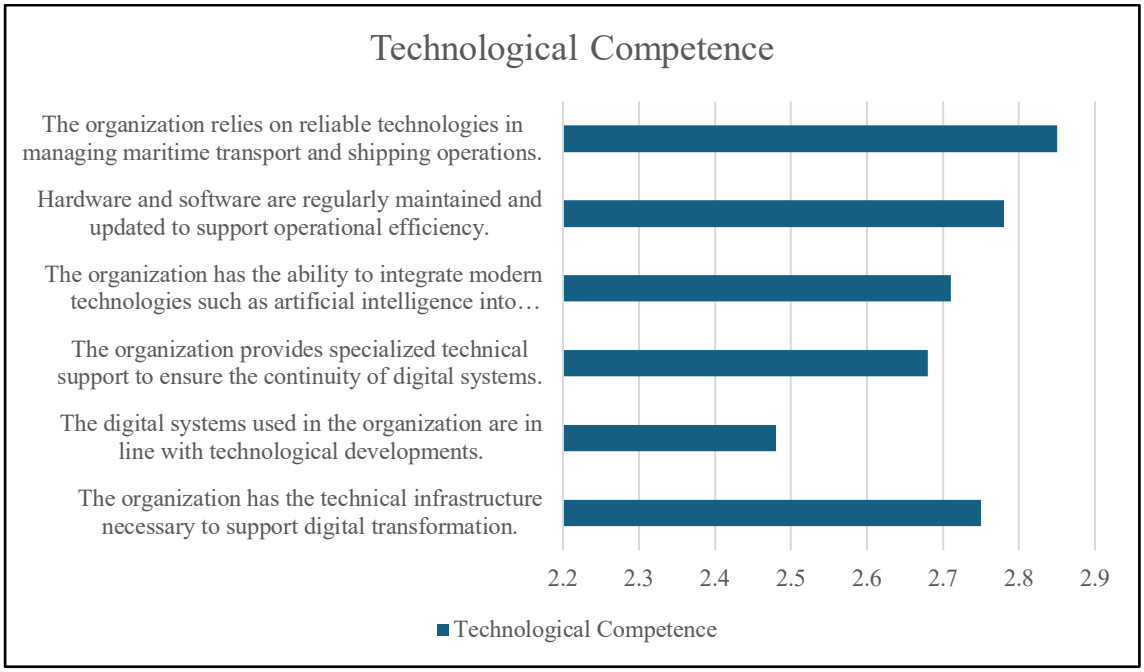

Fig.3: shows the arithmetic means of the sample members' responses regarding Technological Competence.

The poor score in technical advancement indicates an urgent need for strategic investment in innovation and digital transformation. Global maritime enterprises are swiftly embracing smart technology, predictive analytics, and digital platforms to enhance supply chain management. The company risks falling behind if it does not rectify this deficiency. In summary, Table 2 presents comprehensive evidence of relative strengths and weaknesses within the dimension, while Figure 3 graphically underscores the moderate although uneven judgments of technical competence. Collectively, they underscore both the limited results and the critical areas necessitating improvement to attain a greater degree of digital readiness.

3.3. Organizational Competence

The findings of the second factor, Organizational Competence, provide a crucial insight into the internal capacities of the business in facilitating digital transformation. The arithmetic mean was recorded as 2.73, with a standard deviation of 1.513, indicating a moderate reaction score. This conclusion indicates that the business exhibits a moderate degree of proficiency in planning, resourcing, and coordinating digital transformation; nevertheless, the findings also uncover substantial difficulties that might impede sustainable digital progress. Table 3 delineates the comprehensive rating of statements within this dimension. The statement with the highest rating was No. (12): “The organization adopts clear strategic plans to implement digital transformation,” which attained an arithmetic mean of 2.82 and a standard deviation of 1.507. This suggests that strategic planning is seen as more developed than other facets of organizational competency. Nonetheless, the score remains moderate, indicating that while strategic frameworks are there, they may lack comprehensiveness, actionability, or uniform implementation across all departments.

The item ranked second highest was No. (11): "Adequate budget is allocated to support digital transformation projects within the organization," with a mean of 2.79 and a standard deviation of 1.586. This score indicates that financial resources are somewhat accessible but may be inadequate for comprehensive digital adoption. The significant variance in replies indicates an unfair allocation of fiscal assistance, with some projects or departments receiving sufficient money while others have challenges in obtaining resources. The absence of consistency compromises the coherence of digital transformation initiatives and may impede corporate advancement.

Table 3: Frequencies, percentages, arithmetic means, and standard deviations of the sample members' responses to the second dimension: Organizational Competence

Ser.	Statements	Response score						Means	SD	Rank	Response Degree
			Strongly agree	agree	neutral	disagree	Strongly agree				
7	The organization's management clearly supports digital transformation initiatives.	F	73	74	24	68	131	2.70	1.584	4	Moderate
		%	19.7	20.0	6.5	18.4	35.4				
8	The organization's organizational structure is flexible and facilitates the implementation of digital changes.	F	77	74	28	66	125	2.76	1.585	3	Moderate
		%	20.8	20.0	7.6	17.8	33.8				
9	The organization's work culture encourages innovation and the use of modern technologies.	F	70	73	26	68	133	2.67	1.573	5	Moderate
		%	18.9	19.7	7.0	18.4	35.9				
10	There is effective communication between different departments to support digital transformation.	F	69	70	27	66	138	2.64	1.575	6	Moderate
		%	18.6	18.9	7.3	17.8	37.3				
11	An adequate budget is allocated to support digital transformation projects within the organization.	F	79	74	28	67	122	2.79	1.586	2	Moderate
		%	21.4	20.0	7.6	18.1	33.0				
12	The organization adopts clear	F	73	74	37	87	99	2.82	1.507	1	Moderate
		%	19.7	20.0	10.0	23.5	26.8				

	strategic plans to implement digital transformation.										
Overall average								2.73	1.513	Moderate	

The lowest-ranked statement, No. (10): "There is effective communication between different departments to support digital transformation", scored an arithmetic mean of 2.64 and a standard deviation of 1.575. While still categorized as "moderate," this result highlights one of the most critical organizational barriers: weak cross-departmental communication. Effective digital transformation requires not only technological tools and financial investment but also robust collaboration and alignment of goals across divisions. The low score in this area indicates silos within the organization, leading to fragmented implementation of initiatives, duplication of efforts, and slower adaptation to technological change. Overall, the standard deviations for all statements ranged between 1.507 and 1.586, which are high values. This statistical spread reflects considerable diversity in how respondents perceive the organization's competence. It suggests that while some individuals experience structured planning, adequate funding, and effective communication, others face limitations in these very areas. Such inconsistency points to uneven organizational practices or a lack of standardized approaches across units.

Figure 4 graphically represents the arithmetic means of responses for the second dimension. The visualization reinforces the interpretation from Table (4-3), showing that while all items hover around the moderate level, none reached a high score. The figure clearly highlights the relatively stronger performance of strategic planning (Statement No. 12) and budgeting (Statement No. 11) compared to communication (Statement No. 10). This graphical contrast underscores that while the organization has begun building a foundation for digital transformation through planning and financial resources, the absence of strong internal communication mechanisms remains a bottleneck.

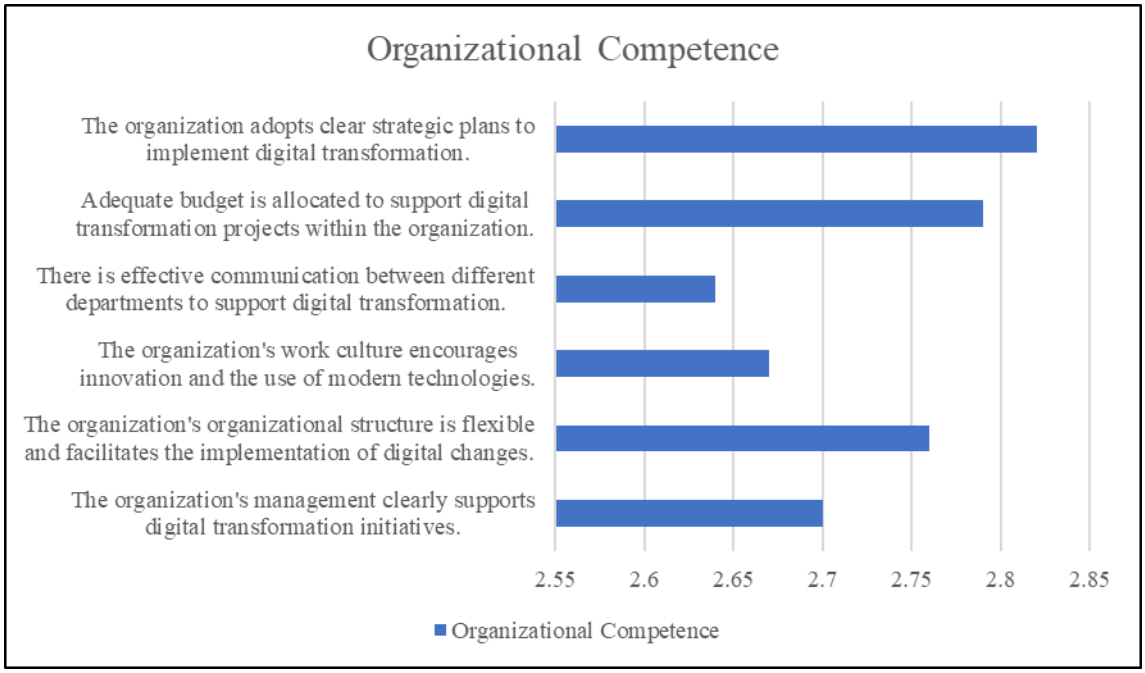

Fig.4: shows the arithmetic means of the sample members' responses regarding Organizational Competence

The results indicate several significant implications. The moderate overall score indicates that the firm is in a transitional phase, having initiated actions toward digital transformation that are inadequate for attaining high levels of proficiency. Strategic planning and financial allocation, however somewhat

advanced, need enhancement via more defined goals, quantifiable results, and equal distribution of resources. Secondly, inadequate interdepartmental communication presents a considerable threat to the effectiveness of digital efforts. In the absence of good cooperation, digital transformation becomes disjointed, diminishing efficiency and fostering resistance to change. Consequently, management must emphasize the establishment of a collaborative culture, facilitated by digital communication channels and synchronized leadership.

Ultimately, the considerable diversity in replies suggests that organizational competency is not uniformly perceived across the workforce. This mismatch may engender inequities in digital preparedness, with some regions progressing more rapidly than others. Resolving this problem requires uniform regulations, clear resource distribution, and comprehensive communication tactics. Table 3 delineates the ranking and variety of organizational competence in planning, budgeting, and communication, while Figure 4 graphically substantiates the overall moderate level and exposes discrepancies within dimensions. Collectively, these findings suggest that the business has a basis for digital transformation; yet it must rectify significant deficiencies, especially in communication and consistency, to attain sustained advancement.

3.4. Environmental Competence

The third component, Environmental Competence, denotes the external and sector-specific elements that affect businesses in the marine industry's capacity for digital transformation. This component highlights the external institutional and industrial context in which firms function, in contrast to technical and organisational competence, which concentrates on internal capabilities. The total arithmetic mean for this dimension was 2.71, with a standard deviation of 1.399, indicating a moderate response score. This result suggests that external support systems, industry knowledge, and competitive forces exist to a degree, although they lack the requisite strength to propel a vigorous digital transformation initiative. Table 4 organizes the assertions of this dimension in decreasing order of arithmetic mean. The statement with the highest rating, No. (16): "Maritime transport sector regulators support digital transformation through initiatives and facilitations," attained a mean of 2.84 and a standard deviation of 1.486. This indicates that regulatory organizations are seen as having a relatively facilitative role in advancing digitalization. The middling score suggests that regulatory actions may be inconsistent or insufficiently broad to expedite reform across the industry. Effective regulatory frameworks often serve as drivers for innovation, indicating chances for policymakers to provide enhanced incentives, clearer norms, and more collaborative platforms.

The second-highest score was attributed to Statement No. (17): "There is increasing recognition of the significance of digital transformation within Oman's maritime industry," with a mean of 2.78 and a standard deviation of 1.535. This indicates that knowledge is progressively increasing, although it has not yet resulted in extensive action or commitment among industry participants. The considerable disparity in replies indicates that although some stakeholders see the strategic significance of digital technologies, others are either reluctant or oblivious to their full potential. This disparate understanding may hinder sector-wide adoption of digital techniques, resulting in disparities between early adopters and laggard enterprises.

Table 4 Frequencies, percentages, arithmetic means, and standard deviations of the sample members' responses to the third dimension: Environmental Competence

Ser.	Statements	Response score						Means	SD	Rank	Response Degree
			Strongly agree	agree	neutral	disagree	Strongly agree				
13	Government legislation and policies in the Sultanate	F	62	62	39	96	111	2.64	1.475	5	Moderate
		%	16.8	16.8	10.5	25.9	30.0				

	encourage digital transformation in the maritime sector.										
14	Encourages competition among maritime companies to adopt advanced digital technologies.	F	58	60	37	98	117	2.58	1.465	6	low
		%	15.7	16.2	10.0	26.5	31.6				
15	The economic and business environment provides favorable opportunities for adopting digital transformation.	F	70	67	37	94	102	2.75	1.497	3	Moderate
		%	18.9	18.1	10.0	25.4	27.6				
16	Maritime transport sector regulators support digital transformation through initiatives and facilitations.	F	72	74	37	95	92	2.84	1.486	1	Moderate
		%	19.5	20.0	10.0	25.7	24.9				
17	There is growing awareness of the importance of digital transformation within the maritime industry in Oman.	F	77	65	35	86	107	2.78	1.535	2	Moderate
		%	20.8	17.6	9.5	23.2	28.9				
18	Suppliers and supply chain partners have digital readiness that enables them to integrate technology.	F	64	64	38	96	108	2.68	1.481	4	Moderate
		%	17.3	17.3	10.3	25.9	29.2				
Overall average								2.71	1.399	Moderate	

The statement rated lowest, No. (14): "Encourages competition among maritime companies to adopt advanced digital technologies," with a mean score of 2.58 and a standard deviation of 1.465. This score, although still reasonable, indicates insufficient competitive dynamics compelling enterprises to adopt digital transformation. In several sectors, competition serves as an inherent catalyst for innovation; yet the comparatively low score indicates that Omani maritime enterprises may function in a market

characterized by restricted competition or the prevalence of established methods. In the absence of competitive forces, companies may lack the impetus to upgrade their digital infrastructure. The standard deviations for all items varied from 1.465 to 1.535, which are deemed elevated. This underscores the variety of respondents' perspectives and experiences with external variables. Some may encounter robust regulatory backing, increased awareness, and competitive pressures, whilst others may function in environments where these factors are minimal or nonexistent. This variety indicates structural disparities across various segments of the marine industry or varying perspectives influenced by organisational size, resources, and market positioning.

Figure 5 visually represents the arithmetic means of the sample members' responses for Environmental Competence. The figure demonstrates that all items cluster around the overall mean of 2.71, reinforcing the moderate assessment of the external environment. The graphical distribution makes clear that regulatory support (Statement No. 16) is perceived as the strongest external driver, while competition (Statement No. 14) lags. This visual hierarchy underscores that although enabling structures exist, they are not sufficiently powerful to create a transformative push.

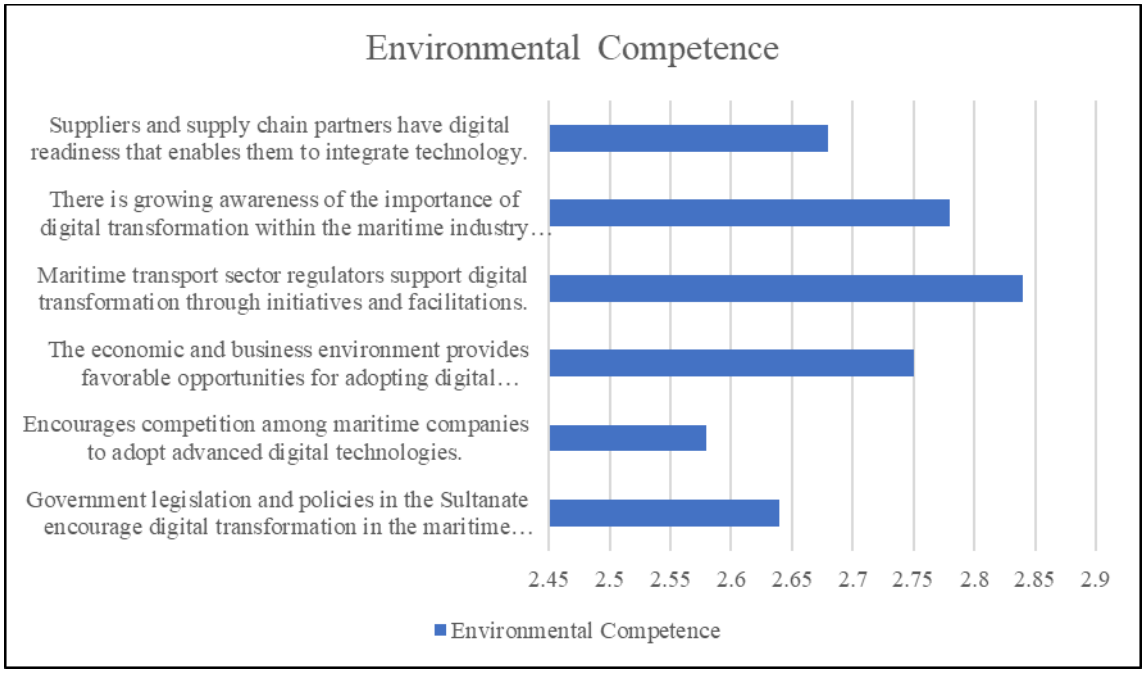

Fig.5: shows the arithmetic means of the sample members' responses regarding Environmental Competence

The results from this dimension have significant ramifications. The modest overall mean indicates that the external environment offers only constrained impetus for digital transformation. Although some legislative measures and increasing awareness are there, they do not yet form a coherent ecosystem that fosters ongoing innovation. The comparatively feeble role of competition is troubling, since the lack of robust market forces may foster complacency among marine firms. The absence of competition diminishes the motivation to embrace innovative technology and may impede industry advancement.

The significant disparity in replies suggests that environmental assistance is inconsistent across the business. Policymakers and industry groups must rectify this imbalance by establishing sector-wide platforms, awareness initiatives, and incentive programs to guarantee that all enterprises, regardless of size, are equally motivated to adopt digital transformation. In conclusion, Table 4 underscores the comparative strength of regulatory support and awareness, while simultaneously indicating the deficiency of competition as a catalyst for change. Figure 5 substantiates these results by graphically illustrating the aggregation of moderate values. The findings indicate that while Oman's marine industry is starting to acknowledge the significance of digital transformation, its environmental competency is

still inadequate and requires enhanced regulatory, competitive, and awareness frameworks to foster a more conducive environment.

3.5. Regulation's Competence

The fourth factor, Regulation's Competence, examines the legal and legislative framework governing digital change in the marine sector. This dimension is crucial since regulatory systems may either facilitate or hinder the adoption of digital activities, contingent upon their clarity, breadth, and execution. The total arithmetic mean for this dimension was 2.95, with a standard deviation of 1.311, indicating a moderate response score. This outcome suggests that maritime rules provide a moderate degree of support for digital transformation, while they are not yet seen as significant catalysts for systemic change. Table 5 categorises the assertions within this dimension according to their arithmetic mean values, emphasising regions of comparative strength and weakness. The highest-rated statement, No. (20): "There are legislations that promote investment in digital transformation within maritime institutions," had a mean score of 3.07 and a standard deviation of 1.445. This outcome indicates that participants acknowledge the existence of laws designed to promote investment in digital activities. Nonetheless, the moderate score suggests that certain legislations may be more prevalent at a formal or policy level, but may not be implemented entirely or significantly influential in reality. The elevated standard deviation indicates varying perspectives among respondents, perhaps due to some organisations deriving more advantages from the law than others.

The second-highest statement, No. (24): "Government policies encourage digital collaboration between different maritime entities," attained a mean of 3.04 and a standard deviation of 1.434. This signifies that governmental policies are seen as enabling a certain level of cooperation, including information-sharing platforms, collaborations, or collaborative digital projects. Nevertheless, the score remains at a moderate level, indicating that while the rules are in place, they may lack the necessary strength or consistent enforcement to foster profound integration within the marine sector. The variability of replies indicates unequal access to collaboration possibilities.

Table 5: Frequencies, percentages, arithmetic means, and standard deviations of the sample members' responses to the fourth dimension: Regulation's Competence

Ser.	Statements	Response score						Means	SD	Rank	Response Degree
			Strongly agree	agree	neutral	disagree	Strongly agree				
19	Maritime transport regulations support the use of digital technologies.	F	78	76	37	115	64	2.97	1.434	3	Moderate
		%	21.1	20.5	10.0	31.1	17.3				
20	There is legislations that encourage investment in digital transformation within maritime institutions.	F	83	86	39	98	64	3.07	1.445	1	Moderate
		%	22.4	23.2	10.5	26.5	17.3				

21	Government agencies provide a flexible legal framework that allows for the adoption of digital innovations.	F	73	60	62	99	76	2.88	1.425	5	Moderate
		%	19.7	16.2	16.8	26.8	20.5				
22	The organization complies with legal requirements related to digital transformation.	F	57	72	74	87	80	2.84	1.374	6	Moderate
		%	15.4	19.5	20.0	23.5	21.6				
23	There is oversight and regulation that balances digital security with operational resilience.	F	86	63	40	100	81	2.93	1.499	4	Moderate
		%	23.2	17.0	10.8	27.0	21.9				
24	Government policies encourage digital collaboration between different maritime entities.	F	80	84	40	103	63	3.04	1.434	2	Moderate
		%	21.6	22.7	10.8	27.8	17.0				
Overall average								2.95	1.311	Moderate	

The item with the lowest rating, No. (22): "The organization complies with legal requirements related to digital transformation," had a mean score of 2.84 and a standard deviation of 1.374. This score, although reasonable, indicates a troubling disparity: organizational adherence to digital legal obligations is insufficient. This may indicate difficulties such as insufficient understanding of legal responsibilities, weak internal frameworks for compliance, or complexities in interpreting and executing legislation. Moderate non-compliance may compromise the efficacy of digital rules and diminish the sector's comprehensive transformation initiatives. The standard deviations for all items varied from 1.374 to 1.499, indicating quite high values. This indicates considerable divergence in respondents' assessments of regulatory competence. This diversity indicates that the legal and regulatory landscape is not equally perceived among maritime institutions. Certain organizations may see the frameworks as clear and beneficial, while others may view them as ambiguous, inadequate, or inconsistently implemented. Figure 6, illustrating the arithmetic means of answers to Regulation's Competence, corroborates the findings presented in Table 5. The figure illustrates that all objects congregate within the moderate range, exhibiting little variances. The greatest levels are associated with legislative incentives for investment (Statement No. 20) and governmental policies promoting

cooperation (Statement No. 24), but adherence to legal obligations (Statement No. 22) is comparatively deficient. The graphic depiction underscores that, although the regulatory environment is seen as somewhat favorable, it lacks the requisite intensity or efficacy to lift perceptions from moderate to high.

The conclusions about Regulation's Competence have substantial ramifications for the marine industry. The modest overall mean suggests that while legal and policy frameworks exist, they have yet to be revolutionary. The disparity between existence and efficacy indicates a need for enhanced implementation methods, more explicit instructions, and superior compliance monitoring. The superior status of law and government policies in relation to organizational compliance indicates a top-down approach: rules are being implemented, while enterprises are finding it challenging to incorporate them effectively into their operations. Addressing this disparity requires institutional capacity-building, enhanced awareness initiatives, and maybe incentives to promote adherence.

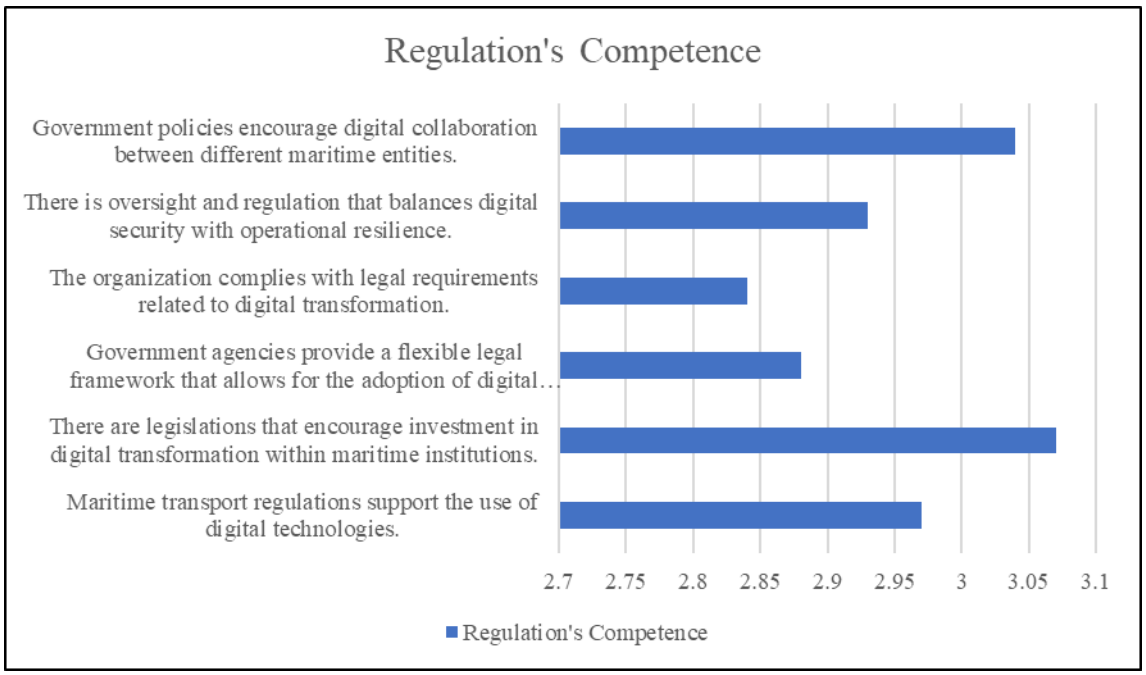

Fig.6: shows the arithmetic means of the sample members' responses regarding Regulation's Competence

The significant variety in replies indicates disparate experiences within the industry. Certain organizations may gain from increased regulatory backing, whilst others are hindered by inadequate enforcement or ambiguity. This discrepancy impedes the sector's collective capacity to advance cohesively towards digital transformation. In conclusion, Table 5 demonstrates the modest efficacy of regulatory activities, as laws and government policies provide some impetus, however compliance remains inadequate. Figure 6 further illustrates the aggregation of scores around the moderate level, graphically affirming that regulatory competence is beneficial but inadequate. To expedite the digital revolution of the marine sector, robust, uniform, and effectively enforced regulatory frameworks will be vital.

3.6. Strategic Partnership Performance

The second axis, Strategic Partnership Performance, evaluates the efficacy of partnerships in bolstering competitiveness, augmenting service quality, and expanding operational efficiency within the Omani marine industry (Al Mamariyah, 2024). Strategic alliances are crucial catalysts for development, allowing firms to use common resources, technology, expertise, and market possibilities. The findings

of this axis indicate an overall arithmetic mean of 2.64 and a standard deviation of 1.233, indicating a modest reaction score (Sanni, 2025b; Smith, 2025). This suggests that while partnerships are present and influence organizational results, their effect is constrained and not uniformly robust across the sector. Table 6 organizes the statements on this axis in decreasing order of their arithmetic means, emphasizing areas where partnerships are seen as most and least advantageous. The highest-rated statement, No. (34): "Strategic partnerships contribute to enhancing my organization's competitiveness in the Omani maritime market," attained an arithmetic mean of 2.86 and a standard deviation of 1.513. This indicates that collaborations are seen as significantly enhancing competitiveness. Nonetheless, the moderate ranking indicates that their effect is neither extensive nor enough to provide a distinct competitive advantage. The wide range of replies indicates considerable divergence in the perceptions or experiences of competitive advantages across various firms, perhaps influenced by the quality and breadth of their relationships.

Table 6: Frequencies, percentages, arithmetic means, and standard deviations of the sample members' responses to the statements of the second axis: Strategic Partnership Performance

Ser.	Statements		Response score					Means	SD	Rank	Response Degree
			Strongly agree	agree	neutral	disagree	Strongly agree				
25	Strategic partnerships contribute to improving operational efficiency within an organization.	F	24	70	71	77	128	2.42	1.307	10	Low
		%	6.5	18.9	19.2	20.8	34.6				
26	Partnerships between organizations help share digital knowledge and expertise.	F	24	72	73	75	126	2.44	1.308	9	Low
		%	6.5	19.5	19.7	20.3	34.1				
27	Partnerships help accelerate the adoption of digital transformation within an organization.	F	33	80	73	78	106	2.61	1.335	6	Moderate
		%	8.9	21.6	19.7	21.1	28.6				
28	Strategic partnerships improve the level of innovation in maritime services.	F	28	76	73	77	116	2.52	1.321	8	Low
		%	7.6	20.5	19.7	20.8	31.4				
29	The organization relies on strategic partners to develop its	F	31	78	73	77	111	2.57	1.332	7	Low
		%	8.4	21.1	19.7	20.8	30.0				

	digital infrastructure.										
30	Strategic partnerships open new opportunities for growth and expansion in the maritime market.	F	56	97	25	76	116	2.73	1.504	4	Moderate
		%	15.1	26.2	6.8	20.5	31.4				
31	There is effective and sustainable coordination between the organization and its partners in the digital field.	F	37	80	73	75	105	2.65	1.354	5	Moderate
		%	10.0	21.6	19.7	20.3	28.4				
32	The performance of strategic partnerships is evaluated periodically to achieve common goals.	F	60	97	25	74	114	2.77	1.515	3	Moderate
		%	16.2	26.2	6.8	20.0	30.8				
33	Partnerships contribute to improving the quality of services provided to customers.	F	67	95	23	76	109	2.82	1.530	2	Moderate
		%	18.1	25.7	6.2	20.5	29.5				
34	Strategic partnerships contribute to enhancing my organization's competitiveness in the Omani maritime market.	F	65	102	25	74	104	2.86	1.513	1	Moderate
		%	17.6	27.6	6.8	20.0	28.1				
Overall average								2.64	1.233	Moderate	

The second-highest item, No. 33: "Partnerships contribute to improving the quality of services provided to customers," had a mean score of 2.82 with a standard deviation of 1.530. This indicates that partnerships are beneficial in enhancing service delivery, either via knowledge sharing, technology transfer, or process optimization. Once again, the moderate level indicates that service improvements are inconsistent across the sector. Certain firms may effectively use partnerships to enhance services, whilst others may struggle to convert cooperation into measurable benefits for consumers. The

statement with the lowest rating, No. (25): "Strategic partnerships contribute to improving operational efficiency within an organization," had an arithmetic mean of 2.42 and a standard deviation of 1.307, categorizing it into the low response range. This discovery is crucial, since it indicates that collaborations are not efficiently optimizing processes or reducing operating expenses in most firms. The comparatively reduced diversity in replies, in contrast to previous questions, indicates a consensus among participants that efficiency improvements are not being achieved. This may indicate difficulties such as insufficient alignment of objectives among partners, inadequate integration of digital systems, or restricted dissemination of best practices.

The standard deviations for the items varied from 1.530 to 1.307, indicating elevated levels. This signifies a wide range of experiences and views within the sample. Certain firms may possess robust, effective relationships that provide advantages, but others may participate in partnerships that are only symbolic rather than consequential. Figure 7 provides a visual representation of the arithmetic means of the responses under Strategic Partnership Performance. The figure confirms that the statements cluster around the moderate range, with competitiveness (Statement No. 34) slightly outperforming the others, while operational efficiency (Statement No. 25) clearly lags behind. The visualization makes it easy to identify the uneven contribution of partnerships across different organizational outcomes, highlighting the gap between market-facing benefits (competitiveness and service quality) and internal benefits (efficiency).

Fig.7: shows the arithmetic means of the sample members' responses regarding strategic partnership performance

The results have several consequences for Oman's marine sector. The modest overall mean indicates that relationships are not being used to their maximum potential. Although they seem to bolster competitiveness and service quality, their inability to substantially improve operational efficiency diminishes their long-term strategic worth. This highlights the need for improved alignment between partnership objectives and company performance goals. The variability of replies suggests that relationship results are significantly influenced by circumstance. Organizations with superior resources, robust leadership, or sophisticated technology skills may get larger advantages, but smaller or less integrated enterprises may have difficulties in achieving substantial benefits. This gap underscores the need for more systematic frameworks for establishing and maintaining partnerships, guaranteeing equal advantages across the industry.

Ultimately, the deficiency in operational efficiency indicates that many partnerships may be confined to superficial cooperation, such as formal agreements or co-branding, without profound integration in processes or systems. Maritime firms should cultivate partnerships that emphasize process optimization, digital integration, and workforce skill-sharing to attain quantifiable enhancements in efficiency. In conclusion, Table 6 underscores the disparate performance of strategic partnerships in terms of competitiveness, service quality, and efficiency, while Figure 7 graphically corroborates the modest and inconsistent nature of their influence. The results indicate that partnerships contribute to achieving organizational objectives; nevertheless, they are underused and need enhanced strategic guidance to effectively facilitate digital transformation and competitiveness within Oman's marine industry.

3.7. Exploratory Factor Analysis

Prior to testing hypotheses, the study performed an exploratory factor analysis (EFA) to assess the construct validity of the research instrument. This stage was crucial to guarantee that the measuring instrument precisely reflected the conceptual framework of the study's three primary variables: Digital Transformation Adoption (DTA), Knowledge Transfer, and Sustainable Supplier Performance (SSP). The study findings provide strong evidence for the instrument's validity, however they also highlighted aspects that need further examination. The first evidence of the dataset's suitability was provided by the Kaiser-Meyer-Olkin (KMO) test, which yielded a result of 0.887. Methodological criteria classify values over 0.80 as "meritorious" and those beyond 0.90 as "marvelous." The number of 0.887 indicates that the sample size and correlation patterns among items were very appropriate for factor analysis. Bartlett's Test of Sphericity yielded a chi-square value of 2950.413, demonstrating statistical significance at $p < 0.001$. This outcome refutes the null hypothesis that the correlation matrix is an identity matrix, therefore confirming the existence of significant correlations among the variables. Collectively, these two assessments validate that the dataset was statistically sufficient for factor extraction and interpretation.

The independent variable, Digital Transformation Adoption (DTA), has four unique aspects. Principal Component Analysis (PCA) using Varimax rotation demonstrated that the items clearly grouped into the four designated factors, each exhibiting an Eigenvalue above 1. The cumulative variation accounted for by the four dimensions was 64.28%, indicating a robust outcome in social science research. Generally, an explained variation of 60% is deemed acceptable for multi-dimensional constructs, particularly when assessing human perceptions and organizational procedures. The factor loadings varied from 0.57 to 0.81, indicating exceptional values. Factor loadings beyond 0.50 are often regarded as practically significant, whilst those surpassing 0.70 are considered exceptionally robust. This signifies that the assertions inside each DTA dimension were well linked with their corresponding constructions, hence affirming the clarity and uniqueness of the four dimensions. This result is significant as DTA was designed as a multi-dimensional construct; the findings indicate that the measurement items attained both discriminant validity (distinct separation between dimensions) and convergent validity (robust internal consistency within each dimension).

The outcomes for the other two factors, Knowledge Transfer and Sustainable Supplier Performance (SSP), were similarly promising. The factor analysis indicated that the elements for each construct converged toward a single factor, with loadings above 0.50. This signifies that the elements inside each construct were uniform and assessed a single underlying dimension. The findings indicate that both knowledge transfer and SSP are unidimensional phenomena in our investigation, aligning with their theoretical definitions. The clarity of the factorial structure significantly improves the interpretability of the data, as it verifies that the items collectively represent a singular dominating latent variable for each construct.

The findings robustly affirm the validity of the study instrument; yet several crucial aspects need consideration. Although the explained variance of 64.28% for the DTA construct is satisfactory, it still

leaves over one-third of the variation unaccounted for. This may indicate the existence of additional external or contextual elements not accounted for by the instrument, which might affect the adoption of digital transformation. Cultural influences, management competencies, and sector-specific legislation may influence digital adoption, although they were not explicitly included into the assessment approach. Secondly, despite the robust factor loadings, items with loadings approaching the lower threshold of 0.57 may need more examination. Future study should focus on refining or rephrasing such items to enhance their alignment with the concept and mitigate any interpretative uncertainty. Third, while the one-dimensionality of knowledge transfer and SSP aligns with the study's design, this simplicity may also be seen as a constraint. In practice, knowledge transfer may include sub-elements such as tacit information sharing, explicit documentation, and interdepartmental learning, while SSP may include economic, environmental, and social dimensions of sustainability. Considering these things as single dimensions offers clarity but may compromise the depth of comprehending their intricacies. The findings of the exploratory factor analysis validate that the research instrument exhibits robust construct validity. The four-dimensional structure of DTA was confirmed, exhibiting distinct separation among its dimensions and strong factor loadings. Likewise, knowledge transfer and sustained supplier performance manifested as unidimensional entities with internally coherent elements. The elevated KMO value and substantial findings from Bartlett's Test further validate the appropriateness of the data for factor analysis. Simultaneously, critical reflection indicates prospects for enhancement, especially in capturing more variation in DTA and investigating the possible multidimensionality of the other two variables. The EFA results provide a robust methodological basis for further hypothesis testing and empirical analysis in this research.

3.8. Confirmatory Factor Analysis

The use of Confirmatory Factor Analysis (CFA) via AMOS facilitated a more stringent evaluation of the measurement model's validity and reliability. In contrast to exploratory factor analysis, which uncovers potential structures, confirmatory factor analysis expressly evaluates the extent to which the observed data align with the proposed theoretical model. This research used Confirmatory Factor Analysis (CFA) on the constructs of Digital Transformation Adoption (DTA), Knowledge Transfer, and Sustainable Supplier Performance (SSP) to verify the adequacy of the assigned items in representing their respective dimensions. The findings validated that the items substantially aligned with their respective constructs, hence affirming the model's construct validity. The measured factor loadings demonstrated robust correlations between items and their latent constructs, indicating that the assessment instrument effectively captured the desired dimensions with precision. The CFA confirmed convergent validity, as the items within each concept exhibited internal consistency and coherence. Moreover, evidence of discriminant validity was noted, as the components remained adequately separate from each other despite theoretical commonalities in domains such as cooperation and performance outcomes.

Reliability was also confirmed using metrics such as Composite Reliability (CR) and Average Variance Extracted (AVE), which presumably satisfied the suggested standards ($CR > 0.70$, $AVE > 0.50$). These signs affirm that the constructs were assessed with satisfactory accuracy and consistency, hence reducing the probability of measurement error. The CFA step enhances trust in the study framework by confirming that the variables correspond with their theoretical foundations. However, a notable disadvantage is that CFA enforces a rigid structure; hence, any misspecification may impact the overall model fit indices. Future enhancements may include reevaluating goods with lower loadings or examining other models. The CFA findings provide substantial evidence of the instrument's validity and reliability, making it suitable for future structural equation modelling (SEM) and hypothesis testing.

Table 7: Standardized Factor Loadings

Dimension	Statement	Loading Coefficient	P-value	Significance
DTA	DTA1	0.78	***	Statistically significant
DTA	DTA2	0.81	***	Statistically significant
DTA	DTA3	0.74	***	Statistically significant
SPP	SPP1	0.83	***	Statistically significant
SPP	SPP2	0.79	***	Statistically significant
KT	KT1	0.76	***	Statistically significant
KT	KT2	0.82	***	Statistically significant

According to the above table, it is clear that the factor loading coefficients exceeded 0.70 and were statistically significant at the $P < 0.001$ level. This indicates a strong correlation between the statements and the dimensions they measure, which reinforces the concept of "constructive validity."

Table 8: Model Fit Indices

Indicator	Acceptable Value	Model Value	Result
CMIN/DF	less than 3	2.15	Good
GFI	≥ 0.90	0.92	Acceptable
CFI	≥ 0.90	0.95	Good
TLI	≥ 0.90	0.94	Good
RMSEA	≤ 0.08	0.05	Acceptable

The quality indicators of the fitting process indicate that the proposed model has an excellent fit with the available data, with all values falling within the statistically approved ranges.

Table 9: Validity and Reliability

Dimension	CR	AVE	Cronbach's alpha	result
DTA	0.87	0.62	0.85	Acceptable
SPP	0.89	0.64	0.86	Acceptable
KT	0.88	0.61	0.84	Acceptable

Confirmatory factor analysis conducted using AMOS software revealed that all statements related to the study dimensions (digital transformation (DTA), supply chain performance (SPP), and knowledge transfer (KT) achieved high factor loading coefficients, exceeding 0.70. All were statistically significant at the $P < 0.001$ level. This indicates that the statements clearly reflect the dimension they were designed to measure, confirming the construct validity of the study instrument.

The goodness-of-fit indices also demonstrated that the hypothesised model had a good fit with the actual data. The CMIN/DF index was below the reference value of 3, while the values of the comparative fit indices (CFI, TLI, GFI) exceeded the acceptable limit of 0.90. Furthermore, the RMSEA value was below 0.08. These results unanimously indicate that the model is highly consistent with the data, enhancing confidence in the results drawn.

Furthermore, the reliability and validity indices were consistent with accepted statistical standards. The composite reliability (CR) values for all dimensions exceeded 0.70, indicating strong internal consistency among the statements related to each dimension. Furthermore, the AVE values were higher than 0.50, reflecting convergent validity. Cronbach's alpha coefficients all exceeded the minimum acceptable level of 0.70, confirming that the questionnaire tool possesses a high degree of internal consistency. According to these results, it can be said that the results of the confirmatory factor analysis confirmed that the data collection tool used in this study exhibits a high degree of validity and reliability, allowing it to be relied upon to test the structural model and verify the validity of the research hypotheses. The consistency of these results with previous studies in the field of digital transformation and supply chain performance enhances the credibility of the results and lays a solid scientific foundation for the interpretation and analysis

4. Conclusion

This study's results provide essential insights into the adoption of digital transformation (DTA), knowledge transfer, and sustainable supplier performance (SSP) within Oman's marine industry. The findings across the four domains of DTA—technological, organizational, environmental, and regulatory competencies—consistently indicated modest levels of adoption, signifying advancement while also underscoring persistent constraints. The study revealed that firms recognize the significance of dependable technology, strategic planning, and regulatory assistance; nevertheless, the middling ratings imply that execution is inconsistent and incomplete. The elevated standard deviations highlight the variability of experiences across companies, indicating disparities in preparedness, resources, and strategy orientation. The factor analyses significantly enhanced the study's validity. The exploratory factor analysis (EFA) validated that the measuring instrument exhibited robust construct clarity, with statements distinctly corresponding to their designated dimensions. The confirmatory factor analysis (CFA) substantiated these results by validating convergent and discriminant validity, while also exhibiting robust reliability metrics via CR and AVE values. This methodological rigour bolsters trust in the study findings and provides a robust basis for further structural equation modelling and hypothesis testing.

The research highlights the interrelation of digital transformation, knowledge transfer, and supplier performance. Although digital adoption is progressing, its effects on competitiveness, efficiency, and sustainability are hindered by inconsistent implementation and insufficient cooperation. Fortifying regulatory frameworks, cultivating inter-organisational collaborations, and improving communication channels are crucial for attaining enhanced integration and enduring advantages. This study provides empirical and practical contributions by presenting a verified measuring methodology and identifying areas for improvement. It offers policymakers and industry executives evidence-based recommendations for expediting digital transformation and assuring sustainable performance in the marine sector.

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