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Designing a Model of the Impact of Human Resource Empowerment Factors with a Knowledge Management Orientation Using the ISM Approach (Case Study: Marine Projects)

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ABSTRACT

In today's world, knowledge has become a key resource for gaining competitive advantage, and organizations must pay special attention to knowledge management and human resource empowerment in order to survive and grow in complex and highly dynamic environments. Human resource empowerment and knowledge management, as vital organizational assets, help organizations achieve survival, development, and progress through the effective utilization of knowledge and the creation of an appropriate cultural context. The purpose of this study is to design a human resource empowerment model with a knowledge management orientation using the Interpretive Structural Modeling (ISM) approach. This research is applied in terms of purpose and exploratory in terms of method. The statistical population of the study consists of seafarers and ship supervising engineers. Data were collected using the Fuzzy Delphi technique and ISM analyses. The results indicate that, based on the derived diagram, there are six levels, with knowledge-oriented leadership and management identified at the sixth level as the most influential criterion, which directly affects the knowledge-oriented performance evaluation criterion at the fifth level. This criterion, in turn, influences the criteria at the fourth level. In addition, the five first-level criteria—use of modern technologies, change management, organizational commitment, organizational support, and creativity and innovation—are directly influenced by the human resource motivation criterion. Based on MICMAC analysis, knowledge-oriented leadership and management (C1) and networking and inter-organizational collaboration (C4) are classified as independent variables. These variables exhibit low dependence and high driving power; in other words, they are characterized by high influence and low susceptibility. The human resource motivation criterion (C5) is classified as a dependent variable with strong dependence and weak driving power, indicating that it is highly influenced by the system but has limited influence on it. The remaining criteria are classified as linkage variables, which possess both high dependence and high driving power. In other words, both the influence and susceptibility of these criteria are very high, and any small change in them leads to fundamental changes in the system. By emphasizing the close relationship between human resource empowerment and knowledge management, this study presents a comprehensive model for improving organizational performance in the marine industries. The implementation of this model can create favorable conditions for enhancing innovation, organizational growth, and productivity improvement.

Keywords: Human Resource Empowerment; Knowledge Management; Marine Projects; ISM Approach; Impact Model Design

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Introduction

In contemporary competitive and turbulence-prone environments, knowledge has become a strategic asset that underpins value creation, organizational learning, and sustained performance. As organizations confront accelerating technological change, stakeholder complexity, and higher expectations for responsiveness, the ability to acquire, convert, share, and apply knowledge is increasingly treated as a core dynamic capability. Knowledge management (KM) has therefore moved beyond an auxiliary administrative function and is now viewed as an integrated managerial system that shapes decision quality, coordination, innovation capacity, and operational reliability. Evidence indicates that KM practices influence organizational performance through their effects on information flows, decision-making patterns, and the alignment of organizational resources with strategic priorities (1, 2). At the same time, contemporary KM emphasizes not only technology and repositories, but also social and behavioral mechanisms that enable knowledge exchange and institutionalization, including critical thinking, learning norms, and cultural compatibility (3, 4). Consequently, organizations seeking to strengthen performance and resilience increasingly prioritize KM-oriented interventions that enhance employees' capability and willingness to engage in knowledge processes.

Within this context, human resource empowerment has gained particular prominence as a managerial approach that improves employees' discretion, competence, meaningfulness, and impact, thereby strengthening their ability to contribute to organizational goals. Empowerment is not merely a motivational slogan; it is a multi-dimensional construct embedded in organizational systems and HR architecture, shaped by leadership, job design, decision rights, capability development, and supportive structures. Empirical work across sectors suggests that empowerment can improve job satisfaction and organizational commitment, which in turn stabilizes human capital and enhances effectiveness (5). Empowerment has also been associated with organizational innovation, especially when employees have autonomy and support to experiment, share ideas, and engage in problem-solving beyond narrow job descriptions (6). These findings position empowerment as a central lever for organizations that must mobilize distributed expertise and adapt quickly under uncertain conditions.

The conceptual and practical connection between empowerment and KM is increasingly recognized in the management literature. KM systems require employees who not only possess knowledge but also actively share, codify, and reuse it; this process depends on psychological and structural conditions that enable participation, voice, and discretionary effort. Studies indicate that empowerment—particularly in its psychological form—can act as a mechanism linking KM practices to sustainable employee and organizational outcomes (2, 7). Additionally, the effectiveness of empowerment initiatives is contingent upon supportive organizational contexts, including organizational support and relational climates that encourage collaboration and reduce the perceived risk of sharing expertise. The interaction between empowerment and organizational support has been shown to enhance employee performance outcomes, highlighting the importance of integrating empowerment with broader organizational systems rather than treating it as an isolated HR initiative (8). In knowledge-intensive settings, empowerment therefore functions as both an input to and an outcome of KM maturity, reinforcing a virtuous cycle of learning, sharing, and performance improvement.

A critical insight in this stream of research is that empowerment is not a single intervention but a configuration of interdependent drivers and enabling conditions. Scholarship has highlighted that empowerment can be reinforced through HR flexibility and adaptive work arrangements, particularly in technology-oriented SMEs where agility and rapid knowledge recombination are essential (9). Likewise, strategic thinking and planning can enhance empowerment outcomes by clarifying priorities, enabling innovation pathways, and strengthening human capital as a mediator between strategic processes and performance (10). Contemporary organizations also increasingly rely on data-driven decision-making infrastructures to support HR processes, which can strengthen empowerment by increasing transparency, improving fairness perceptions, and enabling more responsive talent decisions (11). These developments collectively imply that empowerment in modern organizations should be conceptualized as a system of mutually reinforcing factors that operate across leadership, structure, culture, and technology.

The knowledge-sharing dimension offers an especially important bridge between empowerment and KM. Knowledge sharing—whether among employees, across teams, or between organizations—determines whether knowledge resources remain individualized or become organizationally usable. Research in both organizational and consumer contexts shows that knowledge sharing is driven by motivational, relational, and contextual antecedents and can generate measurable outcomes at the individual and collective levels (12). Within organizations, the role of knowledge sharing appears particularly salient when empowerment is expected to translate into innovation. Recent evidence suggests that empowerment can foster ambidextrous innovation—balancing exploration and exploitation—through knowledge sharing, and that organizational trust can amplify these effects by lowering transaction costs and encouraging open exchange (13). Moreover, knowledge sharing can moderate or condition the relationship between human capital and job empowerment, implying that capability resources alone are insufficient unless knowledge-sharing mechanisms are active and normalized (14). This line of evidence underscores that empowerment initiatives should be designed alongside KM mechanisms that institutionalize sharing behaviors, build trust, and align incentives.

Digitalization adds another layer of complexity and opportunity to empowerment and KM integration. Knowledge processes are increasingly mediated by digital platforms, social media, and collaborative technologies, which expand knowledge reach but also increase risks associated with overload, fragmentation, and low-quality content. Studies of social media-based communities show that digital environments can facilitate knowledge creation and exchange by combining user knowledge, experience, and community interactions, thereby influencing brand- and organization-level outcomes (15, 16). In organizational settings, technology-enabled KM requires governance structures, standards, and routines for codification, retrieval, and reuse, alongside social mechanisms that support participation. The SECI logic of knowledge conversion—socialization, externalization, combination, and internalization—has been used to explain how IT adaptation can support knowledge transformation when organizations manage both technological and behavioral requirements (17). Digital HR systems similarly contribute by formalizing learning and development processes, enabling access to training resources, and supporting capability-building pathways. Recent model development work on electronic HR training and development systems emphasizes their potential role in strengthening administrative system health and improving HR development outcomes (18). These insights suggest that empowerment within a KM orientation should explicitly consider digital infrastructure as an enabling platform, while ensuring that technology adoption is aligned with cultural and behavioral readiness.

Incentives and motivational architectures represent another essential pillar in KM-oriented empowerment. Even in organizations with advanced repositories and collaborative platforms, employees may underinvest in documentation and sharing if incentives are misaligned. Contemporary research has explored incentive design, including gamification, as an approach to motivate knowledge contributions and sustain engagement in KM activities over time (19). Motivational considerations are also tied to broader social and relational resources. Social capital and teamwork, for example, can enhance job performance by strengthening coordination and facilitating access to diverse knowledge resources, which reinforces the importance of team-based empowerment and collaborative climates (20). At the macro level, the interplay between human capital and social capital is also associated with innovation performance, implying that empowerment and KM can contribute to broader innovation outcomes when organizations develop both individual capabilities and relational networks (21). Accordingly, designing empowerment models within KM should address both extrinsic and intrinsic motivation, and should attend to the social architecture that enables knowledge to flow.

In parallel, the literature emphasizes that empowerment and KM are embedded in strategic HRM systems and organizational structures. Strategic HRM actions aligned with KM can influence organizational performance, particularly when HR practices support learning, participation, and capability development. Evidence from public and sectoral contexts indicates that KM and strategic HRM actions jointly shape performance outcomes, reinforcing the argument that empowerment should be configured as part of an integrated HR-KM strategy rather than a discrete program (22). Moreover, sectoral and organizational contexts matter: empowerment and KM models need localization and cultural adaptation to reflect institutional constraints, values, and work practices. Studies on the localization of KM in government organizations highlight the importance of aligning KM with indigenous cultural and ethical foundations, implying that empowerment models should also be culturally congruent to be operationally viable (4). This is particularly relevant in complex, high-stakes industries where safety, regulatory compliance, and coordination requirements are non-negotiable.

The need for context-sensitive empowerment and KM models becomes especially salient in project-based and technically intensive domains. Projects differ from routine operations because they involve temporary structures, interdisciplinary interfaces, and high levels of uncertainty. Consequently, knowledge discontinuities—such as lessons learned not being transferred across projects—can generate repeated errors, efficiency losses, and safety risks. Research on productivity and task processes in knowledge-intensive technical work indicates that understanding and improving work processes can enhance productivity, suggesting that structured approaches to capturing and reusing knowledge are crucial for complex project environments (23). In parallel, conceptual work on management knowledge development emphasizes the importance of rigorous empirical approaches and methodological discipline in building actionable management knowledge, which supports the rationale for systematic modeling methods in complex organizational phenomena (24). When empowerment is considered in such environments, the interdependencies among factors—leadership, participation, training, technology use, change management, commitment, and support—are likely to be stronger and more consequential, making structural modeling approaches particularly appropriate.

Recent studies have increasingly pursued model development to identify empowerment factors and their structural relationships with KM. For example, empowerment components and indicators have been examined in virtual education contexts through a KM lens, suggesting that digital learning modalities can be leveraged to build empowerment capabilities when KM principles guide content and process design (25). Strategic mapping and integrated modeling approaches have also been applied to empowerment, including meta-synthesis combined with interpretive-structural techniques to structure empowerment drivers in specific industries and to enable prioritization and sequencing of interventions (26). Related efforts have identified and predicted empowerment factors based on organizational structure and KM among employees, providing evidence that empowerment drivers can be empirically modeled and used for predictive and diagnostic purposes in organizational settings (27). Additional research has emphasized empowerment's roles in KM-driven performance improvement, confirming the relevance of psychological empowerment as a mediator between KM practices and performance outcomes (2, 7). These contributions collectively support the premise that empowerment factors can be systematically identified, screened, and structurally arranged to guide managerial action.

Nevertheless, gaps remain in understanding how empowerment factors interrelate and how they should be sequenced to build KM capabilities effectively. Many studies test linear relationships (e.g., empowerment → commitment → performance), but fewer address the structural hierarchy of factors and the feedback mechanisms among them. In complex organizations, interventions often fail because they target symptoms (e.g., low knowledge sharing) without addressing upstream drivers (e.g., leadership commitment, participation structures, or training systems). The ISM methodology is particularly well-suited for such contexts because it enables researchers to convert expert judgments into a multi-level structural model that clarifies dependence and driving power. When paired with expert-consensus methods (e.g., Delphi or fuzzy Delphi), ISM can help identify robust factors and map their directional relationships to produce an actionable hierarchy of interventions. Prior applications of interpretive-structural modeling in empowerment contexts demonstrate its utility for strategic mapping and prioritization, especially when empowerment is conceptualized as a system of interdependent conditions (26). At the same time, advancing such modeling requires careful factor identification, rigorous screening, and transparent articulation of conceptual definitions, which aligns with broader calls for methodological rigor in management knowledge development (24).

Another underexplored dimension concerns the role of managerial information and reporting in empowerment and KM. Human capital reporting and HR accounting information can influence managerial understanding, resource allocation, and the perceived legitimacy of empowerment investments. Research on human capital reporting emphasizes that disclosure practices can shape stakeholder perceptions and managerial priorities, which can indirectly influence empowerment and KM initiatives by affecting accountability and strategic focus (28). Similarly, studies examining the provision of information on human resource accounting suggest that informational transparency can affect management performance, highlighting the managerial value of structured HR information systems for decision-making and performance oversight (29). These insights reinforce that a KM-oriented empowerment model should be compatible with managerial measurement and reporting systems that enable monitoring, evaluation, and iterative improvement.

The present study is positioned within this theoretical and practical landscape and responds to the need for an integrated, context-sensitive, and structurally explicit model of empowerment factors oriented around KM. In project-based marine contexts, where technical complexity, safety requirements, and inter-organizational interfaces are pronounced, the interactions among empowerment drivers are likely to be non-linear and hierarchical. Inter-organizational collaboration and networking, for instance, can be decisive for knowledge transfer across contractors, suppliers, and operational units, linking strategic and operational knowledge flows. Empirical and conceptual work suggests that strategic models can incorporate both intra- and inter-organizational mechanisms to support HR self-development in governmental and complex organizational settings, providing a relevant parallel for project-based industries with multiple stakeholders (30). In addition, emergent reviews and synthesis studies underline that empowerment continues to be a central determinant of HR performance and organizational productivity, reinforcing the managerial importance of clarifying empowerment pathways and intervention priorities

(31). Given the importance of KM strategies in operational systems such as supply chains and project networks, selecting and aligning KM strategies with organizational conditions is also essential to ensure that empowerment initiatives translate into performance outcomes (32). Therefore, an ISM-based model that clarifies the hierarchy and dependencies among empowerment factors offers both theoretical contribution and practical guidance.

Overall, the literature indicates strong conceptual linkages among empowerment, KM, knowledge sharing, organizational support, commitment, innovation, digital systems, and performance; however, it also indicates the necessity of structurally mapping these linkages to guide effective implementation. Existing studies provide evidence for individual relationships—such as empowerment's effects on commitment and innovation (5, 6), KM's effects on performance (1, 2), and knowledge sharing's mediating or moderating roles (13, 14)—yet fewer studies develop an ordered, multi-level model that identifies which factors function as fundamental drivers and which emerge as dependent outcomes in a specific operational context. Addressing this gap can help managers prioritize interventions, allocate resources efficiently, and avoid fragmented empowerment programs that lack systemic coherence, while also supporting researchers in refining theoretical mechanisms linking empowerment and KM.

The aim of this study is to design and validate a hierarchical interpretive-structural model of human resource empowerment factors with a knowledge management orientation in marine projects, using expert-based screening and structural mapping to identify key drivers, dependencies, and intervention priorities.

Methods and Materials

The present study is generally qualitative in nature, and interviews were used for data collection. This research is considered an exploratory study aimed at designing a model for human resource empowerment with a knowledge management orientation, using the Delphi method and the ISM model in the context of marine projects. Since the study also provides practical recommendations, it can also be regarded as applied research. Therefore, in terms of research approach, this study is classified as exploratory–applied.

The present study, in terms of its nature, is defined as exploratory research because it examines an issue that has not previously been addressed in this manner or at this level. The purpose of this research is to provide new and practical insights into human resource empowerment from a knowledge management perspective.

Findings and Results

The present study, entitled *"Designing a Model of the Impact of Human Resource Empowerment Factors with a Knowledge Management Orientation Using the ISM Approach (Case Study: Marine Projects),"* investigates the key factors influencing human resource empowerment and examines the role of knowledge management in this process using various techniques, particularly Interpretive Structural Modeling (ISM). The main objective of this study is to develop a comprehensive model of the influence of different empowerment factors on knowledge management and to identify the relationships among these factors in marine projects.

To validate and screen the human resource empowerment factors with a knowledge management orientation, the Fuzzy Delphi method was employed, as presented below.

At this stage, 81 components related to the research topic (measuring the impact of human resource empowerment components on knowledge management) were initially identified. To achieve expert consensus, the Fuzzy Delphi method was applied. Accordingly, a questionnaire containing all 81 components was designed and distributed to 12 experts. After data collection and analysis, it was found that the defuzzified values of 36 factors exceeded 0.80 (the threshold value). Therefore, 36 components were confirmed by all experts, and the remaining components were rejected.

Table 1. Accepted Components in the First Round

No.	Components	Fuzzy Mean (L)	Fuzzy Mean (M)	Fuzzy Mean (U)	Defuzzified Value	Status
1	Knowledge-Oriented Leadership and Management	0.6667	0.9167	1.0000	0.8611	Accepted
2	Participation	0.6250	0.8750	1.0000	0.8333	Accepted
3	Provision of Specialized Training	0.6250	0.8750	0.9583	0.8194	Accepted
4	Development of Training Programs	0.6458	0.8958	1.0000	0.8472	Accepted
5	Networking and Inter-Organizational Collaboration	0.6250	0.8750	1.0000	0.8333	Accepted
6	Human Resource Motivation	0.6042	0.8542	0.9792	0.8125	Accepted
7	Recognition and Reward	0.7500	1.0000	1.0000	0.9167	Accepted
8	Learning and Innovation Culture	0.6875	0.9375	1.0000	0.8750	Accepted
9	Team Building and Collaboration	0.6250	0.8750	1.0000	0.8333	Accepted
10	Use of Modern Technologies	0.6250	0.8750	1.0000	0.8333	Accepted
11	Career Advancement Opportunities	0.6458	0.8958	1.0000	0.8472	Accepted
12	Provision of Individual Development Programs	0.6042	0.8542	1.0000	0.8194	Accepted
13	Change Management	0.6875	0.9375	1.0000	0.8750	Accepted
14	Organizational Commitment	0.6458	0.8958	1.0000	0.8472	Accepted
15	Reward	0.6250	0.8750	1.0000	0.8333	Accepted
16	Improvement of Technical Infrastructure	0.5833	0.8333	1.0000	0.8056	Rejected
17	Job Enrichment	0.6250	0.8750	0.9792	0.8264	Accepted
18	Educational Opportunities	0.6458	0.8958	0.9792	0.8403	Accepted
19	Supportive Policies	0.6875	0.9375	1.0000	0.8750	Accepted
20	Professional Development Opportunities	0.6875	0.9375	1.0000	0.8750	Accepted
21	Quality Improvement Programs	0.6875	0.9375	1.0000	0.8750	Accepted
22	Individual Development Opportunities	0.6875	0.9375	1.0000	0.8750	Accepted
23	Professional Networking	0.5833	0.8333	1.0000	0.8056	Accepted
24	Employee Engagement and Involvement	0.6667	0.9167	1.0000	0.8611	Accepted
25	Participation in Decision Making	0.6875	0.9375	1.0000	0.8750	Accepted
26	Organizational Support	0.6458	0.8958	1.0000	0.8472	Accepted
27	Organizational Flexibility	0.6667	0.9167	1.0000	0.8611	Accepted
28	Establishment of Documentation Procedures	0.6667	0.9167	1.0000	0.8611	Accepted
29	Knowledge-Oriented Leadership	0.6458	0.8958	1.0000	0.8472	Accepted
30	Existence of Knowledge Networks	0.6250	0.8750	1.0000	0.8333	Accepted
31	Creativity and Innovation	0.7500	1.0000	1.0000	0.9167	Accepted
32	Delegation of Authority	0.5833	0.8333	1.0000	0.8056	Accepted
33	Technical Support	0.6042	0.8542	0.9792	0.8125	Accepted
34	Process Documentation	0.6042	0.8542	1.0000	0.8194	Accepted
35	Change Management	0.6250	0.8750	1.0000	0.8333	Accepted
36	Knowledge-Oriented Performance Evaluation	0.7292	0.9792	1.0000	0.9028	Accepted

In the previous stage, out of the initial 81 components, 36 were accepted. At this stage, another questionnaire was developed and again submitted for evaluation by 15 experts. After data collection and analysis, it was determined that the defuzzified values of 12 factors exceeded 0.80 (the threshold value). Consequently, 12 components were confirmed by all experts, and the remaining components were rejected.

Table 2. Accepted Components in the Second Round

No.	Components	Fuzzy Mean (L)	Fuzzy Mean (M)	Fuzzy Mean (U)	Defuzzified Value	Status
1	Knowledge-Oriented Leadership and Management	0.6333	0.8833	0.9667	0.8278	Accepted
2	Participation	0.6833	0.9333	0.9833	0.8667	Accepted
3	Provision of Specialized Training	0.6167	0.8667	0.9667	0.8167	Accepted
4	Networking and Inter-Organizational Collaboration	0.6000	0.8500	0.9667	0.8056	Accepted
5	Human Resource Motivation	0.6000	0.8500	0.9500	0.8000	Accepted
6	Use of Modern Technologies	0.6167	0.8667	0.9833	0.8222	Accepted
7	Change Management	0.6333	0.8833	0.9833	0.8333	Accepted
8	Organizational Commitment	0.6167	0.8667	0.9833	0.8222	Accepted
9	Organizational Support	0.6167	0.8667	0.9833	0.8222	Accepted
10	Organizational Flexibility	0.6833	0.9333	1.0000	0.8722	Accepted
11	Creativity and Innovation	0.6167	0.8667	0.9833	0.8222	Accepted
12	Knowledge-Oriented Performance Evaluation	0.6167	0.8667	0.9667	0.8167	Accepted

In the previous stage, out of the 36 components from the second round, 12 were accepted. At this stage, another questionnaire was developed and again submitted to the experts for evaluation. After data collection and analysis, it was found that the defuzzified values of the same 12 factors obtained in the previous stage remained above 0.80 (the threshold value). Therefore, the same 12 components were once again confirmed by all experts. Table 3 presents the results of the Fuzzy Delphi process in the third round.

Table 3. Accepted Components in the Third Round

No.	Components	Fuzzy Mean (L)	Fuzzy Mean (M)	Fuzzy Mean (U)	Defuzzified Value	Status
1	Knowledge-Oriented Leadership and Management	0.6167	0.8667	0.9667	0.8167	Accepted
2	Participation	0.6167	0.8667	0.9833	0.8222	Accepted
3	Provision of Specialized Training	0.6333	0.8833	0.9667	0.8278	Accepted
4	Networking and Inter-Organizational Collaboration	0.6000	0.8500	0.9667	0.8056	Accepted
5	Human Resource Motivation	0.6167	0.8667	0.9667	0.8167	Accepted
6	Use of Modern Technologies	0.6167	0.8667	0.9833	0.8222	Accepted
7	Change Management	0.6167	0.8667	0.9833	0.8222	Accepted
8	Organizational Commitment	0.6833	0.9333	0.9833	0.8667	Accepted
9	Organizational Support	0.6000	0.8500	0.9500	0.8000	Accepted
10	Organizational Flexibility	0.6167	0.8667	0.9667	0.8167	Accepted
11	Creativity and Innovation	0.6333	0.8833	0.9833	0.8333	Accepted
12	Knowledge-Oriented Performance Evaluation	0.6833	0.9333	1.0000	0.8722	Accepted

In this section, the 12 components confirmed through the Fuzzy Delphi method are hierarchically structured using the ISM approach. The stages of this method are presented below.

In the first step, the Structural Self-Interaction Matrix of the study is constructed based on respondents' judgments. To form the SSIM, experts consider the criteria in pairs and respond to the pairwise comparisons according to the following scale:

V: Factor in row *i* leads to the realization of the factor in column *j*.

A: Factor in column *j* leads to the realization of the factor in row *i*.

X: Both factors in the row and column lead to the realization of each other (i.e., factors *i* and *j* have a bidirectional relationship).

O: There is no relationship between the factor in the row and the factor in the column.

Table 4. Structural Self-Interaction Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	—	V	V	V	V	V	V	V	V	V	V	V
C2		—	O	X	O	O	X	A	O	O	V	O
C3			—	O	V	X	A	A	A	O	V	O
C4				—	V	O	O	O	O	O	V	O
C5					—	O	O	O	O	O	V	A
C6						—	X	O	O	O	X	O
C7							—	X	X	X	X	A
C8								—	X	X	X	V
C9									—	X	X	V
C10										—	V	V
C11											—	A
C12												—

In the second step, the initial reachability matrix must be constructed by converting the Structural Self-Interaction Matrix (SSIM) into binary values (0 and 1). For this purpose, the following rules are applied:

If the symbol in cell *ij* is V, a value of 1 is placed in that cell and 0 is placed in the symmetric cell.

If the symbol in cell *ij* is A, a value of 0 is placed in that cell and 1 is placed in the symmetric cell.

If the symbol in cell *ij* is X, a value of 1 is placed in that cell and 1 is also placed in the symmetric cell.

If the symbol in cell *ij* is O, a value of 0 is placed in that cell and 0 is also placed in the symmetric cell.

Table 5. Initial Reachability Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	1	1	1	1	1	1	1	1	1	1	1	1
C2	0	1	0	1	0	0	1	0	0	0	1	0
C3	0	0	1	0	1	1	0	0	0	0	1	0
C4	0	1	0	1	1	0	0	0	0	0	1	0
C5	0	0	0	0	1	0	0	0	0	0	1	0
C6	0	0	1	0	0	1	1	0	0	0	1	0
C7	0	1	1	0	0	1	1	1	1	1	1	0
C8	0	1	1	0	0	0	1	1	1	1	1	1
C9	0	0	1	0	0	0	1	1	1	1	1	1
C10	0	0	0	0	0	0	1	1	1	1	1	1
C11	0	0	0	0	0	1	1	1	1	0	1	0
C12	0	0	0	0	1	0	1	0	0	0	1	1

After obtaining the initial reachability matrix, its internal consistency must be established. For example, if Variable 1 leads to Variable 2 and Variable 2 leads to Variable 3, then Variable 1 must also lead to Variable 3. If this condition is not reflected in the reachability matrix, the matrix must be revised and such relationships must be added or corrected. This consistency is achieved by incorporating transitive (secondary) relationships into the initial reachability matrix, even if they were not directly identified. In Table 6, the cells marked with 1* indicate relationships that were added during the process of developing the consistent matrix.

Table 6. Consistent Initial Reachability Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	Driving Power
C1	1	1	1	1	1	1	1	1	1	1	1	1	12
C2	0	1	1*	1	1*	1*	1	1*	1*	1*	1	0	10
C3	0	0	1	0	1	1	1*	1*	1*	0	1	0	7
C4	0	1	0	1	1	1*	1*	1*	1*	0	1	0	8
C5	0	0	0	0	1	1*	1*	1*	1*	0	1	0	6
C6	0	1*	1	0	1*	1	1	1*	1*	1*	1	0	9

C7	0	1	1	1*	1*	1	1	1	1	1	1	1*	11
C8	0	1	1	1*	1*	1*	1	1	1	1	1	1	11
C9	0	1*	1	0	1*	1*	1	1	1	1	1	1	10
C10	0	1*	1*	0	1*	1*	1	1	1	1	1	1	10
C11	0	1*	1*	0	0	1	1	1	1	1*	1	1*	9
C12	0	1*	1*	0	1	1*	1	1*	1*	1*	1	1	10
Dependence	1	10	10	5	11	12	12	12	12	9	12	7	

In this step, the input (prerequisite) set and the output (reachability) set are calculated for each criterion, and then the intersection set is identified. A criterion is assigned to the highest level when its output (reachability) set is equal to its intersection set. After identifying this variable (or variables), the corresponding row and column are removed from the table, and the procedure is repeated for the remaining criteria. The outputs and inputs are extracted from the consistent initial reachability matrix. Specifically, the number of 1s in each row represents the output set, and the number of 1s in each column represents the input set. The results for determining Level 1 are presented in Table 7.

Table 7. Level 1 Criteria

Criterion	Output Set	Input Set	Intersection Set	Level
C1	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C1–	C1–	
C2	C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–	C1–C2–C4–C6–C7–C8–C9–C10–C11–C12	C2–C4–C6–C7–C8–C9–C10–C11–	
C3	C3–C5–C6–C7–C8–C9–C11–	C1–C2–C3–C6–C7–C8–C9–C10–C11–C12	C3–C6–C7–C8–C9–C11–	
C4	C2–C4–C5–C6–C7–C8–C9–C11–	C1–C2–C4–C7–C8–	C2–C4–C7–C8–	
C5	C5–C6–C7–C8–C9–C11–	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C12	C5–C6–C7–C8–C9–	
C6	C2–C3–C5–C6–C7–C8–C9–C10–C11–	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C2–C3–C5–C6–C7–C8–C9–C10–C11–	1
C7	C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	1
C8	C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	1
C9	C2–C3–C5–C6–C7–C8–C9–C10–C11–C12	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C2–C3–C5–C6–C7–C8–C9–C10–C11–C12	1
C10	C2–C3–C5–C6–C7–C8–C9–C10–C11–C12	C1–C2–C6–C7–C8–C9–C10–C11–C12	C2–C6–C7–C8–C9–C10–C11–C12	
C11	C2–C3–C6–C7–C8–C9–C10–C11–C12	C1–C2–C3–C4–C5–C6–C7–C8–C9–C10–C11–C12	C2–C3–C6–C7–C8–C9–C10–C11–C12	1
C12	C2–C3–C5–C6–C7–C8–C9–C10–C11–C12	C1–C7–C8–C9–C10–C11–C12	C7–C8–C9–C10–C11–C12	

In Table 7, the Level 1 criteria were extracted, including criteria C6, C7, C8, C9, and C11. To determine the Level 2 criteria, the rows and columns corresponding to these five criteria were removed from the consistent initial reachability matrix (Table 6), and the calculations for output and input were performed again. The results are presented in Table 8.

Table 8. Level 2 Criteria

Criterion	Output Set	Input Set	Intersection Set	Level
C1	C1–C2–C3–C4–C5–C10–C12	C1–	C1–	
C2	C2–C3–C4–C5–C10–	C1–C2–C4–C10–C12	C2–C4–C10–	
C3	C3–C5–	C1–C2–C3–C10–C12	C3–	
C4	C2–C4–C5–	C1–C2–C4–	C2–C4–	
C5	C5–	C1–C2–C3–C4–C5–C10–C12	C5–	2
C10	C2–C3–C5–C10–C12	C1–C2–C10–C12	C2–C10–C12	
C12	C2–C3–C5–C10–C12	C1–C10–C12	C10–C12	

In Table 8, the Level 2 criterion was identified as C5. To determine the Level 3 criteria, the row and column corresponding to this criterion were removed from the consistent initial reachability matrix, and the calculations of output and input were performed again. The results are presented in Table 9.

Table 9. Level 3 Criteria

Criterion	Output Set	Input Set	Intersection Set	Level
C1	C1–C2–C3–C4–C10–C12	C1–	C1–	
C2	C2–C3–C4–C10–	C1–C2–C4–C10–C12	C2–C4–C10–	
C3	C3–	C1–C2–C3–C10–C12	C3–	3
C4	C2–C4–	C1–C2–C4–	C2–C4–	3
C10	C2–C3–C10–C12	C1–C2–C10–C12	C2–C10–C12	
C12	C2–C3–C10–C12	C1–C10–C12	C10–C12	

In Table 9, the Level 3 criteria were identified as C3 and C4. To determine the Level 4 criteria, the rows and columns corresponding to these two criteria were removed from the consistent initial reachability matrix, and the calculations of output and input were repeated. The results are presented in Table 10.

Table 10. Level 4 Criteria

Criterion	Output Set	Input Set	Intersection Set	Level
C1	C1–C2–C10–C12	C1–	C1–	
C2	C2–C10–	C1–C2–C10–C12	C2–C10–	4
C10	C2–C10–C12	C1–C2–C10–C12	C2–C10–C12	4
C12	C2–C10–C12	C1–C10–C12	C10–C12	

In Table 10, the Level 4 criteria were identified as C2 and C10. To determine the Level 5 criteria, the rows and columns corresponding to these two criteria were removed from the consistent initial reachability matrix, and the calculations of output and input were performed again. The results are presented in Table 11.

Table 11. Level 5 and Level 6 Criteria

Criterion	Output Set	Input Set	Intersection Set	Level
C1	C1–C12	C1–	C1–	6
C12	C12	C1–C12	C12	5

In the fifth step, using the levels obtained for the criteria, the interaction network is constructed, and the final diagram is drawn by eliminating transitive links and segmenting the levels. In this research model, six levels exist. At the sixth level, the criterion of knowledge-oriented leadership and management is identified as the most influential factor and directly affects the criterion of knowledge-oriented performance evaluation at the fifth level. This criterion, in turn, influences the Level 4 criteria. In addition, the five Level 1 criteria, namely use of modern technologies, change management, organizational commitment, organizational support, and creativity and innovation, are directly influenced by the human resource motivation criterion.

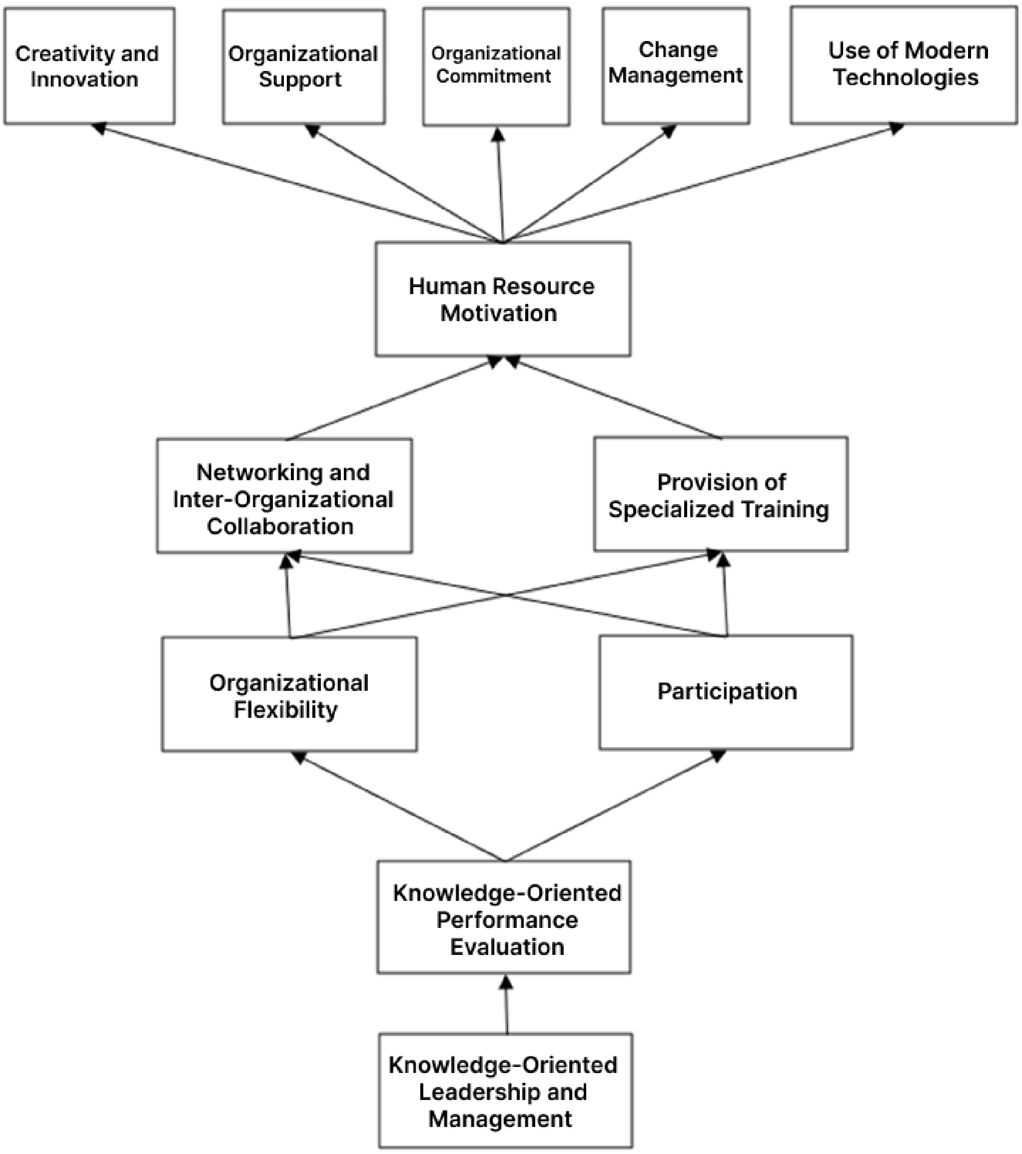

Figure 1. ISM Model of the Study

The research model can also be illustrated in terms of driving power and dependence, as shown in Figure 2. Accordingly, knowledge-oriented leadership and management (C1) and networking and inter-organizational collaboration (C4) are classified as independent variables. These variables exhibit low dependence and high driving power; in other words, they are characterized by high influence and low susceptibility. The human resource motivation criterion (C5) is classified as a dependent variable, with strong dependence and weak driving power. This criterion is therefore highly susceptible to influence and exerts limited influence on the system. The remaining criteria are classified as linkage variables. These variables possess both high dependence and high driving power; in other words, both their influence and susceptibility are very high, and any small change in these variables leads to fundamental changes in the system.

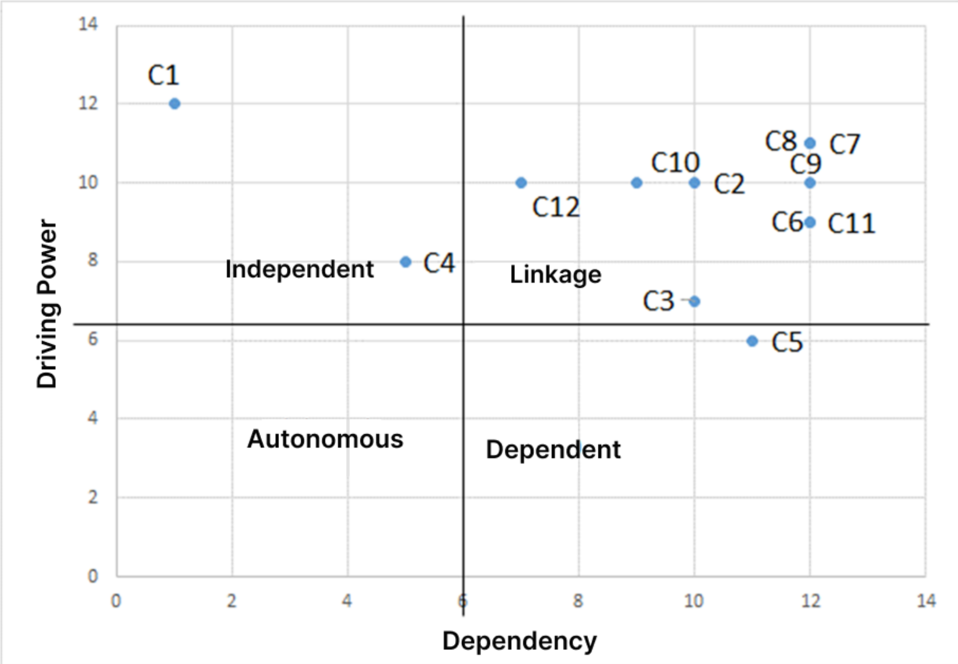

Figure 2. Driving Power–Dependence Matrix

Discussion and Conclusion

The present study aimed to design and validate a hierarchical model of human resource empowerment factors with a knowledge management orientation in marine projects using the ISM approach. The findings reveal a structured, multi-level system in which empowerment factors do not operate independently but rather interact in a layered and directional manner. At the highest level of influence, *knowledge-oriented leadership and management* emerged as the most powerful driving variable, exerting a direct impact on *knowledge-oriented performance evaluation*, which in turn influences mid-level organizational and behavioral factors. At the lower levels of the model, operational and behavioral outcomes—namely the *use of modern technologies, change management, organizational commitment, organizational support, and creativity and innovation*—were found to be primarily shaped by *human resource motivation*. This configuration indicates that empowerment in marine projects is fundamentally a leadership-driven, knowledge-centered system, with motivation functioning as the critical transmission mechanism that converts strategic direction into operational behavior.

These results are strongly aligned with prior empirical and theoretical research emphasizing the centrality of leadership in enabling knowledge processes and empowerment climates. Knowledge-oriented leadership has been shown to directly affect organizational learning, decision quality, and knowledge utilization, particularly in complex operational contexts (1, 3). The dominance of leadership in the highest level of the ISM model corroborates the argument that without sustained managerial commitment and strategic guidance, neither technological infrastructure nor employee autonomy can generate lasting empowerment or knowledge performance (9, 24). In knowledge-intensive environments such as marine projects, leadership's role in coordinating interdependent actors and aligning KM initiatives with strategic goals becomes especially decisive, confirming earlier observations regarding leadership's foundational influence on empowerment effectiveness (5).

The placement of *knowledge-oriented performance evaluation* at the second-highest level of the hierarchy reflects the critical mediating function of measurement and feedback systems in translating leadership intent into sustainable organizational behavior. Performance evaluation systems aligned with knowledge objectives institutionalize KM priorities and legitimize empowerment investments by embedding them within accountability structures. This finding is consistent with evidence that managerial information systems and human capital reporting shape strategic focus and influence management performance (28, 29). Furthermore, research suggests that KM-aligned evaluation frameworks reinforce learning behaviors, stimulate knowledge sharing, and strengthen organizational memory (4, 32). Therefore, the present model's structure supports the view that empowerment must be anchored not only in leadership values but also in performance systems that reward knowledge behaviors and learning outcomes.

At the mid-levels of the ISM model, variables such as *networking and inter-organizational collaboration, participation, specialized training, organizational flexibility,* and *organizational commitment* were identified as linkage factors, characterized by both high driving power and high dependence. This indicates that these factors function as structural transmission channels through which strategic intent and leadership influence are converted into employee-level empowerment and knowledge practices. The prominence of networking and collaboration in particular reflects the project-based and inter-organizational nature of marine operations, where knowledge boundaries extend across contractors, suppliers, and regulatory agencies. This finding aligns with studies emphasizing the strategic importance of human capital and social capital in driving innovation and performance (20, 21). It also corresponds with recent evidence that inter-organizational empowerment models enhance HR self-development in public and complex organizational systems (30).

The identification of *human resource motivation* as a dependent variable occupying a lower hierarchical position but exerting direct influence on multiple operational outcomes highlights motivation's catalytic role in empowerment systems. Motivation translates structural conditions and managerial intent into actual behavior—knowledge sharing, innovation, adaptability, and commitment. This supports extensive prior research showing that empowerment initiatives enhance job satisfaction and motivation, which in turn reinforce organizational commitment and performance (5, 8). Moreover, the mediating role of psychological empowerment between KM and sustainable employee performance has been empirically confirmed (2, 7). The present findings extend this evidence by demonstrating that motivation is not merely an outcome but also a functional bridge linking leadership, knowledge systems, and frontline operational behaviors.

The model further reveals that the lowest level of empowerment outcomes—*use of modern technologies, change management, organizational commitment, organizational support, creativity and innovation*—are not independent drivers but consequences of higher-level structural and motivational conditions. This challenges simplistic views that technological investment or innovation programs alone can generate empowerment. Instead, the findings suggest that technological adoption and innovative behavior depend on leadership commitment, KM alignment, organizational structures, and motivational dynamics. This interpretation is consistent with evidence that digital KM systems and electronic HR platforms enhance empowerment only when embedded within supportive cultural and leadership frameworks (15, 18). Similarly, studies on ambidextrous innovation show that empowerment and knowledge sharing jointly foster creativity when supported by trust and organizational support (13). The current model therefore provides a coherent explanation for why fragmented empowerment initiatives—focused solely on tools or incentives—often fail to produce lasting change.

The MICMAC analysis further reinforces the systemic nature of empowerment in marine projects. The classification of *knowledge-oriented leadership and management* and *inter-organizational networking* as independent variables with high driving power and low dependence confirms their foundational role. These variables represent strategic levers that, once activated, initiate cascading effects throughout the system. This finding converges with research emphasizing the primacy of strategic leadership and human capital alignment in driving organizational transformation and performance (10, 31). In contrast, *human resource motivation* was categorized as a dependent variable, underscoring its sensitivity to upstream conditions and its limited ability to drive systemic change in isolation. The remaining linkage variables—training, participation, flexibility, commitment—function as structural stabilizers, capable of amplifying or dampening the effects of leadership interventions, a pattern consistent with KM models that highlight the interactive roles of structural, social, and cognitive mechanisms (17, 22).

Collectively, these findings contribute to both theory and practice by offering an integrated, empirically grounded architecture of empowerment in knowledge-intensive project environments. Unlike prior studies that examine pairwise relationships (e.g., empowerment–performance or KM–innovation), the present study demonstrates how empowerment factors form a hierarchical, interdependent system. This extends existing empowerment and KM literature by providing a structural explanation of causality and dependency among key drivers, thereby supporting calls for more systematic modeling of complex managerial phenomena (24, 26). The results also resonate with contemporary research highlighting the strategic value of KM-driven empowerment in enhancing decision-making quality, productivity, and organizational resilience (1, 11).

Despite its contributions, this study is subject to several limitations. First, the reliance on expert judgment, while appropriate for ISM modeling, introduces subjectivity that may influence factor selection and relationship strength. Second, the study's empirical context was confined to marine projects, which may limit generalizability to other industries with different structural and cultural characteristics. Third, the cross-sectional design prevents observation of dynamic changes in empowerment structures over time.

Future studies could extend this research by testing the proposed model quantitatively using structural equation modeling across diverse industries and organizational contexts. Longitudinal research designs would allow examination of how empowerment structures evolve as KM systems mature. Comparative studies between project-based and routine operational environments could further clarify contextual differences in empowerment dynamics. In addition, future research may integrate performance metrics to examine how specific configurations of empowerment factors influence organizational outcomes over time.

Managers in marine and other knowledge-intensive project environments should prioritize knowledge-oriented leadership development as the cornerstone of empowerment strategy. Organizations should align performance evaluation systems with KM objectives to institutionalize learning and knowledge behaviors. Investment in technology and innovation should be accompanied by interventions that strengthen motivation, participation, and inter-organizational collaboration. Empowerment programs should be designed systemically rather than as isolated HR initiatives, ensuring coherence among leadership practices, structural supports, and employee motivation mechanisms.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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