Exploring The Factors Influencing Knowledge Management Strategy in the European Shipbuilding Industry: A Pilot Study

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Knowledge is an important asset in shipbuilding. This paper aims to explore the key factors of knowledge management (KM) in European Shipbuilding to improve its strategic performance. This pilot study can form an important reference for knowledge management strategy implement in European shipbuilding. Data collected from project partners are used to test seven hypotheses by means of linear regression analysis, to identify the key factors of knowledge management strategy in European shipbuilding. This paper provides ideas for shipyards to consider when conducting knowledge management as part of the Smart European Shipbuilding (SEUS) project.

Keywords: knowledge management, European shipbuilding, knowledge management strategy

INTRODUCTION

The conception of knowledge management (KM) is not new, although the precise definition of KM has remained vague, due to its broad understanding in many fields. However, research into knowledge can be traced back to the last century. During the 1980s, many organizations realized that KM was an important business asset. A list of knowledge-related concepts was proposed, e.g., knowledge worker, knowledge engineering, etc. The notion of the knowledge worker was proposed by Peter Drucker, a respected researcher in the modern management field. He promised that knowledge is an important resource for the economy. This paper therefore intends to draw attention to both tacit and explicit knowledge, as well as contributing to research in KM.

KM has experienced various changes. For example, in the 1990s, KM practices emerged simultaneously with the technology boom. Information technology plays a crucial role in knowledge-related activities. Information systems facilitate the integration of business processes, information flows, and knowledge resources(Sambamurthy & Subramani, 2005). During this period, knowledge management became increasingly intertwined with information and technology. In the 21st century, KM was integrated into more tacit knowledge management. Organizations started to focus on the tacit knowledge asset. KM is now utilized for dealing with complex projects with semantic technology, e.g., leveraging semantic wikis for managing architectural knowledge (Boer & Vliet, 2011). KM has been widely used in different fields and strongly connected with organizational management and computer science. However, the core of knowledge management is still derived from early researchers' work in philosophy and psychology.

Furthermore, the development of labour-hungry industries in pre-industrial times spawned the need for organizational management. This also led to the need for conducting KM at the organizational management level.

Large and complex megaprojects are now becoming increasingly popular (Flyvbjerg, 2014). It is therefore meaningful to focus on knowledge management in such projects. Uncertainty adds to project complexity and is a fundamental aspect of it (Williams, 1999). It exists not only in the internal environment, but also in the external one. Effective management of uncertainty is significantly enhanced by both organizational and individual knowledge management and learning (Atkinson et al., 2006). Greater complexity necessitates more explorative learning (Eriksson et al., 2017). Therefore, knowledge management is an essential topic for a complex environment. The importance of KM does not decrease as time passes. In fact, the need for KM is increasing, even for traditional industries in post-industrial times in many developed countries. In the shipbuilding industry, the knowledge needed to bridge the gap between engineering and construction is now spread across various geographic locations (Kristoffersen, 2012). KM in complex projects in the shipbuilding industry must support a culture of knowledge creation, valorization, and sharing. However, KM is less integrated in shipbuilding, which is a traditional labour-hungry industry. The practice of KM is still expanding in this area.

Our research can promote a strong awareness and application of KM in European shipbuilding as part of the Smart European Shipbuilding (SEUS) project funded by Horizon Europe. Thus, this paper proposes the study of knowledge management based on SEUS by means of:

1. Introducing the key factors in a knowledge management based on a literature review.
2. Identifying the key factors in a knowledge management model based on knowledge practices in SEUS.

The practical contribution of this paper is based on shipbuilding practices in SEUS. Our objective is the European shipbuilding industry. The competitiveness in the global shipbuilding market is high. The construction time in shipbuilding is often over 12 months, but depends on the type of ship. A cruise ship may take longer time to build, compared with a fleet one. This differs from most industrial products. The long construction time can create more challenges for KM. According to Sharma and Tae-wan, heavy industries, such as shipbuilding, differ from consumer product ones. They require extensive customization in the design process and engineering software, focusing more on construction and assembly rather than production (Sharma & Tae-wan, 2010). This difference provides more flexibilities; at the same time, it produces greater requirements for knowledge management. Our plan for conducting research is based on the milestones in the shipbuilding lifecycle, as knowledge is generated, shared, and used in every stage. We first draw attention to the knowledge involved in each stage, then outline the key factors of knowledge management according to this lifecycle. The stages of shipbuilding involve six general phases: client requirements, the concept design, engineering, assembly and construction, sea trial and delivery, and operation and maintenance. These can be simplified into three main elements: preparation, assembly, and delivery.

1. We focus on the knowledge transmission based on the real work at different stages of shipbuilding.

During the client requirements phase, a large number of solutions for ship design and a schema of the ship are created. This stage also involves communication among different stakeholders to confirm the contract in both informal and formal ways. These informal ways may include e-mails, phone calls, and discussion. The next one is the concept design phase, during which complex concept documents are delivered. This involves a high level of design and technical knowledge, as well as familiarity with standards. The most time-consuming part during the lifecycle of shipbuilding is the engineering one, which encompasses a high number of 2D and 3D models, working schedules, bills of materials (BOM), etc. How do we do to have our advantages in the shipbuilding from knowledge management perspective. A strategic approach involves generating ideas and developing innovative solutions aimed at achieving a competitive edge(Geier, 2024). Therefore, knowledge management strategy can lead to the effective way of using knowledge asset to achieve the competitive edge in the market. We suggest that this paper includes the following novelty regarding knowledge management in shipbuilding practice:

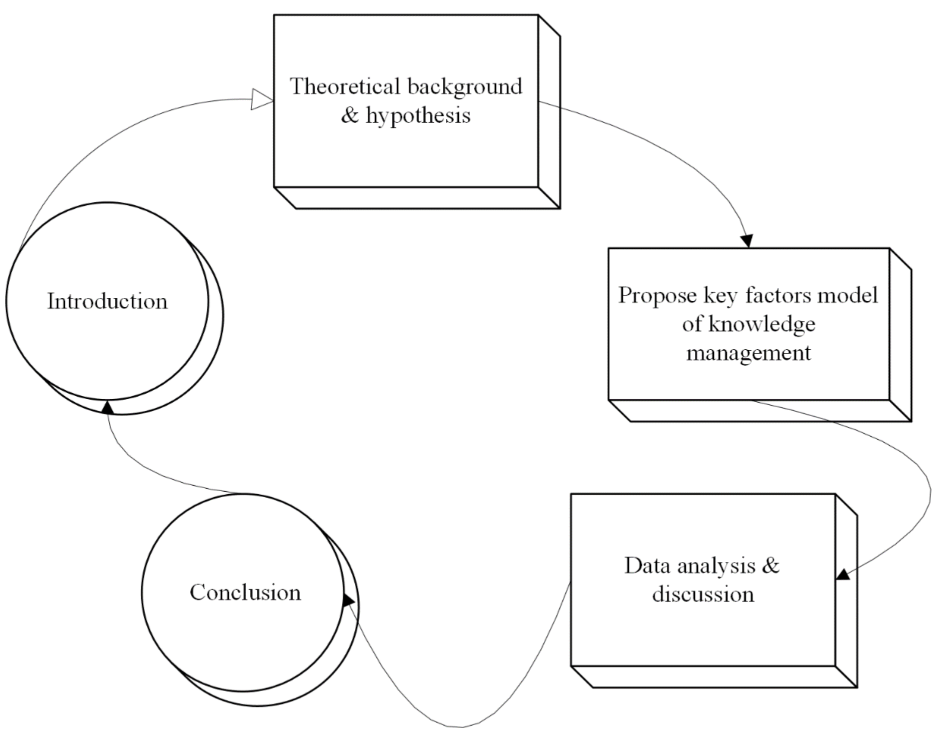
1. We focus on knowledge management based on the strategic needs in the shipbuilding lifecycle in SEUS.

The shift of maritime and shipbuilding supply chains towards digital ecosystems increases operational complexity and necessitates reliable communication and coordination (Diaz et al., 2023). This drives the need to promote effective knowledge sharing, which leads to sustainable shipbuilding. Project teams are not only organizationally but also geographically dispersed, with diverse backgrounds and multiple languages(Kasvi et al., 2003). Knowledge management plays a crucial role in connecting them and aligning their focus on the project's goals. On the one hand, various factors influence knowledge sharing among individuals. On the other, the differing constraints and requirements of projects make optimizing and facilitating knowledge sharing among employees a complex issue (Hosseini & Akhavan, 2017). Based on the aforesaid points, our paper contributes in the following aspects:

1. Taking all the possible parameters into account in knowledge management in SEUS and developing a comprehensive knowledge management model for SEUS.
2. Identifying the knowledge management model for shipbuilding practices based on a survey of European shipyards.
3. Analysing the shipbuilding lifecycle in SEUS.
4. Focusing on knowledge sharing in knowledge management in SEUS.

The research question of this paper is: how strongly are the following factors related to knowledge management in European shipbuilding? This study focuses on two main areas: knowledge management and European shipbuilding. The structure of this paper is outlined in Figure 1 and the individual steps in the process are then described.

FIGURE 1
WORKFLOW FOR EXPLORING KNOWLEDGE MANAGEMENT IN EUROPEAN SHIPBUILDING



Step 1: Based on the research question, we collect relevant literature regarding knowledge management in shipbuilding. We employ "ScienceDirect" and "Scopus" to gather publications in the areas of

“knowledge management”, “industry”, “shipbuilding” and” factors”, using the following groupings: Group 1: “knowledge management “AND “industry”, Group 2: “knowledge management” AND “shipbuilding”, and Group 3: “knowledge management” AND “factors” AND “shipbuilding”.

Table 1 shows the current data for publications about knowledge management in shipbuilding. We can see that there are far fewer works on knowledge management in shipbuilding, although this number may change in the future. Our study can enhance the research in this field.

TABLE 1
THE NUMBER OF PUBLICATIONS ON KNOWLEDGE MANAGEMENT IN SHIPBUILDING BY RELEVANCE

Source	Group Number	Number of Publications	Source	Number of Publications
ScienceDirect	Group 1	19341	Scopus	12649
ScienceDirect	Group 2	195	Scopus	62
ScienceDirect	Group 3	165	Scopus	0

Step 2: We propose a hypothesis based on the literature review for each factor of knowledge management in shipbuilding.

Step 3: We create a framework outlining the relationships between the factors involved in knowledge management in shipbuilding.

Step 4: We analyse whether we can use multiple linear regression analysis in this case. We identify all the factors and whether they are related to knowledge management in SEUS through a questionnaire survey.

Step 5: Discussion and conclusions.

THEORETICAL BACKGROUND AND HYPOTHESIS

Knowledge Transmission in a Shipyard

In shipyards, a large amount of tacit knowledge is used during and even before the assembly phase. Shipyards can offer practically feasible alternative layouts based on the tacit knowledge gained through experience (Dixit et al., 2020). We need to focus more on the knowledge transmission during the preparation and assembly phases. As we have mentioned, obstacles to knowledge transmission arise not only in the assembly phase, but also in the preparation one. This includes the design process, which is considered a milestone in shipbuilding. According to Tann and Shaw, due to higher costs, shipyards spend significantly more time on the typical design and construction process. The design phase, along with its communications and decisions, greatly impacts the potential savings in manufacturing (Tann & Shaw, 2007).

FIGURE 2
THE TRANSMISSION OF KNOWLEDGE IN SHIPBUILDING

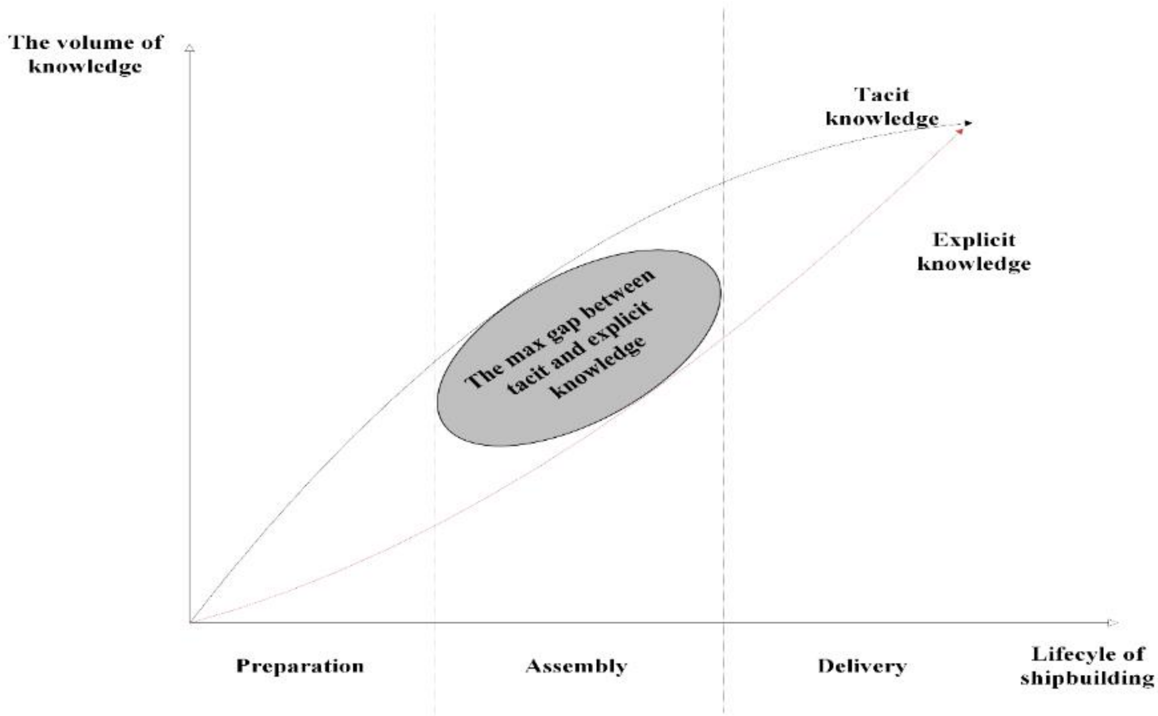


Figure 2 illustrates knowledge transmission during the lifecycle of shipbuilding. The black dotted curved line represents the change in the incrementation of tacit knowledge and the red dotted curved line corresponds to that of the explicit type. The shift in tacit knowledge in shipbuilding always develops quickly in the assembly and construction phase, as a high level of practical knowledge is created and delivered during this time. At the end of the shipbuilding lifecycle, the incrementation of tacit knowledge drops, although its volume rises. Tacit knowledge still plays a pivotal role in the final phase of shipbuilding, which involves the delivery of ships. The final phase will decide the success of the whole project. According to Cheng et al., throughout the construction process, the ship owner’s requirements often change, and substantial information regarding ship design and construction is updated. Additionally, significant ship-related information, technical expertise, experience, and relevant knowledge are accumulated during other stages of shipbuilding (Cheng et al., 2011).

As we can see from the figure, the max knowledge gap always occurs in the assembly stage. In the early phase of shipbuilding, a high level of knowledge is delivered and utilized. From the order to the contract, this includes formal and informal communication with clients, the design information, and bills of materials (BOM), etc., which are considered explicit knowledge. Therefore, many studies mention the use of Extensible Markup Language (XML) to facilitate information and knowledge management (Rezayat, 2000; Ying-Han & Heiu-Jou, 2004; Yoo & Kim, 2002). This also involves a large amount of intangible knowledge (e.g., organizational culture, as well as personal emotional knowledge, working experience, skills, etc.). The speed of the incrementation of knowledge develops quickly in the early stage. In relational value chains, buyers and sellers share implicit knowledge with each other (Mendes Primo & DuBois, 2012). As the negotiation of the order goes further, more knowledge is used and created. In addition, when the project involves a larger number of stakeholders, more tacit and explicit knowledge is generated. Generally, the volume of tacit knowledge is greater than the explicit type. This is due to the experiential knowledge acquired during the lifecycle of shipbuilding and shows the importance of tacit knowledge. This paper will refer to this point in the following part, to draw attention to tacit knowledge dissemination. It also demonstrates that the level of tacit knowledge is higher than he explicit form.

Based on the abovementioned points, we extract seven key factors for knowledge management in shipbuilding. These are people, process, interaction, and multiple dimensions, as well as resource, environment, and technology. We develop seven hypotheses and test them through regression analysis.

The most frequent mistake in implementing knowledge management is the inability to synchronize efforts between information technology and human resources, according to Lin and Ha (2015). They point out that the process plays a pivotal role in KM. There are also other opinions of KM. For example, the formation and distribution of knowledge are closely related to its management (Pepple et al., 2022). This shows that the process factor is relevant to KM. We can also identify the connection between KM and the process from other definitions of KM. The purpose of knowledge management is to identify sources within the company, uncover gaps, regulate and evaluate internal knowledge processes, and store and utilize information. The aim is to enhance knowledge practices, as well as improve organizational behaviour, facilitate better decision-making, and boost organizational performance (Ramadhani & Er, 2019). Engineering-to-order (ETO) systems in shipbuilding can be influenced by internal processes, supply-side sources, and demand, in addition to the organization's own control systems (Alfnes et al., 2023). Based on this point, we can consider the process factor to be the key one involved in KM. It connects and coordinates all the parts to work together effectively, in order to formulate an effective system.

H1: *The process of shipbuilding is a key factor for knowledge management in shipbuilding.*

Interaction plays an essential role in a system. It also influences the system in terms of conducting knowledge management in an organization. Considering major clusters of innovations from a systems perspective may be beneficial(Rosenberg, 1979). Novelties arise from the interplay of various forces within complex systems, stem from the fusion of prior discoveries, and evolve in domains once considered challenging to access (Fronzetti Colladon et al., 2025). Knowledge creation needs this interdependent force to generate. Furthermore, successful strategy implementation relies on effective communication that flows not only from the top down, but also from the bottom up and across organizational boundaries(Tawse & Tabesh, 2021).

H2: *Interaction is a key factor for knowledge management in shipbuilding.*

Diversity is essential for knowledge management in SEUS. What influence does diversity have on the activities of KM in shipyards? Garcia-Vega conducted a study that collected data from 544 firms in Europe. The result shows that greater technological diversity can lead to increased innovation (Garcia-Vega, 2006). Through storage, sharing, creating, and updating, all the knowledge needs to be managed in a multi-dimensional way. The goal of knowledge management for an organization should be to establish a learning organization by measuring, storing, and leveraging employee expertise, thereby creating an entity that exceeds the sum of its parts (Bollinger & Smith, 2001). This multi-dimensional factor emphasizes that we need to pay attention to the different aspects and diversity of KM. In the meantime, we need to integrate all the dimensions leading to the success of a project.

H3: *Multiple dimensions play an important role in knowledge management in shipbuilding.*

Resources represent an essential factor for obtaining success in knowledge management. Diverse resources can influence knowledge management. One study suggests that the primary limitation for academics in less competitive regions is that their capacity restricts the income they can generate from participating in knowledge exchange activities (Zhang et al., 2016). Given the substantial budget and extended timeline associated with shipbuilding projects, managers often seek more accurate predictions and estimations before bidding on new projects (Li et al., 2018). This reminds us to focus on the potential of resources in knowledge management activities. Resources can limit the development of knowledge management in an organization.

H4: *Resources play a pivotal role in knowledge management in shipbuilding.*

Resources include employees in an organization. As Pee and Kankanhalli noted, explicit knowledge can be stored in electronic knowledge repositories and document management systems. In contrast, tacit and less easily codified knowledge can be shared by employees through expert directories, which link knowledge seekers with experienced colleagues (Pee & Kankanhalli, 2016). Tenold et al. show that tacit knowledge in shipbuilding can be shared across different organizations, using the example of the transfer of tacit knowledge between Scotland and South Korea. Their research indicates that people are the key factor in transferring tacit knowledge across cultural barriers and continents (Tenold et al., 2021).

H5: *People influence knowledge management in shipbuilding.*

The environment factor is considered an important one for knowledge management. As we know, knowledge management cannot exist independently in an organization. It relies on the internal and external environment involving the organizational culture, leadership, etc., which are visible aspects. It also involves invisible elements, such as, for example, the space for knowledge creation. This can be a meeting room, a suitable office for knowledge workers, etc., and applies not only in shipbuilding, but also in other sectors. For instance, the practices, interactions, and communications among software designers are deeply integrated into their daily work activities (Chen, 2022). This reminds us that the environment factor can influence knowledge management through daily work activities. We can also find references from other fields. For example, different cultural types encompass unique behaviours, values, beliefs, and assumptions that significantly enhance the knowledge management process in the healthcare industry (Moreno-Domínguez et al., 2024). Successful knowledge management in shipbuilding includes the factor of the ideal knowledge environment. Knowledge management in complex shipbuilding projects must foster a culture of knowledge creation, valorization, and sharing (Cerezo-Narváez et al., 2021). The ideal environment creates the possibility of creating successful knowledge management in shipbuilding.

H6: *Environment is an important factor in knowledge management in shipbuilding.*

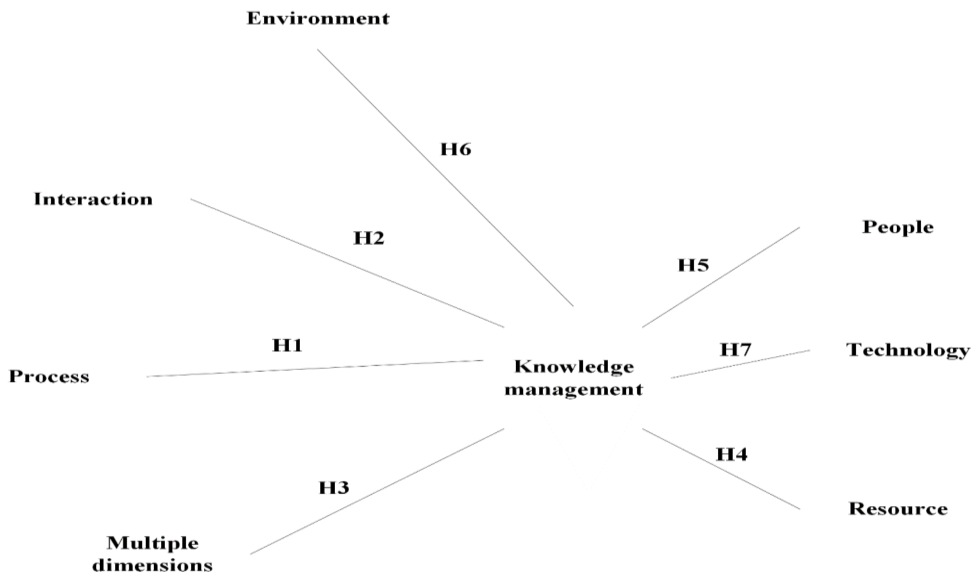
Technology plays an important role in knowledge management. We must depend on technological tools like networks, personal computers, and databases to facilitate the sharing of explicit knowledge (Kanyundo et al., 2023). Knowledge management relies on the development of technology. Pee and Kankanhalli (2016) state that technology enables KM and modern KM initiatives, which involve the implementation of technologies such as electronic knowledge repositories. According to Yi et al., the challenges and high risks associated with unified management highlight the need to enhance the information system. Simultaneously, it is crucial to implement smart technologies in shipbuilding, considering the vast factory areas, as well as the large-scale construction, dense workforce, and diverse, complex old equipment (Yi et al., 2023). Other related models also reflect key parameters of KM (i.e., digital knowledge management [DKM]). The three essential parameters of DKM—process, people, and technology—are crucial for ensuring business continuity (Panduwiyasa et al., 2024). This model is also a good projection for our shipbuilding model.

H7: *Technology is related to knowledge management in shipbuilding.*

THE KEY FACTORS MODEL OF KNOWLEDGE MANAGEMENT IN SEUS

We develop a knowledge management framework in shipbuilding according to the key factors based on the seven hypotheses outlined above. We assume that these seven factors contribute to the KM positively in a linear way. The seven factors are independent in KM and play different roles. However, this model does not explain the relationship between each factor of KM. Basic factors refer to those that constitute KM, while connection factors connect the basic factors and promote the work of KM.

FIGURE 3
THE KNOWLEDGE MANAGEMENT MODEL BASED ON SEVEN KEY FACTORS



The final version of the knowledge management model absorbs all the key factors of KM in shipbuilding(see Figure 3).

Knowledge exists in the lifecycle of shipbuilding, can be extracted from every individual unit of shipbuilding, and can also be derived from the interconnection among all of them. When the information involved in shipbuilding is valuable and used, we can treat it as knowledge. Success in shipbuilding involves knowing how to deal with that knowledge well. This is because the knowledge asset is becoming increasingly important in the modern ship market.

METHODOLOGY

Seven factors can affect knowledge management in SEUS. We have developed the knowledge management model for shipbuilding practices based on a survey of European shipyards. The questionnaire we used consisted of eight questions, as outlined in the Table 2.

TABLE 2
QUESTIONNAIRE USED IN THE STUDY

Number	Labels in SPSS	Question
1	KM	How strongly do you believe the following factors are related to effective knowledge management in your organization?
2	Technology	Technology (product lifecycle management system, customer relationship management system, etc.)
3	People	People (employees)

4	Process	Process (project procedures, from potential orders, negotiation, contracting, and construction to the final stage, which is delivery)
5	Interaction	Interaction (among a group of people, related to meetings and training in SEUS)
6	Environment	Environment (involves organizational culture, organizational structure, uncertainty, etc.)
7	MultipleDimensions	Multiple dimensions (these involve different aspects and stages of conducting knowledge management, generally including knowledge collection, creation, storage, etc.)
8	Resource	Resource (involves the web, as well as manuals, standards, stakeholders, etc., which can offer essential data for creating knowledge. Resources include physical and invisible resources. For example: external experts are a kind of invisible resource)

The questions listed above are intended for confirming the key factors of conducting knowledge management in SEUS. Because the objective of the research is SEUS, the data have been sourced from SEUS project partners. In order to ensure the high quality of the data and avoid the disadvantages of a small-sized sample, we applied the pilot-testing method for this investigation. We collected the data from a defined group of people who can provide high-quality feedback for the study of smart European shipbuilding.

RESEARCH INFORMATION

Table 3 displays the basic information relating to the research.

TABLE 3
BASIC INFORMATION ABOUT THE RESEARCH

Demographics	Description
Grading scale	11-point Likert scale (from 0 = not at all, to 10 = very well).
Scope	SEUS project partners
Sample size	17 individuals
Survey format	Online and site
Confidence level	95%
Completion date	03/12/2025
Independent variables	7
Dependent variables	1

The questionnaire survey was completed by the SEUS project partners. This is because the aim of our research was to confirm the key factors involved in conducting KM in SEUS. Seventeen experts in SEUS took part in the questionnaire survey, representing different stakeholders. In order to make sure the quality of the data source was high, the data collection was conducted through online forms as well as on site, where the experts received all the essential information for answering this survey. The analysis of the data was performed with SPSS software. Furthermore, the approach presented in the authors' study suggests that conducting a pilot study with sample sizes of 5, 12, and 25 corresponds to underpower probabilities of approximately 30%, 20%, and 10%, respectively, in the subsequent main study, assuming a 60% power threshold is used to define underpowering(Tseng & Sim, 2021). The sample size in our study fulfils the pilot study requirement.

Statistical Methods

A regression analysis is conducted to identify the correlations between two or more variables that have cause-and-effect relationships, and to make predictions based on these relationships (Uyanık & Güler, 2013). We used multiple linear regression analysis to analyse how strongly key factors relate to effective knowledge management in shipbuilding.

The mathematics formula of this model is as follows:

$$\mathcal{Y} = \beta_0 + \beta_1 \mathcal{X}_1 + \cdots \beta_n \mathcal{X}_n + \mathcal{E}$$

$\mathcal{Y}$*: dependent variable which is effective knowledge management*
$\mathcal{X}_n$*: independent variables which are key factors of knowledge management*
β_1*: parameters*
$\mathcal{E}$*:error*

In our statistical model, we assume that there are seven factors have a linear relation with KM. The model reflects that a multiple linear relationship exists between the key factors and KM in European shipbuilding. During the test, we used the stepwise method for excluding the factors which do not have a great significance for KM.

RESULTS AND DISCUSSION

Table 4 helps us understand the overall significance of our regression model. This format can help us evaluate our model of the key factors of KM in European shipbuilding. It shows which factor is considered for this model from the linear regression perspective. Generally, a value of Sig. lower than 0.05 can be considered a good sign for the proposed model.

TABLE 4
ANALYSIS OF VARIANCE OF THE RESEARCH DATA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.783	1	12.783	4.679	.047b
	Residual	40.982	15	2.732		
	Total	53.765	16			

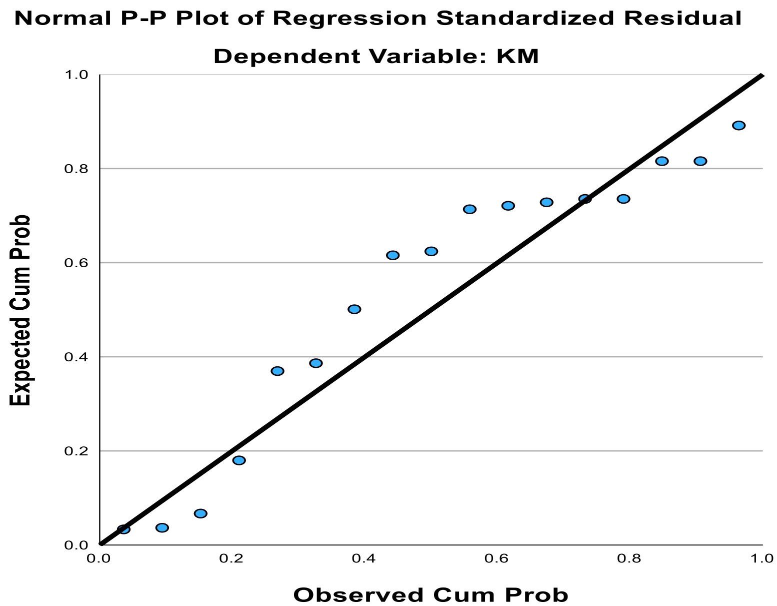
a. Dependent Variable: KM
b. Predictors: (Constant), Process

Sig. is the significance level of the F-statistic. A value of 0.047 indicates that the model is statistically significant at the 0.05 level.

In summary, Table 4 shows that the model significantly explains the variance in the dependent variable (KM) with the predictor (process) being significant.

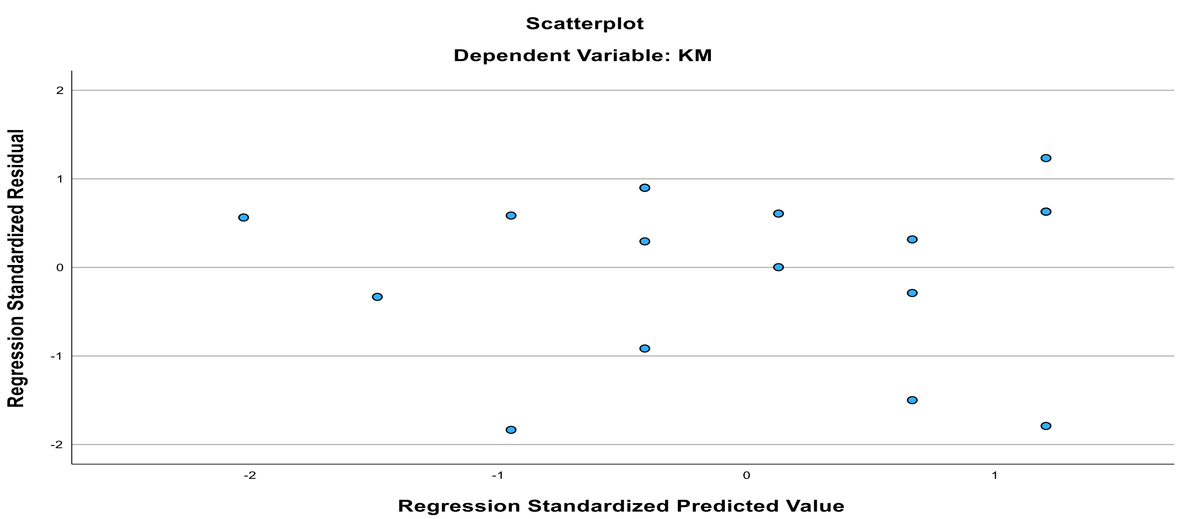
We use SPSS software to analyse the linear relationship between the dependent variable (KM) and potential key factors. We also examine the residuals of the model by scatterplot (see Figures 4 and 5).

FIGURE 4
LINEAR REGRESSION PLOT BETWEEN KM AND KEY FACTORS



Based on Figure 4, we can see that most of the factors are around the KM line. The overall fit of the points to the diagonal line indicates that the model's residuals are behaving as expected under the assumption of normality. It shows that the model's predictions are close to the actual data points, suggesting a good fit.

FIGURE 5
SCATTERPLOT OF PREDICTED VALUE



The residuals appear to be fairly randomly distributed around the horizontal axis, which is a good sign. There are no obvious patterns or clusters, suggesting that the model's assumptions are likely met.

Table 5 shows the correlations among KM and seven potential key factors in a numeric way.

TABLE 5
CORRELATIONS OF THE RESEARCH DATA

Sig. (1-tailed)								Pearson Correlation								
Interaction	**Environment**	**Multiple Dimensions**	**Process**	**Resource**	**People**	**Technology**	**KM**	**Interaction**	**Environment**	**MultipleDimensions**	**Process**	**Resource**	**People**	**Technology**	**KM**	
.094	.087	.137	.024	.238	.135	.132		-.355	.346	.281	.488	.185	.284	.288	1.000	**KM**
.175	.409	.002	.055	.055	.486		.132	-.242	.060	.672	.401	.401	-.009	1.000	.288	**Technology**
.339	.165	.301	.006	.482		.486	.135	-.109	.252	.136	.595	-.012	1.000	-.009	.284	**People**
.228	.241	.028	.162		.482	.055	.238	.194	.183	.470	.255	1.000	-.012	.401	.185	**Resource**
.349	.009	.004		.162	.006	.055	.024	-.101	.566	.625	1.000	.255	.595	.401	.488	**Process**
.210	.060		.004	.028	.301	.002	.137	-.209	.392	1.000	.625	.470	.136	.672	.281	**MultipleDimensions**
.231		.060	.009	.241	.165	.409	.087	.191	1.000	.392	.566	.183	.252	.060	.346	**Environment**
	.231	.210	.349	.228	.339	.175	.094	1.000	.191	-.209	-.101	.194	-.109	.242	.335	**Interaction**

Based on the results above, we can see that the resource factor has the least influence for knowledge management in SEUS. The process, environment, and multiple dimensions factors show significant influence for the effectiveness of knowledge management in projects. However, our literature review suggests that there are seven factors which can influence the KM effectively. The survey reflects that the expert pay attention to these three factors (i.e., process, environment, and multiple dimensions).

KM has moderate positive correlations with technology which is 0.288 and people who are 0.284, and a weaker positive correlation with resource which is 0.185. Technology shows a moderate positive correlation with resource which is 0.401 and a strong one with multiple dimensions which are 0.672. The people factor has a significant correlation with process which is 0.595. Resource has moderate positive correlations with process which is 0.255 and multiple dimensions which are 0.470.

According to the value of significance (1-tailed), we can conclude that process has significant correlations with KM, people, and Technology. The multiple dimensions factor has significant correlations with technology and resource.

THE STRATEGY OF KNOWLEDGE MANAGEMENT FOR SHIPBUILDING

We develop the KM strategy for SEUS based on key factors and SECI model. The description in this section below is based on "SECI, Ba and Leadership: a Unified Model of Dynamic Knowledge Creation" (Nonaka et al., 2000). We then summarize our findings (see Table 6).

From Tacit Knowledge to Tacit Knowledge (Socialization)

Due to the uncertainty of the order, the shipbuilding manager collects tacit knowledge from different external stakeholders and other shipyards, then delivers their own experience to the shipyard by organizing meetings or other practical activities. Tacit knowledge can be delivered from the external environment to the internal one as well as from an individual to a group. Environment is a key factor in this phase. The more suitable the environment for KM, the more possible it is for companies to obtain success in knowledge management. The environment factor contains invisible (e.g., leadership, learning culture, strategy, etc.) and physical parameters (office, meeting room, etc.).

From Tacit Knowledge to Explicit Knowledge (Externalization)

During this phase, interaction becomes very important for the shipyard. A group of people learn about each other by using special ways of thinking (i.e., Nonaka et al. proposes "abductive thinking" in the externalization phase), which makes tacit knowledge explicit. This relies on the communication among a group of people. We can also consider this to be interdependence.

From Explicit Knowledge to Explicit Knowledge (Combination)

Nonaka et al. calls this the combination phase, meaning that we need to stabilize the knowledge in this phase. We require IT to accomplish this, and can use a database and knowledge base. In the current SEUS project, we are developing a product lifecycle system (PLM) to store the shipbuilding data, in order to facilitate knowledge management throughout shipbuilding. Technology in this phase can improve the speed and quality of knowledge use as well as the efficiency of the whole project.

From Explicit Knowledge to Tacit Knowledge (Internalization)

The environment is also a key factor in this phase. Managers actively influence the team in different ways. The manager encourages employees to learn and improve their commitment, and improves intangible competitiveness to obtain success in shipbuilding.

Table 6 shows the essential information for adapting KM for shipbuilding based on the key factors. The four parts of the SECI model represent the four main stages of European shipbuilding. Adaptation refers to the stages of the knowledge management process in European shipbuilding. The key factors relate to KM in European shipbuilding.

TABLE 6
THE SECI MODEL IN EUROPEAN SHIPBUILDING

SECI	Stage of European Shipbuilding	Adaptation	Key Factors
Socialization	Preparation	Knowledge collection	Resource; Process
Externalization	Design	Knowledge creation	Interaction; Process
Combination	Assembly	Knowledge storage	Technology; Process
Internalization	Delivery	Knowledge delivery	Environment

Table 6 displays the general key points for adapting KM for shipbuilding based on the key factors. These play an important role in the whole process of KM in European shipbuilding. However, we need to emphasize that it is very necessary to think of the process factor in designing and conducting KM in European shipbuilding. In addition, the design phase consumes a significant part of the total time of shipbuilding. Furthermore, the success of conducting KM before assembly can reduce more costs than the following phases. It should be noted that Table 6 is only a general description of the adaptation of key factors of KM in European shipbuilding. A detailed design solution needs to be developed in the future.

CONCLUSIONS

The results reflect that the resource factor has a weak influence on KM. This element can also impact KM through the factors of process, technology, and multiple dimensions. Generally, the identified seven factors can all affect KM in SEUS positively. However, based on the literature review, process plays a very important role in conducting KM. The complexity of SEUS means that we need to pay attention to KM in the process of shipbuilding projects. KM must also satisfy the needs of the process of shipbuilding. The shipping industry, with its enduring characteristics and need for continuous research, technological advancement, and innovation, is an appealing sector for implementing organizational management models that prioritize knowledge (Bernal Wilson et al., 2012). However, there is no evidence from the survey that shows that all the given factors play pivotal roles in knowledge management in smart European shipbuilding. This is due to the self-evaluation method and small sample. If we expand the scale of the survey, the results may change. This pilot study gives the initial study of key factors of influencing the knowledge management strategy. The important thing during regulating the knowledge management strategy in European shipbuilding is that paying attention to the process factor. Even though other factors need to be taken into account, process factor should be highlighted in the beginning of KM strategy implementation. Furthermore, varying levels of openness in strategic processes have a notably positive effect on employees' awareness and understanding of the organization's strategy, independent of their hierarchical position(Stadler & Scheidegger, 2024). The environment factor can affect the implementation of knowledge management strategy. We cannot ignore the interaction among all the factors from knowledge management strategy perspective.

In accordance with our results, we emphasize that we need to conduct KM based on the whole process of European shipbuilding. This way of conducting lifecycle KM shows the possibility of achieving success for European shipbuilding in the global market. Furthermore, we cannot ignore other factors. Shipbuilding is a complex system. KM therefore needs to absorb and integrate all the aforesaid factors to lead to success in this area. There is strong evidence that the identified seven factors may potentially be key factors in KM strategy in European shipbuilding. Our paper does have some limitations, such as the small sample size, although the objective of the research limits our sample scale. The high data quality may lower the bias of the result. The reliability of the evaluation derives from its basis in a wide literature review and expert survey. Furthermore, the result of the data analysis demonstrates that it fulfils the requirement of linear regression analysis. It would be useful to conduct further study on this topic. Future work should continue to analyse the key factors of KM in shipbuilding by expanding the scale of sample. In the meantime, the key factors can be used for the architecture of a knowledge management system in shipbuilding.

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