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CUSTOMER KNOWLEDGE MANAGEMENT IN ENTERPRISE SOFTWARE DEVELOPMENT COMPANIES: ORGANIZATIONAL, HUMAN AND TECHNOLOGICAL PERSPECTIVE

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Abstract:
In this study, Knowledge-Based View (KBV) and Theory of Technology in a Generic Customer Knowledge Management (CKM) Framework were assimilated to demonstrate the Organizational, Human and Technological antecedent factors that enable CKM processes to improve software product quality. A Theoretical CKM Framework was developed by extracting Human, Organizational and Technological factors from the literature, then, the "Technique for Order of Preference by Similarity to Ideal Solution" (TOPSIS) Multi-Criteria Decision Making (MCDM) method was applied to find the importance level of factors to CKM development in software companies. The weight and priority of factors were determined by 31 experts in enterprise software development companies. The results show that, from an expert viewpoint, CKM antecedent factors are categorized into high priority and low priority groups. Organizational factors such as "Customer Involvement", "Customer-Centric Culture" and "CKM Strategy Development" are high priority.

Key words: *qualimetry, knowledge management, enterprise software development, TOPSIS, summarizing indicator, multicriteria quality assessment, dimensionless scale*

INTRODUCTION

Product quality in organizations requires a long enhancement process and mature business processes for product production [1, 2]. According to KBV, CKM are effective organizational factors that enhance software quality in software companies [3, 4]. Integrating Customer Knowledge (CK) in enterprise software development is still immature, as it lacks a theoretical framework to fully capture CKM [5, 6]. There are significant challenges regarding the transfer and integration of customer knowledge inside software companies [7, 8, 9, 10]. A lack of senior management commitment to CKM, poor communication, a lack of cultural readiness, and a lack of customer management skills are barriers to the design and implementation of CKM [9, 10, 11, 12]. Most major problems for the effective application of CKM in many companies are organizational and not technical [1, 2, 13, 14, 15, 16]. There is no doubt that appropriate communication and customer collaboration in different phases of Enterprise Software (ES) development project would help increase overall customer satisfaction and the overall success of the entire project [12, 15, 17, 18, 19]. Successful CKM in software companies improves product quality.

LITERATURE REVIEW

The rate of application of CKM in ES is low. For example, according to an investigation of 22 software development companies that proposed their product in ELECOMP 2014 (Big annual ICT exhibition in Tehran), 69% had no solution or guidelines for gathering customer knowledge. 81% of them mentioned that the software production process in their companies is product centric rather than customer centric. There is a lack of systematic CKM processes in many companies [5, 13, 20]. Ignoring the utilization of CK in several firms [21, 22, 23], an inadequate theoretical framework for CKM antecedent factors and a lack of comprehensive theoretical framework for CKM effects on software quality in enterprise software development reflect a fundamental need for further exploration [1, 3, 9, 24, 25]. Most software companies in this study are Small

and Medium Enterprises (SMEs) [20, 24, 25, 26, 27, 28, 29, 30]. SMEs face resource constraints [1, 4, 6, 31]. Regarding the high rate of failure in CKM projects [32, 33, 34, 35], determining important CKM success factors that decrease the risk of failure is vital for managers and practitioners in software companies. The outcomes of this study help companies focus on high priority CKM factors and reduce organizational resource waste. Due to a history of poor solutions coupled with technology failures, many companies have a hard time justifying CKM initiatives [18, 23, 33, 36, 37, 38, 39, 40]. Understanding the antecedent weights helps software companies improve the success rate for CKM projects and motivate managers to implement CKM. Despite many studies that have examined CKM antecedent factors in multiple contexts, none of them are comprehensive enough to capture all factors into one single framework. In this study, an empirical study was conducted to investigate possible factors influencing CKM in ES development companies [41, 42]. The questions that were asked in this study are: (a) What are the antecedent factors that affect CKM in an organization based on Human, Organization and Technology frameworks? (b) What framework is appropriate to weigh and prioritize antecedent factors using TOPSIS for ES development companies?

GOAL OF THE WORK

This paper evaluates the importance level of CKM critical factors. This study proposes a framework to weigh and prioritize CKM antecedent factors based on expert viewpoints using TOPSIS in enterprise software development.

OBJECTS AND METHODS OF RESEARCH

CKM Framework for the Software Companies

This study investigates what of the extracted CKM antecedent factors [43] are suited for enterprise software development companies. Appropriate techniques were chosen to select suitable CKM antecedent factors for the scope and purpose of this study. The TOPSIS method was used to choose appropriate factors and develop a framework for CKM for software development companies.

Data Collection

After extracting the CKM impact factors, the priority and weight of the factors were used to select appropriate factors for ES development. This study consulted with ES development experts using a survey questionnaire designed to find out what extracted impact factors are most important for ES. The survey questionnaire included a list of CKM enablers and their definitions. This study asked experts to evaluate each factor using a 5-point Likert scale (not important, low important, important, moderate important, and very important). When it comes to MCDM procedures, no guidelines exist for deciding the number of respondents. As TOPSIS is not based on statistics, a modest sample size was adequate [44, 45, 46]. In the opinion of Dyadyura [47], MCDM such as TOPSIS and AHP (Analytic Hierarchical Process) are scientifically applicable and do not require a large sample size. In the study conducted by Trishch, et al. [48, 49], MCDM procedures were used to rank factors based on the viewpoint of 12 experts. Taking these views into consideration, this study decided to use 50 specialists for the data gathering stage. After distributing the survey questionnaire to 50 ES experts from 13 different companies, 31 completed questionnaires were returned.

TOPSIS Analysis

In this study, we rank CKM success factors based on importance and relevance in ES development using TOPSIS. According to Cherniak, et al. [50], the TOPSIS procedure has five steps. After forming an initial decision matrix, the procedure starts by normalizing the decision matrix. This is followed by building a weighted normalized decision matrix in Step 2, determining the positive and negative ideal solutions in Step 3, and calculating separation measures for each alternative in Step 4. The procedure ends by computing the relative closeness coefficient. The set of alternatives (or candidates) is ranked according to the descending order of the closeness coefficient [51]. The procedure for the TOPSIS method consists of the following steps:

Given a set of alternatives, $A = \{A_i | i = 1, \ldots, n\}$ and a set of criteria, $C = \{C_i | i = 1, \ldots, m\}$, where:

$\tilde{X} = \{\tilde{x}_{ij} \mid i = 1, \cdots, n;\ j = 1, \cdots m\}$ denotes the set of ratings and $\widetilde{W} = \{\widetilde{w}_j \mid j = 1, \cdots, m\}$ is the set of weights.

$\Sigma\ w_i = 1 = w_1 + w_2 + w_3 + w_4 + w_5 = 0.066667 + 0.133333 + 0.2 + 0.266667 + 0.333333 = 1$

The first step of TOPSIS is to calculate normalized ratings by Eq. (1). Then we calculate the weighted normalized ratings by Eq. (2).

$$\tilde{r}_{ij}(x) = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{n} \tilde{x}_{ij}^2}}, i = 1, \cdots, n; j = 1, \cdots, m \tag{1}$$

$$\tilde{v}_{ij}(x) = \widetilde{w}_j \tilde{r}_{ij}(x), i = 1, \cdots, n; j = 1, \cdots, m. \tag{2}$$

In the next step, the Positive Ideal Point (PIS) and the Negative Ideal Point (NIS) are calculated (see Table 1) using Eq. (3).

$$\begin{aligned} PIS = \tilde{A}^+ &= \{\tilde{v}_1^+(x), \tilde{v}_2^+(x), \cdots, \tilde{v}_j^+(x), \cdots, \tilde{v}_m^+(x)\} \\ &= \{(\max_i \tilde{v}_{ij}(x) | j \in J_1), \quad (\min_i \tilde{v}_{ij}(x) | j \in J_2) | i = 1, \cdots, n\} \\ NIS = \tilde{A}^- &= \{\tilde{v}_1^-(x), \tilde{v}_2^-(x), \cdots, \tilde{v}_j^-(x), \cdots, \tilde{v}_m^-(x)\} \\ &= \{(\min_i \tilde{v}_{ij}(x) | j \in J_1), \quad (\max_i \tilde{v}_{ij}(x) | j \in J_2) | i = 1, \cdots, n\} \end{aligned} \tag{3}$$

where:

J_1 and J_2 are the benefit and the cost attributes, respectively.

Table 1

Positive Ideal Point (PIS) and the Negative Ideal Point (NIS)

Max Vi1	Max Vi2	Max Vi3	Max Vi4	Max Vi5
0.03306122	0.059446777	0.065833774	0.094859067	0.133627638
Min Vi1	**Min Vi2**	**Min Vi3**	**Min Vi4**	**Min Vi5**
0	0	0.005486	0.007905	0

The following step is to calculate separation from PIS and NIS by the alternatives. The separation values are measured using a Euclidean distance given as:

$$\tilde{S}_i^+ = \sqrt{\sum_{j=1}^{m} [\tilde{v}_{ij}(x) - \tilde{v}_j^+(x)]^2}, i = 1, \cdots, n \tag{4}$$

$$\tilde{S}_i^- = \sqrt{\sum_{j=1}^{m}[\tilde{v}_{ij}(x) - \tilde{v}_j^-(x)]^2}, i = 1, \cdots, n \quad (5)$$

$$max\{\tilde{v}_{ij}(x)\} - \tilde{v}_j^+(x) = min\{\tilde{v}_{ij}(x)\} - \tilde{v}_j^-(x) = 0. \quad (6)$$

Accordingly, the similarities to PIS are calculated using Eq. (7).

$$C_i^* = \frac{D(S_i^-)}{[D(S_i^+)+D(S_i^-)]}, \qquad i = 1, \cdots, n \quad (7)$$

where:

$$C_i^* \in [0,1] \quad \forall i = 1, \cdots, n \quad (8)$$

Finally, the preferred orders are ranked according to C_i^* in descending order. In Table 2 the ranks of 22 CKM factors are presented.

Table 2

Distance from positive and negative ideal

Factors	$D(S_i^+)$	$D(S_i^-)$	$D(S_i^+) + D(S_i^-)$	C_i^*
Customer involvement	0.08272	0.120818	0.203538	0.59359
Customer-centric culture	0.091899	0.132759	0.224658	0.590937
CKM Strategy development	0.096197	0.138431	0.234628	0.590003
Collaboration system	0.086869	0.123678	0.210548	0.587413
Cross-functional cooperation	0.086056	0.118937	0.204993	0.580199
Individual competences and skills	0.092332	0.123465	0.215798	0.572135
Trust between customer and company	0.084384	0.110967	0.19535	0.568038
Top manager support	0.088304	0.114491	0.202795	0.564566
CRM technology infrastructure	0.093538	0.118261	0.2118	0.558364
Training	0.087253	0.105486	0.192739	0.547299
Knowledge map	0.094539	0.112504	0.207043	0.543385
Key customer management	0.123427	0.079196	0.202623	0.390853
Reward system	0.123696	0.076964	0.20066	0.383553
CK Oriented BP	0.128879	0.080094	0.208973	0.383275
CK Quality	0.13581	0.081571	0.21738	0.375244
Individual Motivation	0.123018	0.071631	0.194649	0.368001
Program champion	0.144845	0.075245	0.22009	0.341885
Integrated knowledge Repository	0.130877	0.06798	0.198857	0.341851
Community of practice	0.153343	0.077045	0.230388	0.334415
Social Media	0.147994	0.071706	0.2197	0.32638
Provide Privacy for customers	0.137138	0.061561	0.198699	0.309822
Respect for Intellectual Property	0.145573	0.065002	0.210576	0.308688

The final ranking shows the overall viewpoint of 31 experts on the significance of each factor for enhancing CKM in the enterprise software development domain. The overall viewpoint of the experts indicated that "Customer Involvement" and "Customer-Centric Culture" have the most significant effect on enhancing CKM in software companies to achieve quality software. However, "Privacy for customers" and "Intellectual Property" have a less significant effect on enhancing CKM in software companies. It is clear from Table 2 that the distance between the rank of "Key Customer Management" and "Knowledge Map" is considerable. The factor rankings before "Key Customer Management" are very near to each other (0.3 < Ranks > 0.4).

Furthermore, the ranks of the factors after "Knowledge Map" are very near each other as well (0.4 < Ranks > 0.6). Thus, there is a breakpoint between the rank of these two factors ("Key Customer Management" and "Knowledge Map") that can categorize the antecedent factors into two groups. The first group refers to high priority CKM antecedent factors (Rank > 0.5) and the second group refers to low priority CKM antecedent factors (Rank < 0.4). 11 out of 22 factors are in the high priority CKM antecedent group. This high priority group includes Organizational factors ("Customer Involvement", "Customer-Centric Culture", "CKM Strategy Development", "Cross-Functional Cooperation", "Senior Management Support", "Training"), Human factors ("Competencies and Skills", "Trust between customer and company") and Technological factors ("CRM Technology Infrastructure", "Collaboration System", "Customer Knowledge Map"). The managers of software companies must give great attention to the successful implementation and deployment of CKM. This study proposed a CKM framework for software companies based on the highest priority CKM antecedent factors.

DISCUSSION

After developing a theoretical framework based on 22 antecedent CKM factors extracted from the literature [52]. The framework was evaluated by 31 experts in enterprise software development in Iran. The TOPSIS method was used to rank the factors and it shows their significance for enhancing CKM to improve software quality in software development companies. Based on the result of the TOPSIS analysis, some findings from previous studies were supported.

As discussed in the previous section, based on factor rankings, the antecedent factors are classified into factors of high importance factors and factors of low importance. In the high importance group, the first three are Organizational factors, which mean that Organizational CKM factors have more priority than Human and Technological factors. CKM is based on people and social interaction, where the organization is responsible for establishing the right conditions for CKM, and information and communication technology helps to facilitate this [53]. This finding was supported by the Theory of Technology. The results

of research work [54] noted that human actions are enabled and constrained by organizations. However, the rules and the structures of organizations are the result of previous actions. Technology is an instantiation of some of the rules and resources constituting the structure of an organization. Technology is created and changed by human action, yet it is also used by humans to accomplish actions. Thus, it is clear from the results that for successful CKM development, managers of software companies must focus on organizational factors to enable the development of other factors.

"Customer Involvement", "Customer-Centric Culture" and "CKM Strategy Development" were given a high priority, and this confirms the result of works developed by [55, 56, 57]. Moreover, "Customer Privacy" and "Customer's Intellectual Property" have a lower priority and experts consider these factors not very important for CKM development. The results of research work [58] noted that customers' wishes, needs, and preferences influence the concept and design of a product or service. It was suggested that customers should be involved within the development phases of a product/service, which includes Idea Generation, Concept Development, Product Design, Prototyping/Testing, and Maintenance. At each different stage, value is created collaboratively as organizations gain insight into customer preferences and ideas based on continuous interaction and feedback from costumers [59, 60]. Important technological factors such as "collaboration system", "CRM Technology Infrastructure" and "Knowledge Map" facilitate absorbing, storing, organizing, and distributing customer knowledge. The knowledge acquired is codified and stored in corporate databases and knowledge warehouses. CRM Technology Infrastructure helps companies to absorb and store all customer transitions and provides a repository of feedback. Knowledge Maps are used to organize explicit and tacit knowledge and collaboration systems provides a collaborative environment for sharing CK inside organizations and between organizations and customers.

"Customer-Centric Culture", "Top Management Supports" and "Training" are important organizational factors that facilitate the absorption, sharing and utilization of customer knowledge. The results of research work [61], successful CKM requires the transformation of organizations from a product-centric focus to a customer centric focus. To provide a customer-centric culture that perceives customers as a valuable source of knowledge, top management must inspire an organizational culture that motivates employees to acquire, share and use CK. Organizations need to change business processes and shape their organizational culture and routines to utilize the potential of CRM systems to generate customer knowledge and optimize benefits. Development of customer knowledge is complementary to knowledge acquisition. Customer knowledge focuses on generating new skills, products, and ideas to meet customer needs.

According to the results, Human factors such as "Individual Competences and Skills" and "Trust between customer and company" are significant for enhancing CKM. This finding is in line with recent studies by [62] and [63], who identified that appropriate training is required to make sure employees have enough IT skills and expertise to effectively absorb, share and utilize CK. The results of research work [64] noted that for successful CKM, three types of customer knowledge competencies are required: customer knowledge acquisition skills, customer knowledge sharing skills and customer knowledge use skills. The results of research work [65] highlighted the importance of trust between customer and company for improving the process of customer knowledge absorption. The results of research work [66] mentioned that one of the key challenges in absorbing knowledge from customers in software development projects is a lack of trust between customers and development teams. Organizational antecedent factors such as CKM strategy, top management support, and training are important for enhancing employees skills and providing a trusting environment [67].

The result of this study shows that from the 22 extracted antecedent factors, 11 factors are in the highly important group based on 31 experts' viewpoint in software development. Implementing and deploying CKM successfully in enterprise software development companies to improve software quality strongly depends on these high priority factors. This finding is supported by the results of the review [68], According to [69, 70], all of the antecedent factors in the high priority group have high iteration in the literature. In [71] shows that CKM was used in a variety of contexts [72, 73, 74] provided evidence and supports our findings, since all high priority factors were already used in IT companies. This study's findings are similar to past findings, but this study is more comprehensive and considers the entire CKM antecedent factors mentioned in previous studies. Some of the high frequency CKM antecedent factors in the literature were not selected in the high priority group because of the specific conditions of software development in Iran. These factors may be more significant in other countries or other contexts.

CONCLUSIONS

The findings of this study build and expand CKM in enterprise software development companies. 22 factors were extracted from the CKM literature and categorized based on the Theory of Technology into Organizational, Human, and Technological factors. According to the findings from the TOPSIS method, 11 factors from the extracted antecedent factors are in the highly important group based on the opinions of 31 software development expert. These factors are critical for successfully implementing CKM. High priory organizational factors ("Customer Involvement", "Customer-Centric Culture", "CKM Strategy Development", "Cross-Functional Cooperation", "Top Manager Support", "Training") activate other factors and provide appropriate conditions for CKM. For example, Cross-Functional Cooperation is necessary for collaboration and sharing customer knowledge through an organization. Therefore, an organization should reorganize its organization structure based on customer value chains to establish

a truly customer centred organization structure. Technological factors ("Collaboration System", "CRM Technology Infrastructure", and "Knowledge Map") facilitate CKM in an organization. These factors provide the core IT infrastructure that is vital for effective CKM. CRM technology is responsible for absorbing and storing customer knowledge. "Knowledge Map" helps organizations to organize knowledge and provide the relationships between explicit and tacit knowledge to experts. It states who knows what to facilitate access to the required customer knowledge. Collaboration systems are used to allow employees to discuss and share CK. This system distributes knowledge though an organization to facilitate communication between employees and customers. Human factors ("Individual Competencies and Skills", "Trust between customer and company") are activated and influenced by organizational and technological conditions. Humans are the heart of any knowledge management system since individuals are responsible for creating and sharing knowledge. Therefore, employees need enough skills to successfully manage knowledge. Organizational enablers such as reward systems and training encourage individuals to share and apply CK. Presenting a CKM Theoretical Framework that is an extension of the Generic CKM Framework is the theoretical contribution of this study. This study clarified how CKM antecedent factors lead to CKM enhancement. This framework justified CKM as a valuable and rare asset for businesses that allows them to quickly respond to customer needs and adapt to changing markets. It is noted that collecting information about customers and offering superior value to these customers based on this knowledge provides a non-imitable advantage. Knowledge is treated as an important resource for organizations as per the KBV of a firm. The KBV of the firm proposition states that organizations exist to create, transfer and transform knowledge into competitive advantage. This theoretical framework sheds light on Human, Organizational and Technological mechanisms to successfully enable CKM organizations to improve software quality. This study helps scholars understand appropriate conditions for achieving CKM enhancement using KBV theory. This study has interesting implications for managers in that it provides a useful model for the successful implementation of CKM. According to the results of this study, CKM antecedent factors are categorized into two categories (high priority and low priority).

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