The Conditions for Repository Knowledge Management System Success in New Product Development

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Abstract

To address the challenges of knowledge sharing in new product development (NPD) processes, many companies implement knowledge management systems (KMSs). KMS projects are, however, often not successful, and the literature disagrees on which factors affect their success. To advance this knowledge, the present study investigates the conditions for KMS success in NPD processes through a series of interviews with NPD professionals. This process identifies 43 concepts, organized under 17 dimensions, influencing the success of repository KMSs. Through the identification of relationships between these dimensions, a conceptual model describing the conditions for KMS success is developed. The study hereby provides two main overall contributions. First, as compared to existing models, the present model provides a more detailed and complete account of the factors that influence KMS success. Second, the study identifies four main characteristics that set KMS projects apart from other enterprise information system projects.

Keywords: Knowledge Management Systems, Knowledge Repositories, Knowledge Sharing, Digital Repositories, New Product Development

1. Introduction

Knowledge sharing is considered an important enabler for achieving and sustaining competitive advantage for companies [46,52]. However, making employees share their knowledge is by no means an easy task, which is illustrated by estimates suggesting that Fortune 500 firms lose $31.5 billion annually because of failing to share knowledge effectively [44]. As a response to the strategic importance of being able to manage organizational knowledge, many companies implement IT-based knowledge management systems (KMSs). The use of such systems has been the focus of several studies, which demonstrate that KMSs, in some cases, can improve the management of knowledge processes [2,55]. On the other hand, in many other cases, KMS projects are not successful [40,41]. In this context, the existent literature only provides sparse explanations of why similar levels of KMS use can produce highly different effects [37,40]. Furthermore, existing KMS success models disagree on which factors to include (as described in the subsequent literature review).

To add to the understanding of the conditions for KMS success, this study investigates the use of KMSs in new product development (NPD) processes. The argument for this focus is that NPD represents a knowledge-intensive environment, which involves significant knowledge sharing challenges [13,23]. Furthermore, in NPD processes, there can be high costs of failing to share knowledge in such processes in the form of product development mistakes and inefficient processes [28,49]. For such reasons, knowledge sharing in NPD processes is a topic that has been given considerable attention in the literature. On the other hand, despite the relevance of KMSs in NPD [10,45], studies of the use of KMSs in NPD are sparse (as the subsequent literature review reveals).

To add to the understanding of which factors affect KMS success in NPD, the present study applies an explorative approach in the form of a series of interviews with NPD professionals (NPDPs) in high-tech manufacturers. To enable comparisons of the NPDPs' experiences while focusing on a technology that is relatively typical in such firms, the scope of the study is limited to repository KMSs. Specifically, digital repositories are typically a central part of KMS implementations and the focus of many, if not most, KMS studies [40].

The remainder of the paper is organized as follows. First, relevant literature is discussed, after which the research method of the study is described. Next, the findings are presented, on which basis, a conceptual model describing the conditions for KMS success is developed. Finally, the contributions of the study and their implications are discussed.

2. Literature Background

2.1. Knowledge Management Systems

KMSs are a class of information systems (ISs) that support individuals in knowledge creation, sharing, and application in organizations [2]. KMSs may be distinguished from other kinds of ISs through their focus on supporting knowledge tasks and providing access to expertise [19]. In this context, emphasis should be placed on the difference between information sharing and knowledge sharing. As argued by Szulanski [50], knowledge sharing should not be understood as merely passing on information but rather as an act involving feedback and learning [50]. Specifically, knowledge sharing involves processes in which tacit knowledge is translated into explicit knowledge ("externalization") and in which explicit knowledge is internalized ("internalization") [47]. Thus, when knowledge is shared, this is not a replication of knowledge, but rather a process in which existing knowledge is modified [4,27]. This is in line with the perspective on knowledge sharing underpinning the present study, i.e., that knowledge sharing through a KMS involves knowledge being transformed into information (in the form of codified knowledge) to be stored in the KMS, after which such information may become knowledge again when processed by a KMS user.

KMSs involve different technologies, which include digital repositories, videoconferencing, workflow systems, expert systems, simulation tools, data mining tools, and search engines [2,6]. Although such technological features can provide value, studies have shown that more technologically advanced KMS are not a guarantee for more efficient use, which also depends on social factors [19,42]. Digital knowledge repositories are typically a central part of KMS implementations and the focus of many KMS studies [40]. The purpose of repository KMSs is to provide a central source of validated knowledge [21], which is done by supporting the capture, codification, and sharing of knowledge [15]. Thereby, they can facilitate the efficient reuse of existing knowledge [20,41].

The use of repository KMSs can make codified knowledge available in a timely manner to reduce the cognitive load and promote learning [48]. By implementing a repository KMS, it also becomes possible to change help-seeking practices by encouraging employees to search the repository KMS before disrupting knowledgeable colleagues with requests for knowledge [33]. In this context, the usefulness of the knowledge in a KMS may be augmented through insights acquired from other people, such as getting the assistance of a colleague for understanding or extending information found in a KMS [33]. Furthermore, KMSs can also help employees in acquiring knowledge outside their own networks, which may increase the benefits and reduce the costs of obtaining knowledge [33,39]. In this context, it should be emphasized that the effects of KMSs are not transient but rather cumulative [41]. Specifically, knowledge stored in a KMS can be applied several times, and when more knowledge is stored, it changes the way that knowledge can be exploited to produce benefits through the improvement of users' cognitive capability [31].

2.2. Conditions for KMS Success

In the present study, the concept of "KMS success" draws on DeLone and McLean's [17] definition of "IS success", which refers to the net benefits of a system. From an overall perspective, the net benefits of KMSs may be understood as a result of three factors: (1) learning benefit from the knowledge, (2) costs of searching for relevant knowledge, and (3) costs of knowledge transfer [36,51]. This does, however, not tell us about the underlying conditions for when the benefits of KMSs exceed their costs. Thus, the literature has investigated such conditions from different perspectives, one of which concerns the fit between KMS knowledge and the tasks it supports [3,14]. Specifically, for tasks that require diverse knowledge, KMSs are more likely to be beneficial [3], while if tasks require narrow knowledge, KMSs are less likely to be so [40]. Additionally, for a

KMS to provide value, it needs to include adequately extensive knowledge to avoid users experiencing fruitless searches in the systems, which in turn will make them stop using the system. However, this initial collection and organization of knowledge before the KMS can go live can be a rather resource-demanding and costly process [41].

Besides the initial implementation, KMSs can also be costly in terms of maintenance. Specifically, the knowledge in a KMS needs to be updated as new knowledge emerges. In other words, just like other ISs, KMSs require ongoing maintenance to sustain their usefulness [18]. This is related to the concept of "environmental dynamism", which describes the extent to which an environment is predictable [7]. Increased environmental dynamics imply a need for rapid changes in the knowledge applied [22]. This affects the value of KMSs, as such changes make certain knowledge obsolete and, therefore, quickly degrade the KMS's value [8,29]. KMS knowledge can obviously be revised to suit the new situation, but it may be difficult and resource-demanding to keep all the codified knowledge updated.

The literature includes several models that explain KMS success. One example is the one by Wu and Wang [53], which is developed based on DeLone and McLean's updated IS success model [17]. Their model keeps three of the dimensions from DeLone and McLean's model ("system quality", "knowledge/information quality", "user satisfaction"), while it leaves out "service quality", merges "intention to use" and "use" into "perceived KMS benefits" and replaces "net benefits" with "KMS use". Their model is partly supported by a survey of Taiwanese top 500 companies. A similar model is proposed by Halawi et al. [34], which merely differs from DeLone and McLean's [17] model by changing the term "information" to "knowledge" and leaving out "use". This model is partly supported by a survey of mid-level managers in the United States. More recently, the systematic literature review by Jackson et al. [38] examines which factors affect KMS implementations. Their analysis includes 54 papers published in the past five years, and it identifies the six main influential factors for KMS implementation success: (a) formal processes, (b) company culture, (c) top-down support, (d) motivation, (e) clear goals, and (f) quality of the KMS.

There are also studies with a specific focus on repository KMSs. This includes the study by Kim et al. [40], which takes its point of departure in the observation that previous research on KMS success has mainly focused on a few variables only (e.g. [32, 41]). With the aim of expanding on this, Kim et al. [40] develop a conceptual model that involves five moderators on the relationship between "repository KMS use" and "performance": "total information intensity", "changing information intensity", "social sources", "physical sources", and "computerized sources". Their model is supported by a longitudinal study of a retail grocery chain.

2.3. KMSs in NPD

Given the challenges of implementing efficient knowledge sharing practices in NPD processes, as well as the significant negative consequences of failing to do so [28,49], this topic has received considerable attention in the literature. On the other hand, as mentioned in the Introduction, the literature on conditions for successful KMS use in NPD is sparse. This can, for example, be illustrated by a Scopus search in the title, keywords, and abstracts of journal papers, using the search string: ("knowledge management system" OR "digital repository" OR "knowledge repository") AND ("product development" OR "product innovation") – yielding only 54 results. While these papers support the relevance of repository KMSs in NPD processes (e.g., [48]), only a few of these focus on the conditions for KMS success (or related concepts, such as barriers and drivers).

One of the exceptions is the study by Chen et al. [9], which develops a model that describes the effects of "KMS quality", "KMS self-efficacy", and "organizational climate" on "attitude towards knowledge sharing" and "knowledge sharing intention". Their model is partially supported by survey data from Taiwan electronic manufacturing companies involved in NPD. Another example is Filieri and Alguezaui [24], who use a case study approach to explore the barriers to knowledge sourcing and reuse from digital repositories in the context of the virtual product prototyping stage of NPD. The resulting model explains "product prototyping time performance" as a result of "repository ease of use", "knowledge quality", "knowledge sourcing", "knowledge reuse", and "knowledge complexity". Finally, based on the original DeLone and McLean [16] model, Filieri and Willison [25] develop a model of KMS success in virtual prototyping processes, which describes the effects of knowledge quality on "knowledge reuse" and the effects of system quality on "knowledge sourcing". Their model involves the operationalization of the "knowledge quality" and "system quality" constructs by using the literature to identify a set of variables describing these dimensions. The model is supported by a survey focusing on the virtual vehicle prototyping process in a large automotive company.

As the literature review shows, across KMS success models, there is disagreement on which factors to include. One explanation for these differences is the approach applied in such studies, which involves using different parts of the literature to develop their models. To avoid the blind spots produced by developing models based on existing knowledge only, the present study applies an explorative approach, implying that the factors constituting the conditions for KMS success are inductively derived from empirical data. While this approach, obviously, has limitations with regards to determining the strength and significance of relationships, it serves to identify possible overlooked factors and relationships.

3. Research Method

3.1. Methodology and Data Sources

As previously mentioned, the purpose of this study is to understand the conditions for KMS success in NPD processes. To investigate this matter, an explorative approach guided by grounded theory [11] was applied in the form of a series of semi-structured interviews with NPDPs employed in different manufacturers of high-tech products. A premise for inclusion in the study was that the NPDPs used digital knowledge repositories in their NPD work. Specifically, they were asked if they used common systems for knowledge sharing that had features supporting systematic capture, organization, and categorization of knowledge-based information. Thereafter, additional questions were asked to ensure that repository KMSs were not confused with simple file sharing, other types of enterprise ISs, or personal knowledge repositories. Contacted NPDPs not using a repository KMS were excluded from the study.

3.2. Data Collection

The interview guide included questions about the types of NPD projects they were involved in, the type of knowledge shared, and their experiences with physical and digital knowledge sharing processes (see Appendix A). The relatively few questions prepared reflect the ambition to minimize the influence on the responses provided by the NPDPs. On the other hand, when the interviewees accounted for their experiences, different lines of questioning were used to make them elaborate on these to strengthen the validity and reliability of the findings [54]. The interviews were conducted by the researchers and research assistants, and they were recorded and transcribed. Additionally, supporting documentation was gathered in the form of textual and graphical project and product descriptions. For the interviews, one hour was scheduled, but these, in some occurrences, lasted longer.

The number of interviews was determined using the logic of data saturation [11, p. 134] – that is the point in data the analysis phase where the collection of additional data does not identify new categories or further develop their properties, dimensions, and relationships [11, p. 139]. After around 16 interviews, the identified categories did not develop further, and data collection ended after interviewing 24 NPDPs. As themes developed during the analysis, a need for additional clarification from some of the first interviewed NPDPs emerged. Thus, seven of these were interviewed again, each interview lasting around 30 minutes. Thereby, in total, 31 interviews were conducted. Information about the interviews is found in Table 1. The interviewees were all employed in companies based in or with operations in Denmark.

Table 1. Interviews conducted

Y*	Position	Company focus	Y*	Position	Company focus
15	Project manager	Lighting systems	7	Lead engineer	Engines and power systems
33	Business engineer	Solar power solutions	14	Project manager	Manufacturing technology
17	System engineer	Pharmaceutical products	20	Mechanical engineer	Production automation technology
2	Project engineer	Processing technology	6	Mechanical designer	Sensor solutions
20	Project manager**	Building automatic	10	Electrical engineer	Data transmission equipment
31	R&D engineer	Medical devices	21	Product manager	Power, automation, and digitalization
12	Product engineer	Energy infrastructure	12	Project engineer	Production facilities and equipment
2	Design engineer	Electronic components	25	Machine engineer	Pharmaceutical products
28	Process engineer**	Food processing solutions	7	Product lead**	Sustainable energy solutions
36	Product engineer	Energy solutions	5	R&D engineer	Heating, cooling, and power systems
5	R&D engineer	Medical equipment	5	Mechanical engineer	Product assembly solutions
9	Product line manager	Physical infrastructure and software	19	Product manager	Manufacturing machinery and equipment
* Years of industrial experience, ** Unavailable for the second interview round					

3.3. Data Analysis

The data analysis also drew on grounded theory [12]. For the first part of the analysis, this involved that open coding was conducted after each interview [30]. Specifically, open coding describes the phenomena in the form of concepts [26], which are identified by disentangling data through assigning meaning to data pieces (single words or short sequences of words) so that codes can be attached to them (i.e., "concepts"). The focus of this part of the analysis was to identify parts of the interviews describing factors affecting the effects of KMS use. Hereafter, concepts with similar characteristics were grouped into categories [12, p. 74].

The second part of the data analysis can be described as "axial coding", i.e., a "complex process of inductive and deductive thinking involving several steps … toward discovering and relating categories in terms of the paradigm model" [12, p. 114]. This process concerned the refining and differentiation of the categories identified, as well as the identification of relationships between substantive categories. In this part of the analysis, attention was paid to concepts and dimensions in the existing literature. Specifically, to avoid introducing new theoretical constructs with high similarity to established ones, it was attempted to converge towards existing terminology while not compromising the meaning and content of identified concepts.

The coding work was carried out by one researcher. To ensure reliability in the coding, five sessions with other researchers were conducted during the coding phase, in which the codes and alternative interpretations were discussed.

4. Findings

The continuous data collection and analysis identified 43 concepts influencing KMS success, which were organized under 17 dimensions. These are shown in Table 2 and subsequently further explained.

Table 2. Conditions for KMS success in NPD

Dimensions	Concepts	Excerpts from interviews
Knowledge dynamics	Internal knowledge dynamics	"We are inventing new things all the time. So, we constantly create new knowledge."
	External knowledge dynamics	"It's going very fast with these technologies... There is something new all the time, so it can be difficult to ensure that all the documents are updated."
Knowledge complexity	Knowledge formalizability	"It is rather difficult to put this kind of knowledge into a document."
	Knowledge understandability	"There is just some knowledge that requires extensive explanations to understand it."
KMS use satisfaction	Utilitarian satisfaction	"The system helps me much. It is really useful."
	Hedonic satisfaction	"I enjoy working with the system."
KMS use	KMS use intention	"I try to use the system whenever possible. But, often, I don't get it done."

	Actual KMS use	"Yes, I use the knowledge base all the time."
KMS software quality	KMS usefulness	"I don't think I get much out of using the system [the KMS]."
	KMS ease of use	"The system provides a good overview of the knowledge, which is in it."
KMS knowledge quality*	Representational quality	"It is important that you make something of it when you add new knowledge, so that others will understand it."
	Timeliness	"There is a lot of obsolete information [in the KMS]. It is not very appropriate."
	Relevance	"There is way too much irrelevant information [in the KMS]."
	Accuracy/credibility	"Sometimes, I am not fully convinced that what is stated is correct."
	Completeness	"If you constantly experience not being able to find what you are looking for, you will stop using it [the KMS]."
KMS service quality	KMS internal service	"My colleagues have been good at helping me with understanding how you do different things [in the KMS]."
	KMS external service	"Our supplier [of the KMS] can be a bit slow to respond when there are technical issues."
Human sources' communicator quality	Explanation skills	"Some things, I would prefer to have it in writing, as it can be extremely difficult to understand when some of my colleagues try to explain it."
	Listening skills	"Sometimes, when I ask about one thing, then I get an answer on something completely different."
Human source knowledge quality*	Representational quality	"They [some colleagues] have a different background than me, so they use other technical terms."
	Timeliness	"Some of my colleagues are not always updated on the latest technological developments."
	Relevance	"Their knowledge is not always relevant for what I am working on."
	Accuracy/credibility	"I am not always sure if they really know what they are talking about."
	Completeness	"Often, when I ask my colleagues, they don't know it."
Human knowledge source availability	Knowledge sharing attitude	"Some do not seem very engaged when it comes to sharing their knowledge [personal sharing]."
	Knowledge sharing opportunity	"There are many who do not have time for it [knowledge sharing]."
Other systems' software quality	Other systems' usefulness	"In some situations, there are other systems that offer much better functionalities [for managing knowledge]."
	Other systems' ease of use	"It's much easier for me to manage knowledge with my own little system."
Other systems' knowledge quality*	Representational quality	"Some users are sloppy when they describe something [in the KMS]. Sometimes, it is better in other systems."
	Timeliness	"When you manage your knowledge yourself, you are sure it is updated."
	Relevance	"The problem is that the system [the KMS] is used by so many users with different needs. Thus, there is a lot of information that is not relevant to me. ...sometimes it works better with smaller systems."
	Accuracy/credibility	"When a system gets many users, it becomes more difficult to assess if everything is correct. ...so, there is some knowledge I prefer to manage locally."
	Completeness	"Sometimes, the knowledge I need is in other systems."
Other systems' service quality	Other systems' internal service	"It is much easier to get someone to help me when I am using our enterprise architecture system:"
	Other systems' external service	"If technical issues [in the KMS] are not fixed, people will use other systems to share their experiences."
Knowledge acquisition need	Knowledge acquisition need	"Some projects just don't demand that I need to collect knowledge."
Social norms	Injunctive norms	"People often tell me that I should remember to contribute to the knowledge base [in the KMS]."
	Descriptive norms	"Most of my colleagues do not really use the system [the KMS]. ...this does not exactly strengthen my motivation for using it."
Management engagement	KMS incentives	"Our manager praises us for sharing knowledge [in the KMS]."
	KMS directives	"There needs to be some pressure from the management before people put enough energy into it [KMS knowledge creation and maintenance]."
	KMS prioritization	"If this shall ever work [KMS use], I think we need to be given time that is dedicated to sharing knowledge [in the KMS]."
Policies and procedures	KMS policies	"Our company has a clear policy that we should become better at sharing knowledge. This is also why we got this solution [KMS]."
	KMS procedures	"We have a document that describes the steps you need to do after a project. In this manner, we ensure that knowledge is shared."

* Only the most frequently mentioned information quality dimensions are included (see [35] for additional dimensions)

The first and second dimensions in Table 2 concern the characteristics of the knowledge in focus. Regarding the "knowledge dynamics" dimension (how frequent knowledge changes), several NPDPs pointed out that the more frequent knowledge changes, the more efforts are needed to create new knowledge entries and remove obsolete ones – at some point rendering the costs too high as compared to the benefits of the KMS. Next, the "knowledge complexity" dimension describes how difficult the knowledge is to understand and formalize, which in turn affects how difficult it is to share digitally or through personal interaction. The interviews supported that both these dimensions have a great influence on if knowledge was shared through the KMS, personal interaction, or other systems, if shared at all.

The third, fourth, and fifth dimensions draw on the naming from the DeLone and McLean model [17], i.e., "use" and " user satisfaction". In this context, the interviews supported the observation by DeLone and McLean [17] that intention is not always converted into use (as illustrated by the interview excerpt in Table 2 under "KMS use").

The sixth, seventh, and eighth dimensions ("KMS software quality", "KMS knowledge quality", and "KMS service quality") also draw on the naming from the DeLone and McLean [17] model. In this context, the interviews showed that, in particular, the KMS knowledge quality affected the intention to use the repository KMS, while, in most cases, the KMS software was not perceived to produce major issues. KMS service quality appeared to be of even less relevance by only being mentioned in a few cases.

The ninth, tenth, and eleventh dimensions concern the knowledge quality, communicator quality, and availability of human knowledge sources. In this context, all the interviewed NPDPs shared knowledge using both the KMS and through direct communication with coworkers, and there was general agreement that in some situations, it was easier and more efficient to share knowledge through personal conversations than through the KMS. In the situations where the knowledge in focus was considered better suited for being shared through personal communication, the central arguments for choosing to use the KMS anyway concerned coworkers not being available, coworkers not being good communicators, and problems in finding someone with the expertise needed.

The twelfth, thirteenth, and fourteenth dimensions concern the use of other systems as a means for sharing knowledge. As for KMS quality, their appeal concerns software, knowledge, and service quality aspects. In this context, the interviews pointed to two main types of challenges, namely competition from the use of personal knowledge repositories and other enterprise ISs. Regarding the first, many of the NPDPs expressed that it was sometimes more convenient to manage knowledge locally, as this was faster and gave better control of the contents. They also pointed out that KMS inputs from others could have representational or trustworthiness issues. Furthermore, some NPDPs found that so much was stored in their KMS that it could be difficult to find what they were searching for, despite the systematic organization of entries. Second, in several cases, the KMS use was challenged by other enterprise systems with overlapping content or even several KMSs in the same company.

The fifteenth dimension concerns the need to acquire knowledge in a project. From the interviews, it was evident that the less the need for acquiring knowledge was, the less relevant the KMS was found to be.

Finally, the sixteenth, seventeenth, and eighteenth dimensions describe a set of organizational factors affecting the intention to use a KMS. In this context, the interviews suggested that instructions on using the KMS from colleagues, as well as their KMS use intensity, influenced the intention of KMS use. Next, the role of relevant managers was emphasized in the form of providing incentives and directives regarding KMS use. However, the main manager-related issue appeared to be KMS prioritization, in the sense that NPDPs often experienced managers not assigning adequate time to share knowledge in such systems. Lastly, the interviewees generally perceived the KMS policies and procedures to promote KMS use by providing clarity about what to do and how to do it.

The discussion of dimensions and their relationships is summarized into a conceptual model in Figure 1, which shows their role in relation to "KMS net benefits" (as defined in Section 2.2). The arrows show the directions of the effects between dimensions, according to the statements provided by the NPDPs (as indicated above).

5. Discussion

This study aimed to provide a deeper understanding of the conditions for KMS success in NPD processes. This was achieved through analyses of 31 interviews with 24 NPDPs, which produced two main contributions. The first contribution is a KMS success model that, as compared to existing such models, provides a more extensive account of the conditions for KMS success. Second, the study offers more detailed explanations of how KMS projects differ from other enterprise IS projects. These contributions are subsequently discussed.

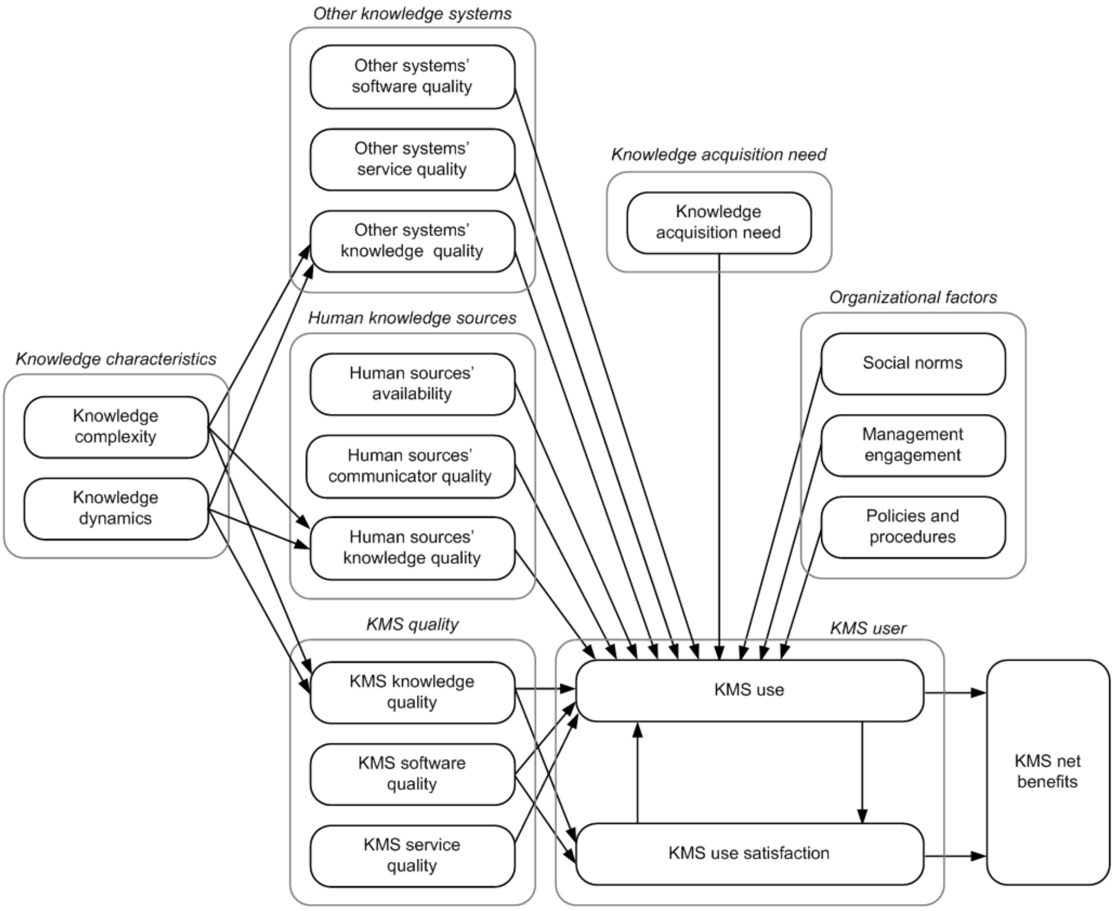

Fig 1. Conceptual model

5.1. Conditions for KMS Success

Several studies focusing on conditions for KMS success have been based on the DeLone and McLean [16,17] IS success model. In this context, the models by Wu and Wang [53], Halawi et al. [34], and Filieri and Willison [25], to a large extent, just adapt the constructs of the DeLone and McLean model by using the term "knowledge" instead of "information". For such reasons, their models do not consider dimensions related to knowledge characteristics, knowledge need, human knowledge sources, other knowledge systems, and organizational factors. In the present study, however, such dimensions were found to be highly relevant, albeit with varying emphasis. Thus, while the model developed in the present study also includes the dimensions of DeLone and McLean's [16,17] IS success model, it offers a more detailed account of the conditions for KMS success by adding several KMS-related dimensions.

Besides the KMS research based on DeLone and McLean's model, some studies apply different approaches. One example is the model by Kim et al. [40], focusing on the conditions for repository KMS success. Specifically, the model by Kim et al. [40] includes five moderators on the relationship between "repository KMS use" and "performance", of which the present study identified dimensions overlapping three of these ("social sources"/"human knowledge sources", "computerized sources"/"other knowledge systems", and "changing knowledge intensity"/"knowledge need"). On the other hand, we did not find that "total information intensity" had an influence other than if this resulted in knowledge complexity or diminished knowledge quality. Also, we found no evidence that the use of "physical sources" had a significant effect on KMS use. These missing effects may be explained by our focus, as compared to Kim et al. [40], on a more knowledge-intensive type of environment, implying that the information intensity is always relatively high and physical knowledge sources are of less relevance. On the other hand, our study included several dimensions not included in the model by Kim et al. [40].

An account of the conditions for KMS success that consider more knowledge-intensive environments is the systematic literature review by Jackson et al. [38], which identifies six factors affecting the implementation of a KMS. These factors, to a large extent, overlap the dimensions of our model – specifically, "formal processes", "company culture", "top-down support", and "clear goals" are captured by the organizational factors in our model, while "motivation" and "quality of KMS" are captured by our "KMS user" and "KMS quality" dimensions (see Figure 1). On the other hand, the model by Jackson et al. [38] does not account for the identified dimensions related to knowledge characteristics, knowledge need, human knowledge source, and alternative knowledge systems. Thus, in comparison, our model provides a more detailed perspective, although the dimensions described by Jackson et al. [38] are a synthesis of the KMS literature across application areas.

5.2. The Distinction Between KMSs and other Enterprise ISs

As touched upon in the discussion above, the present study provides additional clarification of the distinction between KMSs and other types of enterprise ISs. The first characteristic that sets KMSs apart from other enterprise ISs is the role of alternative knowledge sources. Specifically, as shown by our study, in many cases, it was considered easier and more efficient to share knowledge through personal communication. Compared to enterprise ISs holding master and transaction data, such as ERP systems, this would be a much rarer event. As an example, it would seem unlikely that asking a colleague for a verbal account of a product's master data or the sales data for the last year would be considered more convenient or efficient than retrieving these data from an ERP system. While interaction with human experts mostly had a knowledge acquisition focus, the use of other knowledge systems often focused on NPDPs preferring to manage knowledge locally to have more control of such information. Thus, KMS implementations, to a larger extent, seem to involve the challenge of making people use these systems instead of alternative means. This aspect is described by our model's dimensions related to "human knowledge sources" and other knowledge systems".

The second main difference between KMSs and other enterprise ISs concerns the characteristics of the information that is stored in such systems. Specifically, the intangibility and complexity of knowledge make it much harder to control that knowledge is shared, as compared to, for example, investigating if someone has registered the master data for a new product or typed in a sales order. In other words, information in other enterprise ISs typically describes relatively tangible phenomena for which the completeness of inputs is observable to others. On the other hand, the extent of the knowledge possessed by an expert is only known by this person, making it harder to control if all relevant inputs for the KMS have been delivered. Our model touches upon this aspect with the dimensions related to "organizational factors" and "knowledge characteristics", as well as the "KMS knowledge quality" dimension.

Third, the need for knowledge varies across projects. What sets KMSs apart from other enterprise ISs in this regard is the challenge of predicting such needs. Specifically, as shown by the study, it is typically more difficult to predict if certain knowledge will be relevant in future projects, as compared to, for example, predicting the future need for product or sales data in an ERP system. This aspect is described by our model's "knowledge acquisition need" and "knowledge dynamics" dimensions.

Finally, as shown by the interviews, when the knowledge in focus had a certain level of complexity, it was found impossible or too time-consuming to convert into an explicit form. This aspect is described by our model's "knowledge complexity" dimension.

6. Conclusions

The present study sought to improve the understanding of the conditions for KMS success. To do so, an explorative study inspired by grounded theory was applied in the form of a series of interviews with NPDPs. This gave rise to the identification of 43 concepts, organized under 17 dimensions, that influence the success of KMS in NPD. Further analysis of the collected data gave rise to a model describing the relationships between these dimensions.

The study provides two main contributions. First, the study extends existing research on the conditions for KMS success (e.g., [34,38,53]) by providing a more detailed account of such. In particular, the study extends the sparse literature on KMS success in the context of NPD (e.g., [9, 24,25]). From a more overall perspective, the present study contributes to the IT business value literature [1,5,43] by clarifying the conditions for KMSs to provide value. Second, the study provides additional clarification on how KMS implementation differs from other enterprise ISs. Specifically, the empirical studies pointed to four such characteristics: (1) higher competition from alternative knowledge sources (i.e., humans and other ISs), (2) challenges of controlling if experts register their knowledge in the KMS, (3) unclearness about which information (i.e., explicated knowledge) will be of future value, and (4) difficulties of converting knowledge into information.

For practitioners, our KMS success model provides an account of factors to be aware of when engaging in KMS projects. This model may take different roles: it may be used as a means for evaluating the potential benefits and risks of a KMS project, for KMS project planning, and for addressing problems in ongoing projects.

The main limitation of the study is that it does not provide information about the strength and significance of the relationships in the developed model – it only provides evidence that they, to some extent, influence KMS success. Thus, future research needs to test the identified relationships using a quantitative approach. Finally, given the general relevance of the identified dimensions, the developed model appears to be useful in contexts other than NPD, which involve sharing of complex and frequently changing knowledge. However, further studies are needed to confirm this.

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Appendix A: Interview guide

- Which NPD projects are you or have you recently been involved in?
- In these projects, with whom did you share knowledge?
- Which knowledge did you provide for each of these actors, and how?
  - What were the reasons for using these forms of sharing and for not using others?
  - What were the advantages and drawbacks of these forms of knowledge sharing?
- Which knowledge did you receive from each of these actors, and how?
  - What were the reasons for using these forms of sharing and for not using others?
  - What were the advantages and drawbacks of these forms of knowledge sharing?
- Were there situations in which you did not provide the knowledge asked for?
  - In which situations, and why? What did they do instead?
- Were there situations in which it was difficult or impossible to acquire the knowledge you needed?
  - In which situations, and why? What did you do instead?