Project Knowledge Management
Organizational Design and Success Factors – an Empirical Study in Germany

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Abstract

The efficient and effective management of projects is a key success factor for many organizations. Empirical studies indicate that systematic know-how transfer from, between and within projects has significant impact on the success of projects. However, the role of knowledge management in projects has been insufficiently investigated. This research aims at spotting the status quo and causalities of project knowledge management in a sample of companies from different industries and to identify success factors. Based on 27 interviews, the current status, determinants and good practices of effective knowledge management in project environments are identified. The determinants and good practices can be traced back to four categories: cultural, organizational, structural, and process-related aspects. The interrelations between these and project knowledge effectiveness and project success are statistically investigated based on a survey with a sample of 495 questionnaires. Based on the understanding of success factors and cause-and-effect relations management implications are developed.

1. Introduction

The prevalence of projects as a form of organization has only recently been acknowledged [44, 16]. A shift in perspective is taking place from considering projects as exceptional cases to accounting projects as regular business processes creating value [20, 52]. Due to their temporary and unique nature, projects are different from standard organizational processes. They are characterized by discontinuous personnel constellations and work contents, a lack of organizational routines, a short-term orientation and a cross-disciplinary integration of internal and external experts [45, 49, 39, 13]. In many cases, projects are carried out beyond the hierarchical lines of authority and therefore require specific leadership skills [16]. Thus, the management

of knowledge in and of temporary organizations is an increasingly important and even decisive competitive factor. In both areas of research, knowledge management and project management, a substantial quantity of theoretical, conceptual and empirical work deals with the different questions of the respective disciplines. However, little research has tried to combine both areas to analyze the challenges of knowledge management in temporary organizations [39, 8]. In this paper, we hence introduce the specific problems of knowledge management in temporary organizations and present the combined results of an exploratory qualitative study on the prevalence, the organization and the success factors of knowledge management in and between projects as well as the quantitative results of a survey based study.

2. Project knowledge management

Knowledge can be defined as the set of skills, experiences, information and capabilities individuals apply to solve problems [5]. Knowledge management (KM) is the set of practices an organization applies to create, store, use and share knowledge [46]. The concept of KM is well established and advanced. [12, 43, 53, 54]. KM in temporary organizational settings, such as projects however, is a relatively recent field of research. Project knowledge management (PKM) is knowledge management in project situations and thus, the link between the principles of knowledge management and project management.

PKM not only comprises knowledge within projects but also knowledge between different projects and knowledge about projects [50]. Knowledge within projects is closely linked to the project management methodology and the communication practices in projects. Knowledge about projects denotes an overview of the project landscape (the projects being conducted or those that have been conducted) in an organization. The knowledge transfer from and between projects can be referred to as expert knowledge, methodological knowledge, procedural knowledge, and experience

knowledge. Knowledge from and between projects contributes to the organizational knowledge base.

Experience from subsequent projects, information about the buying team, and knowledge about technology and markets are examples of knowledge types that are of particular importance for the early phases of the project. Knowledge about existing (technical) solutions, experience from scheduling, and the application of tools might be more interesting at the stage of implementation.

The theoretical roots of PKM can be found in the knowledge based theory of firms [31, 11, 53]. The knowledge based view considers the superior ability of a firm to integrate specialized knowledge by certain integration mechanisms as key source of competitive advantage. According to Grant, projects can be seen as one possible integration mechanism on the company level [20]. However, projects themselves demand integration and coordination of the internal knowledge of project members and external knowledge from the project environment. According to Grant projects represent means of integration which are particular effective to solve tasks with high complexity and uncertainty. Nonaka regards projects as nonhierarchical self-organizing units particularly suited to perform socialization and externalization tasks [43]. Sense perceives projects als learning entitities referring to the concept of organizational learning [51, 26, 3]. In the same way Lundin&Midler describe projects as "arenas for renewal and learning processes" (p.2) [40].

3. Research demands

The particular challenges of PKM are due to the inherent project characteristics [39]. Projects are unique and temporary undertakings with changing work force. Moreover, projects are often short-term oriented integrating internal and external experts as well as knowledge. Due to the temporary and unique nature of projects, KM and organizational learning in project environments and project-based firms face particular obstacles [13, 18, 45, 30]. Projects are characterized by a temporary constellation of people [45, 13] so that routines and organizational memory can not be developed and stored in the "genetic traits" [45] of the projects in comparison to permanent organizations where departments act as knowledge silos. Thus, project-based organizations lack an organizational memory, routines and other mechanisms for knowledge capturing, storing and disseminating and for organizational learning [45]. After the project is finished the constellation of people working together is resolved, fragmenting the project knowledge [15].

During the last years a number of publications have contributed to the understanding of PKM and its management. Prencipe&Tell developed a landscape of learning mechanisms in project based firms [45]. Keegan&Turner investigated project-based learning practices [30]. Based on interviews in nineteen companies across Europe they identified time pressure, centralization and deferral as key factors influencing learning from and through projects. Schindler identified a number of determinants for PKM based on action and case study research [50]. He grouped the determinants in the following categories: culture, ICT, project management methodology, learning, and organization. Bresnen et al. studied the role of social processes for PKM based on case studies in new product development projects [7]. As a result they pointed out the limits of ICT systems to support knowledge management and suggest a community approach. Schindler&Eppler described the practice and success factors of post project reviews to "harvest" project knowledge [49]. They stressed the importance of a formalized lessons learned process integrated in the project methodology and project goals. Adenfel&Lagerström investigated the role of different knowledge management enablers (structure, culture, ICT) [1] in knowledge creation and sharing in a transnational project. They found out that culture is the most important enabler. Based on three case studies in consulting and research institutions Karlsen&Gottschalk tested the influence of three factors affecting knowledge transfer (information technology, systems&procedures, organizational culture) on project outcomes in IT projects [28]. Both culture and systems&procedures are related to project outcomes, while ICT did not show significant influence. Newell et al. applied the concept of social capital to knowledge management in project context and claim that both bonding and bridging aspects play an important role for knowledge integration in projects [42]. Brookes et al. defined a project social capital to explain access to project knowledge [8]. Reich identified ten knowledge-based risks for IT projects based on a number of interviews with project managers [47]. These risks refer to the project governance process, the operational project process as well as to project inputs and outputs.

The analysis of existing literature on PKM shows that a number of qualitative and conceptual approaches exist. Most of these approaches are based on case studies considering a rather small number of different companies and research settings. In some cases PKM was regarded from a wholistic perspective, incorporating cultural, organizational and technological issues. [1, 50, 28]. Other approaches focused on particular questions of PKM such as the role of tacit knowledge [33], social processes [7], the role of PMO [14], the institutionalization of PKM responsibilities [52] or

transfer mechanisms [56, 8] in different project settings. Only few approaches took a cross industry view [7, 50]. Bresnen et al. concluded that across different sectors "remarkably similar barriers and enablers to manage knowledge for project based learning" (p.165) exist [7]. The questions if there are major differences in PKM practice across industries and project types have not been answered yet. Several studies identified structure, culture and systems as enabling factors [1, 28] but do not provide deeper insight about the factors beyond these abstract expressions.

To date research results are based on rather small samples so that generalization might not be possible [4,25, 51]. Furthermore, literature has identified the specific problems and challenges of knowledge management in project environments, but does not derive general solutions on the management of knowledge in project-based firms and organizations [23, 33]. Prencipe&Tell state that regarding PKM "the relationship between learning effectiveness and overall firm performance has yet to be established empirically" (p. 1391) [45]. In a similar way Kotnour states "additional quantitative studies need to be completed to determine the extent to which the learning process lead to project management success" (p. 405) [29]. Hall&Sapsed conclude: "yet, in spite of recent advances in our understanding of how to manage knowledge, its capture and transfer remain acute problems for project-based firms and organizations" (p. 57) [23]. As a consequence, two major research gaps have to be filled in order to derive solutions for the effective and efficient implementation and use of PKM: (1) The investigation of the status quo of PKM (organization, instruments, methods) across different industries and types of projects and (2) The identification of success factors for PKM.

4. Research approach and methodology

The research approach follows a two step procedure. In a first step, a qualitative study was carried out to identify the factors that facilitate and inhibit the success of knowledge management and the status quo of implementation in projects. A subsequent questionnaire based study was conducted in order to test the factors and to identify those with the most significant impact on project knowledge management.

The quantitative study is based on 26 expert interviews which were conducted in companies from different industries mainly located in Germany comprising major subsidiaries of foreign corporations. The data was collected during the first half of the year 2007 in face-to-face interviews with managers either responsible for knowledge management and/or project management. The interviews were designed as semi-structured, open ended expert interviews. The interviews were recorded and transcribed. In order to avoid a possible industry bias, companies from different industries were included in the sample. Furthermore, the sample comprises different project types.

The qualitative data was subjected to a computer supported content analysis using the software package ATLAS.ti [34]. In order to examine the interview transcripts systematically, we developed empirical categories following the procedure suggested by [41]. According to Mayring a stepwise inductive derivation of categories from the data material was conducted independently by two researchers. The coding frames developed by the two researchers were compared before an iterative process of re-coding started. To give an example of the coding frame, one code was identified to be "integration of knowledge related procedures and mechanisms in the project methodology". This code could in some cases be evaluated according to the characteristics "high integration" to "independent". After two iterations the coded material was evaluated for qualitative and quantitative (frequency) aspects. The detailed results of this analysis are not presented in this paper. The focus of the results presented in this paper however, is to give an overview of current practice in PKM and to identify potential success factors and determinants of PKM for the subsequent quantitative study.

In a second step, the quantitative survey was conducted in the second half of 2007. About 8000 project managers, project leaders, project workers and members of project management offices were asked to complete a paper based or online questionnaire. A response rate of six percent could be achieved, corresponding to an analyzable sample of 496 questionnaires.

Based on the findings of the qualitative study and on sustentative literature, a research model was developed to test the hypothesized interrelations and success factors of PKM. The model is tested with structural equation models. As formative and reflective constructs are tested, the Partial Least Square (PLS) method is applied. The results were also verified with ordinary least squares statistical methods (regression). No major discrepancies concerning the weights and the directions of the relations were identified. All constructs have been tested for construct validity (convergence, discriminance, communality, and multicollinearity) according to common practice in empirical research. All values are within tolerable boundaries.

5. Study results

5.1. Results of the qualitative study

The results show that companies and experts are aware of the problem of PKM throughout industry lines, enterprise sizes, and project types. The potential of PKM is especially high for companies with high project- and knowledge-intensity as can be found in the plant construction sector, the construction sector and consultancy services. For instance, one of the interview partners estimated the potential cost savings by excellent PKM in the plant construction sector at 3-5% of total project volume. Apart from cutting costs, several other objectives of PKM were stated. These can be summarized in five aims: Increasing work efficiency and reducing risk by capitalizing the experience and knowledge gained during earlier projects. A continuous learning process throughout the overall project work, in contrast to a solely improvement during a single project life cycle, allows to revise and develop the processes applied as well as the created products constantly, including the prevention of repeated mistakes. Continuous improvement is also stated as main goal in terms of methods and standards related to project management. Another aim is the favorable staffing of projects. This goes beyond the optimal allocation of available resources and implies the staffing of projects along competences and expert knowledge of project workers. Not least, the identification and fostering of innovation was stated to be an important goal. Here, especially the advantages of interdisciplinary project teams could be used to foster innovative approaches.

Irrespective of these points, the companies show different preferences concerning the kind of knowledge transfer. While the majority focuses on personification, codification as well as combinations of both, are used to transfer knowledge. It is noteworthy that only consultancies where able to actually estimate the proportion of personal to codified knowledge transfer. Here, the ratio of knowledge codification to personification strongly varies. In this respect, a correlation with the company size is noticeable. A higher number of employees seems to require a higher extent of formalization and therefore codification of knowledge. In addition, it is indicated that a strategy of personification is applied if a higher degree of knowledge specialization is used. Several companies clearly focus on people and implicit knowledge.

In principle, different approaches for incorporating PKM in the overall organization can be found. This is due to the dual nature of projects within the organizational setting. The issues of PKM are affiliated to the area of knowledge management, project management or exist as a combination of both. At the same time, the responsibilities for knowledge management and/or project management are established in different forms. Within the interviewed companies, functional units, special departments or integration in the divisions are found in charge of parts of the overall PKM process.

In terms of use and binding character of project management methods, all characteristics were found. While some companies use no specific project management methods at all, others even have different project management methods for each type of project. Thus, a varying use of project management methods can be found within one single company, depending on the type of project and organizational entity. Also, the binding character of the applied methods greatly varies: While some participants offer project management methods without obligatory character, other companies strictly use binding project management methods. In this regard, size and risk of projects are two major factors influencing the consistent application of project management methods.

A similar range of answers was given concerning the integration of PKM in existing project management methods. Lessons learned, one of the most frequently mentioned instruments of PKM (used in 9 companies), only is integrated in compulsory project management standards in some cases (7 companies). Nevertheless, this does not imply that this form of securing project experience is accomplished. The interviewees often stated that time pressure, due to new projects or higher priorities in operational business areas, prevent them from conducting lessons learned workshops or meetings. Also, the rate at which experience is captured varies to a great extent. In some cases, only the project close-out reports were used for mapping lessons learned. Other interview partners stated a cyclical elaboration of gathered experience according to the methodology in use, e.g. at the finalization of subprojects or project milestones.

Significant differences also exist in the evaluation and availability of lessons learned and debriefings. In some companies, the corresponding documents are distributed only within project teams; other companies store these documents electronically conceding access to all employees. Regarding the support of PKM by information technology, several companies use Wiki-technology in addition to other measurements. This platform technique, alike the role model of Wikipedia, enables all users of the company to paste and modify

articles virtually on any subject. Further software tools for the support of PKM vary in extent and use in the interviewed companies. For example, electronic templates for project-specific documents are used in several of the respective companies. While in some organizations these documents belong to standardized and binding project methods, they are applied as mere supportive documents in other organizations. Altogether, the support by information technology tools has proven to be a necessary but not sufficient factor for the quality of PKM.

Success factors and barriers where specifically targeted during the expert interviews. Four categories of success factors could be extracted from the expert interviews: (1) Information- and communication technology; (2) organization; (3) procedures and (4) culture and communication

The areas of information and communication technology merely serve as supporting factors to successful PKM – this contrasts the prevalent approach in the visited companies but is in line with the answers given by the interviewees. Without pertinent support of IT-tools, PKM is difficult to put in use. However, the implementation of the corresponding software should not be considered as a solution in itself. Even the best possible IT-support is not sufficient if the corporate culture does not encourage the use of the provided software and application devices.

The main focus has to be on people and their acceptance of the tools to be used. The primary goal should be the development of a software management process, in which the used tools are integrated. It was often stated that voluntarily used tools (such as the Wikipedia model) need to achieve a critical mass of participants and information in order to be enforced and shared in a company. Additional effort for filling these systems with knowledge should be as small as possible in order to gain a high level of use and enforcement. In general, a self-explaining filling structure and tools with further features should be feasible. This facilitates reusing deposited knowledge by providing efficient search possibilities. The danger of unwanted outflow of knowledge also has to be considered. At the IT-level this could be prevented by corresponding access rights.

Concerning the **organization** and the organizational embedding of PKM in a company, the support by top-management is a fundamental factor. The role model function of top-management as a starting point for supporting soft factors was mentioned by several respondents. *"And this really has to be, this has to be exemplified by the top-management. And if one does not do something, one must face the consequences." (no. 5, consulting)* In

addition, the priority of PKM should be emphasized more as it is crucial for the securing of the sustainable development of the factor knowledge.

Furthermore, the interfaces to other functional areas (e.g. personal development, quality management, IT) that have an impact on knowledge management must be considered. These functional areas should be included in the PKM process by searching for possibilities and facilitations of close cooperation in knowledge management related subjects.

The use of standardized project PKM **procedures** offers a framework and routines to employees facilitating the concentration on the gist. Easy-to-use standards and processes should be chosen on purpose. Most of the time it will not be possible to cover all probable use cases – here a designated person could assist and serve as a reference for possible ideas, questions and suggestions and furthermore can push the subject in the company. In the ideal case, a process of quality assurance exists for the stored knowledge. This implies that a distinct person to the one feeding knowledge into the system analyzes and evaluates the documents. *"But since two years now we have that quality assurance, we now have several reference persons worldwide, which are in charge for defined areas, and who filter what they want to be put in. And this quality assurance is essential for me." (no. 7, consulting)* For more sensitive topics, as the implementation of an expert data base where the qualifications of individual employees can be seen, it is indispensable to include the responsible person for data protection and the workers council.

During the interviews, it became obvious that **cultural factors** are of fundamental importance for the success of PKM. In several interviews, an insecurity concerning the danger of knowledge outflow was signaled. In this context, a trustful cooperation needs to be built and secured. At this point, cultural differences have to be regarded in particular. *"[...] we made the experience, that cultures are in fact very different. Even now, as I am in Switzerland, which is not far away but still a completely different mentality: You simply have to approach people in a completely different manner, in order to ensure that knowledge is absorbed and secured [...]." (no. 7, consulting)*

A supportive corporate culture enhancing interdisciplinary cooperation and knowledge exchange in the geographic distribution of project teams was identified as a key success factor. Also, the willingness to cooperate with participants of different nationalities and to cooperate with external parties (suppliers, consultants, etc.) was shown to have strong influence on a beneficial knowledge exchange environment in a corporation. A goal with regard to enhancing the quality of PKM could be the encouragement of soft factors such

as the cooperativeness, openness and trust. Further factors, such as the initiative of one's own and fault tolerance, must be connected to the observable willingness to admit mistakes and learn from experience.

Of high ranking should be the **communication** of the benefits of PKM in the company. PKM naturally competes with daily business for resources. The overall disregard of the importance of the individual's contribution to PKM seems to be a major obstacle when it comes to a successful implementation of PKM. Here, a prioritization in favor of PKM can be reached by supporting the use of PKM on the individual and on the company level. Correspondingly, the communication across all levels of hierarchy is of importance. One approach, which is above all used in management consultancies, is the systematic support of knowledge exchange on an informal basis. This ranges from regular project rehearsals (among the team/location as well as across teams/locations), performing of trainings and workshops on current topics, to company-wide events with the introduction of best practices. *"This is the typical way, that we do this every three to four weeks, the so-called brown bags, where we just come together during lunch [...] and one is presenting his lately gained knowledge [...] the aim is, to simply make this knowledge accessible to the others." (no. 7, consulting).*

Again, executive personnel serve as a role model when it comes to knowledge transfer and in this function can influence the behavior of the employees. Particularly openness, transparency, the prioritization of PKM related activities and dealing with mistakes properly is essential in this context. It should also be possible to communicate and tolerate mistakes. Connected to this, the willingness to learn and, in the ideal case, the ambition to eliminate mistakes has to exist.

5.2. Development of research model

Based on the findings of the qualitative study and previous literature we develop a research model to test factors influencing the success of PKM and its effects on project performance. The research model consists of two parts. In the first part of the model the impact of hypothesized enabling factors of project knowledge management are related to the success of project knowledge management as an intermediate outcome. In the second part of the model knowledge management success is related to project success as organizational performance variable. The basic idea of the model is based on research on knowledge

management enablers [19, 36] and knowledge management success [35, 58].

From the qualitative research we identify two main factors affecting PKM: (1) availability and use of systems, (2) quality and adequacy of systems.

The availability and use of effective systems facilitates the storage and transfer of knowledge in project environments [55, 1]. This is also supported by general (not project specific) KM literature [24, 12]. Weiser&Morrison conceptualize a system based project memory for knowledge transfer [57]. The quality of these systems refers to the ease of use and task adequacy. In a more general context the role of quality of knowledge management systems has been research by for example Wu&Wang [58] and Choi&Lee [36]. Gray develops an understanding of the importance of system quality for a team's problem solving capability and effectiveness [21]. Therefore we propose that the availability and the quality of ICT are related with the success of PKM.

In the field or structure we identified three main factors affecting PKM: (1) maturity of project management methodology, (2) institutionalisation of PKM in multi project environment (role of the PMO), (3) controlling of PKM activities.

The maturity of the project organisations describes the scope of the project management methodology and the stringency of deployment throughout the project organization. A stringent application of project management methodology serves as the storage of knowledge as routines [7, 49, 50]. While Adenfeld&Lagerström argue that formalization hinders knowledge management in projects environments [1] we suppose that a certain degree of formalization is necessary to overcome the natural "intertia" of people to make effort in knowledge management [49]. From the qualitative study we learned that companies with profound history and experience in project management demonstrate well established and obligatory project management methodology which in several cases explicitly considers PKM aspects. Thus, we propose that the maturity of project management methodology has an influence on PKM.

The "institutionalisation of central responsibility" of knowledge management in a multi project environment describes the structural aspects of the knowledge management process and the anchoring of clear accountabilities. Desouza&Evaristo conceptualize project management offices as knowledge-based archetypes [14]. Söderquist discusses different ways of institutionalizing the roles and responsibilities of KM in NPD project environments [52]. The role of a chief knowledge officer to coordinate knowledge management activities has been discussed in the general KM context [37]. Therefore, we assume that a central responsibility

for and support of PKM is positively related with the success of PKM.

From the qualitative study we learned that the evaluation and control of PKM activities is considered to be important by a number of interviewees. In literature we did not find clear evidence about the role of controlling of PKM [49]. We assume that controlling of PKM is important to guarantee the effectiveness and the quality of PKM.

From qualitative research we identified three main determinants of procedures supporting PK: (1) procedures and (de-central) responsibilities for PKM transfer, (2) organizing and support of PK exploitation, (3) organizing and support for PK storage and retrieval.

A number of interviewees underlined the importance to define clear procedures and de-central responsibilities of PKM on the operational level related to activities within and across projects. These manifestations of the responsibilities were - for example - described as the role of "knowledge champions" responsible for PKM within projects or programs [38]. Linked with the responsibilities are the retrieval and transfer procedures. The use of different channels and sources of knowledge transfer during the project life cycle is a major success factor and meets with the demand of complex dispersed project knowledge. The transfer of PK demands both, the definition of channels as well as the definition of responsibilities and contact persons [15, 47]. While the transfer on the individual level can be facilitated and fostered by the design of the cultural dimension, the transfer on the group and organisational level can be shaped through responsibilities and procedures to a certain degree. We thus assume, that the definition of responsibilities and procedures to support the transfer of project knowledge are related with project management success.

Major parts of the project knowledge base are experience knowledge. Thus, a defined process to identify, to explicate and to transfer the experience knowledge helps to systemize the exploitation and capture of experiences made in projects [49, 22, 45, 10, 32]. Schindler&Eppler as well as Koners&Goffin describe the process of capturing lessons learned and project experience. We hypothesize that procedures and organizational support to exploit project experience is related with successful PKM.

The systematization and quality assurance of PK contents ensures efficiency of PK activities on the operational (not strategic) level. It helps to organise, keep up-to-date and collect PKM from multiple sources, projects and work styles. From the interviews we learned that the quality assurance and the editorial supervision of documented project knowledge are considered particularly important. These aspects have not been explicitly considered in former research in PKM. In particular for the transfer of knowledge between projects and thus between different constellations of people the common understanding [25, 42, 54] is of importance. A standardised and systematic way of presenting and tagging knowledge as well as a universal taxonomy to store knowledge are helpful to facilitate a common understanding. We propose that an organisational support to the storage, the quality assurance and the retrieval of knowledge is related with the success of project management.

We identify four major cultural factors affecting PKM: (1) top management commitment and emphasis, (2) trust and PKM sharing readiness, (3) culture of freedom, creativity and mistake tolerance in projects, (4) informal networks. The role of culture and leadership has been discussed in a number of publications on PKM [7, 1, 27, 36, 2] as well as in general literature on knowledge management [56, 12, 1, 28] identified culture to be the most significant enabling factor of knowledge creation and sharing in projects. Culture to support PKM has several facets and most manifestations are either directly or indirectly influenced by the management.

From the interviews we learned that the top management serves as a role model for PKM on the one hand [17]. On the other hand top management has to create an atmosphere and ensures resource endowment facilitating and fostering PKM [17, 38, 35, 48]. Top management commitment, emphasis and the communication of common advantages ensures participation. Thus, we assume that top management commitment is related to PKM success and decides for the question if PKM is used.

Low barriers between different projects, projects and departments and other organisational units are decisive for open knowledge transfer outside the boundaries of a single project. Those barriers mainly depend on the individuals' readiness to share knowledge and mutual trust. Consequently, trust and readiness to share knowledge are necessary preconditions for all PKM related activities [42, 33, 17, 55]. A culture of mutual trust and understanding of personal and organisational advantages of PKM are considered effective means to facilitate the activity of potential PKM users. Eppler&Sukowski put this as common "norms" consisting of common goals, cohesion and trust [17]. Reward systems were not considered adequate means of motivating knowledge sharing. This finding corresponds with the literature on PKM as no evidence is provided about the effectiveness of reward systems. We hypothesize that the success of project knowledge management and the use of project knowledge is related to the level of mutual trust and readiness to share knowledge.

A culture of autonomy, creativity and tolerance towards mistakes shape an environment of openness and cooperation [2, 17] with room for reflection. From the qualitative study we learned that dealing with project experience is only fruitful in a culture that has a "positive" attitude towards mistakes. The importance of the role of culture tolerance towards mistakes might have been underestimated in previous studies. A second aspect concerning autonomy refers to the availability of time for participating in PKM activities [18, 9]

A fourth cultural factor mentioned in most interviews was the high importance of informal networks and social capital for the integration of dispersed knowledge into projects. This finding is in line with research on social networks to exchange knowledge in project environments [8, 25, 42]. Organisations may offer the conditions for people to establish networks, such as social events or communication facilitating infrastructure. We thus assume that informal networks are related with the success of project knowledge management. The constructs representing the cultural, procedural and system-related success factors have been operationalized based on the results of the qualitative survey and based on a literature review. All independent constructs are reflective, while the constructs of PKM success and project success are formative.

For the modeling of project management success we resorted to prior work on knowledge management success [35, 5, 58, 21, 36]. PKM success is thus represented in three dimensions: PKM infrastructure quality, the PKM usefulness, and project knowledge use. PKM infrastructure quality is described by the constructs: PKM effectiveness, PKM efficiency, knowledge quality. The link between knowledge usefulness and the use of knowledge has been demonstrated in the general KM context [35, 36]; in the context of teams, the relation has been conceptualized by Gray [21]. Kulkarni et al. have also demonstrated the influence of cultural and leadership aspects on the use of knowledge [35]. Thus, we hypothesize that there is a direct relation between the cultural factors and the use of project knowledge.
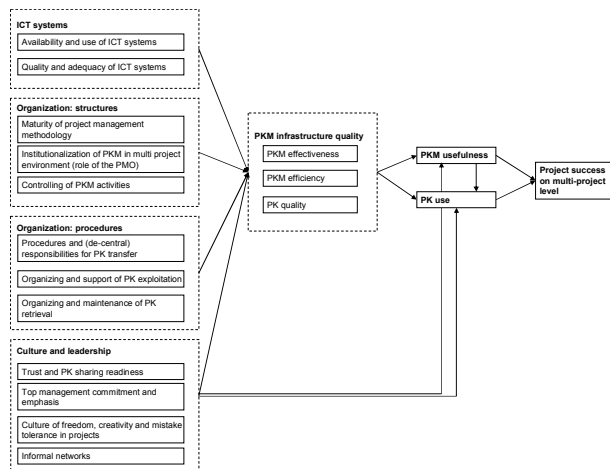

Figure 1: Research model

The PKM effectiveness represents the adequacy of the generation, storage, retrieval and transfer of project knowledge. The PKM efficiency inquires the effort-usefulness relation of PKM activities and their result. The PKM quality refers to the quality of the knowledge per se which is transferred and re-used in projects. PKM usefulness describes the perceived support of the PKM activities for project task completion. The use of project knowledge represents the intensity of use of means to resort to and to exchange both tacit and explicit knowledge. The project success on a multi-project level is operationalized by the degree of goal achievement (time, quality, and budget) and the satisfaction of the project stakeholder with the totality of projects of a certain project type. The research model is presented in figure 1. In additions, the common method bias of the research instrument must be accepted as necessary unavoidable weakness.

5.3. Results of the quantitative study

The results indicate that PKM effectiveness is determined by the following factors. These factors explain 43% of the variance of PKM effectiveness: quality and adequacy of systems, maturity of project management methodology, institutionalization of PKM in multi project environment (role of the PMO), controlling of PKM activities, procedures of PKM transfer on project level, organizing and maintenance of PKM retrieval, and trust and PKM sharing readiness. PKM efficiency is explained by the following factors which together explain 38,4% of the variance: quality and adequacy of systems, maturity of project management methodology, organizing and maintenance of PKM retrieval, trust and PKM sharing readiness. PK quality is determined by the factors explaining 33,4 % of variance of the factor: availability and use of systems, quality and adequacy of systems, maturity of project

management methodology, organizing and support of PKM exploitation, organizing and maintenance of PKM retrieval, trust and PKM sharing readiness.

The detailed results of the analysis are demonstrated in table 1 Together PKM efficiency, PKM effectiveness and PKM quality explain 51 % of the variance of the usefulness of PKM. PKM efficiency influences both, the usefulness of PKM and the use of project knowledge, whereas PKM efficiency and the quality of project knowledge are related with the PKM usefulness only. The use of project knowledge is determined by the PKM efficiency, by the PKM usefulness and the three cultural factors "culture of freedom, creativity and mistake tolerance in projects" and "commitment and emphasis of top management" as well as "informal networks". These factors explain 27,1% of the variance of the use of project knowledge.

Table 1: Empirical test of research model

Path coefficients (β values) from PLS analysis * significant on 0,1% level ** significant on 0.05 % level *** significant on 0,01 % level	PKM effective-ness	PKM efficiency	Knowledge quality	PK usefulness	PK use	Project success on multi-project level
Maturity of project management methodology	0,178 ***	0,163 ***	0,223 ***			
Institutionalization of PKM in multi project environment (role of the PMO)	0,148 *	0,115 (ns)				
Controlling of PKM activities	0,115 **					
Availability and use of systems			-0,178 ***			
Quality and adequacy of systems	0,213 ***	0,289 ***	0,177 ***			
Procedures and (de-central) responsibilities for PK transfer	0,135 ***					
Organizing and support of PK exploitation				0,188 *		
Organizing and maintenance of PK retrieval	0,187 ***	0,223 ***	0,133 ***			
Trust and PK sharing readiness	0,162 ***	0,192 ***	0,331 ***			
Top management commitment and emphasis					0,131 *	
Culture of freedom, creativity and mistake tolerance in projects					0,104 **	
Informal communication					0,146 ***	
PKM effectiveness				0,275 ***		
PKM efficiency				0,348 ***	0,213 ***	
PK quality				0,183 ***		
PKM usefulness					0,137 ***	0,244 ***
PK use						0,246 ***

Together, the use of project knowledge and the usefulness of project knowledge management explain 16,6 % of the variance of project success.

6. Discussion

The factors identified and investigated in the study explain a great percentage of the variance of PKM success. Furthermore, the link between PKM success and project success can be demonstrated. These results imply that it is worth dealing with the management of project knowledge management. In project organizations with a mature project organization and a well developed project culture of trust and autonomy, the role of project knowledge management for project success might even be more important than for the average of project organizations.

The study confirmed a number of factors influencing PKM derived from different qualitative studies in different research settings. In particular, the influence of cultural factors on PKM success is in line with former research findings. In particular, trust and readiness to share knowledge influence the three dimensions of project knowledge management success.

The results also show some new insight for the theory of knowledge management in project contexts. First, the relation between project knowledge management and project success on a multi-project level has been demonstrated. It can be concluded that investment in PKM activities has significant performance impact. Second, a number of factors influencing PKM were confirmed which either have not been considered at all or not tested in a quantitative approach based on a representative sample. The role of the PMO, the role of the maturity of project management methodology, the role of procedures to harvest project experience are examples of such factors.

Contrary to findings of Karlsen&Gottschalk [28], Adenfelt&Lageström [1] and Newell et al. [42], the influence of ICT supporting PKM could be demonstrated. While the availability of systems is negatively related to PKM and thus in line with these results, the quality and usefulness of the system infrastructure are found to be important determinants of PKM success. In other words, the plethora of different ICT systems has negative impact on quality and no impact on the other dimensions of PKM success. However, a high quality of the existing system infrastructure strongly supports PKM success. A factor which did not receive much attention in previous research is the central support and administration of project knowledge. Results show that the operational support is strongly related with effectiveness, efficiency and quality of project knowledge management. Quality aspects again play an important role.

Furthermore, it could be shown that the productive use of project knowledge depends on the perceived usefulness of the PKM infrastructure on the one hand, but on cultural factors such as management commitment, job autonomy and mistake tolerance and informal communication on the other hand. Former studies have set a focus on the cultural factors influencing PKM. This study shows that the infrastructure quality and the cultural and leadership factors have to go hand in hand. Further analysis of moderating effects of cultural factors could be interesting.

Our research provides several implications for further research: The influence of distinct context factors on the suggested research model could provide insights about differences in alternative project settings, industries and project-related situations. These insights could enable a transfer of best practices between

different context situations, such as different industries. Based on the results, research could be intensified to identify best practice cases with regard to the most significant factors and analyze the "why" some companies manage enabling factors better than others do. The role of knowledge transfer mechanisms and procedures have been extensively researched [56, 8]. However, the role of informal networks might provide further insights about knowledge flows in project based companies. These insights might also provide new perspectives for the creation and management of a knowledge friendly culture, since it has been confirmed again to be a very important aspect of PKM.

7. Conclusion

This paper illustrates the findings of a two step study on PKM. The findings of this study strongly support the assumption that PKM is a topic of high relevance in contemporary forms of organization. Further significance arises from the observation that the implementation of knowledge management in project settings still appears to be insufficiently applied. This general shortcoming in business practice is strikingly, concerning the high potential benefits regarding efficiency, effectiveness and innovation resulting from a successful implementation of PKM in different types of firms. The organizational culture and the PKM infrastructure are critical factors for successful PKM. Even the best IT systems and methodologies supporting the storage and dispersion of knowledge gained in projects are useless, if the employees resist using them. However, a high quality IT system and a systematic approach towards PKM, which fit to the needs of the project and the organizational structures, were found to support a successful management of project knowledge. This paper presents the first overall results of the analysis of the collected data.

8. References

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9. Appendix

Interview guideline
(short version, translated from German)

Project management practice
- Company profile
- Description of the project landscape (project types, degree of project orientation, project organisation, dispersion of projects)
- Project management practices (project management methodology, degree of standardisation)
- Institutionalisation of project management (central roles and responsibilities in PM, PMO
- Institutionalisation of multi-project management (central roles and responsibilities of MPM)

Knowledge management in routine organisation
- Knowledge management strategy (existence, contents)
- Practices and institutionalization of KM (methods, institutionalization, embeddedness in organisation link to line functions, link to projects)

Knowledge management in project context
- Objectives of PKM
- Types of relevant PK and flows of PK (types of PKM, flows of PKM)
- Organisation of PKM (responsibilities, PKM activities and procedures, central and de-central roles, link with line function and general KM)
- Cultural background of PKM (role of culture, role of informal networks, management of cultural factors)
- Procedures of PKM, PKM activities in project every-day (description of project work from knowledge perspective)
- Success factors and barriers of PKM

Questionnaire
(translated from German)
Respondents were asked to refer their answers to the multi-project landscape of one type of projects in a company/unit

Procedures and (de-central) responsibilities for PK transfer
- Procedures for knowledge transfer in projects
- Responsibilities for knowledge transfer in projects
- Procedures for knowledge transfer between projects
- Responsibilities for knowledge transfer between projects

Organizing and support of PK exploitation
- Lessons learned after project
- Lessons learned during project

- Involving project stakeholder in lessons learned
- Mechanisms to adopt lessons learned in project methodology
- Mechanisms to systematize and store lessons learned
- Mechanisms to distribute lessons learned

Organizing and maintenance of PK retrieval
- Organization and systematization of PK
- Ensuring and checking of contribution of PK
- Quality assurance of PK
- Mediate and connect K carriers

Controlling of PKM activities
- Measurement of PKM goals
- Measurement of intensity of use of PKM activities
- Measuring users' satisfaction with PKM
- Measurement of intensity of use of PKM systems

Maturity of project management methodology
- Standardized PM methodology
- Stringent application of PM methodology
- Training in PM methodology
- Certification in PM methodology

Institutionalization of PKM in multi project environment (role of the PMO)
- Project management office
- Project manager pool
- Central responsibility of PKM

Availability and Use of Systems
- Collaboration tools
- Communication tools
- Expert database
- Virtual project rooms
- Experience / lessons learned database
- Expert knowledge database
- Proposal database

Quality and Adequacy of Systems
- Integration of systems integrated in project work
- Effective structure
- Easy of use
- Supporting storage of knowledge
- Supporting search of knowledge
- Supporting distribution of knowledge

Trust and PK sharing readiness
- Mistrust
- Trust
- Readiness to share (providing knowledge)
- Readiness to share (taking time)

- Readiness to share (complete knowledge)
- Perception of organizational benefits
- Perception of personal benefits

Top management commitment and emphasis
- Rewards
- Communicating benefits of PKM
- Foster participation
- Role model
- Allow freedom and time availability

Informal networks
- Informal communication
- Informal meetings
- CoPs
- Facilitation of informal communication

Culture of freedom, creativity and mistake tolerance in projects
- Heterarchical communication
- Project members decision autonomy
- Project members own initiative
- Project members own creativity
- Open communication of mistakes
- Readiness to admit mistakes

PKM efficiency
- Positive effort/benefit ration
- Adequate effort to find PK
- Adequate preparation of PK
- Intensity of use

Information and knowledge quality
- Accuracy of PK
- Completeness of PK
- Actuality of PK

PKM effectiveness
- Effective support of K generation in projects
- Effective support of K storage
- Effective support of K search
- Effective support of K transfer

PKM usefulness
- Perceived usefulness to improve project work (time)
- Perceived usefulness to improve project work (cost)
- Perceived usefulness to improve project work (quality)
- Perceived usefulness to improve project work (decision making)

Project knowledge use
- Use of PK from colleagues (known)
- Use of PK from colleagues (not known)
- Use of PK from project manager networks
- Use of PK from project documents
- Use of PK from databases
- Use of PK from lesson learned
- Use of PK from checklists and templates

Project success on multi-project level
- Goal achievement (costs)
- Goal achievement (time)
- Goal achievement (quality)
- Goal achievement (stakeholder satisfaction)
- Goal achievement (project member satisfaction)
- Goal achievement (project manager satisfaction)
- Goal achievement (customer satisfaction)