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Success factors of knowledge management in temporary organizations

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Abstract

The prevalence of temporary forms of cooperation and project-based work is increasing. Likewise, the knowledge-intensity of work contents is growing. However, the unique and temporary nature of projects and programs does not support knowledge transfer from, between and within projects.

This research aims at spotting success factors of knowledge management in temporary organizations. Based on a cross-industry sample with 414 organizations, we apply the partial least square (PLS) method to test the influence of cultural, organizational, structural, and process-related factors on knowledge management effectiveness.

Besides IT-support and formal elements of the organization, it is cultural factors that strongly influence knowledge management success. In temporary organizations they compensate for the lack of organizational routines and organizational memory. Our results contribute to a more differentiated understanding of knowledge management in project environments.

Keywords: Temporary organization; Project; Project management; Organizational learning; Knowledge; Knowledge management

1. Introduction

The increasing importance of knowledge as a critical resource is mirrored by theoretical approaches underlining the relevance of knowledge. The knowledge-based view of the firm considers knowledge and the ability to integrate individual knowledge in the context of a common task fulfillment to be essential for the creation of competitive advantage (Kogut and Zander, 1992; Grant 1996; Spender 1996; Conner and Prahalad, 1996). Likewise, the degree of temporary forms of cooperation and working constellations, i.e. projects and programs, is growing (Midler 1995; Lundin and Söderholm, 1998; Maylor et al. 2006; Beaume et al. 2009). The discipline of project management (PM) is not only important for project-based industries like construction, management consulting, film-making, and software engineering but also for many other industries where projects are employed to generate innovative products and services and to bring about organizational change.

Little research has tried to combine both fields of research and to analyze the challenges of KM in temporary organizations (Demarest 1997; DeFillippi and Arthur, 1998; Brookes et al. 2006). Due to their uniqueness and short-term orientation temporary organizations face particular obstacles in their KM. After a project is finished the constellation of people working together is resolved, fragmenting the project knowledge. In contrast to permanent organizations where departments and divisions act as knowledge silos, in temporary organizations routines and organizational memory hardly emerge. There is a lack of mechanisms for knowledge capturing, storing and disseminating and for organizational learning (Disterer 2000; Meyerson et al. 1996; Prencipe and Tell, 2001; Sydow et al. 2004).

More recently, several studies addressed the problem of KM in temporary organizations. On the basis of case studies and qualitative research, the status quo of KM in individual firms, industries, and project types has been investigated. Extant research also identified several success factors and barriers with regard to KM in and between projects (Schindler and Eppler,

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2003; Brookes et al., 2006; Love et al. 2005; Hanisch et al. 2009). As these results are based on rather small samples, single cases, specific industries and project types, generalization might not be possible. The aim of our study therefore is to identify success factors for KM in temporary organizations on a broad empirical basis. We aim at determining the relative importance and the interrelationships of the different success factors identified in previous studies. As the most prevalent form of temporary organizations, we focus on projects and investigate project knowledge management (PKM). A large sample serves to control for effects of firm size, industry, and project type amongst others.

The paper is organized as follows. The next section sketches the conceptual foundations of knowledge management in temporary settings. In Section 3, we provide an overview on existing research on PKM. We derive our hypotheses and develop a research model in Section 4. It follows the description of the empirical basis and the research methodology. In Section 6 and seven we present and discuss the empirical results. We conclude with a summary of the main findings and its implications for project management practice.

2. Knowledge processes and project knowledge management

Although knowledge is one of the most important resources in modern organizations, a variety of different definitions in the academic literature exits. Koskinen and Philanto (2008: 43) consider "knowledge (as) an individual's perception, skills and experience, which are all dependent on what experiences the individual's worldview contains in the form of meanings." They underline one important aspect of knowledge: it is the dependency on the personal and social context an individual is embedded in. We build on this definition by adding one more dimension of knowledge. Nonaka and von Krogh (2009: 636) explain that "knowledge (…) is the actuality of skillful action (…) and (…) the potentiality of defining a situation so as to permit (skillful) action."

Linking the individual perspective of knowledge to the organizational level, organizational knowledge creation theory is concerned with the processes which make available individual knowledge to the organizational knowledge system (Nonaka and von Krogh, 2009). This knowledge processes consist of several steps, starting with the creation of knowledge followed by the use of knowledge, the transfer and sharing of knowledge, and the storage and retrieval for further use (Seufert et al. 2004). A crucial and difficult step in the organizational knowledge process is the conversion of tacit knowledge into explicit knowledge. Tacit (implicit) knowledge is unarticulated and rooted in experience and intuition and tied to the senses. Explicit knowledge is uttered, can be formulated in sentences, has a universal character and is accessible through consciousness (Nonaka and von Krogh, 2009). Only explicit knowledge can be integrated in the organizational knowledge base. To support the transformation of tacit to explicit knowledge and to facilitate the remaining steps of the organizational knowledge process, the discipline of knowledge management has evolved since the early 1990s (Nonaka 1999; Spender 1996). Knowledge management (KM) involves all practices of an organization to create, store, use and share knowledge (Probst et al. 1998).

The development of knowledge management originally took place under the (implicit) assumption of relatively stable organizational settings. However, projects and programs as temporary forms of organizing are characterized by specific characteristics which pose specific challenges for project knowledge management (Schindler and Eppler, 2003; Love et al. 2005; Fong 2005, Koskinen and Pihlanto, 2008):

1. The uniqueness and temporariness of projects hinders the emergence and development of organizational routines, organizational memory and therefore impedes organizational learning (Bresnen et al. 2003; Fong 2005).
2. Discontinuous working constellations/contents and discontinuous team compositions lead to a fragmentation and disintegration of individual and organizational knowledge (Prencipe and Tell, 2001; Kasvi et al. 2003).
3. In contrast to permanent organizations projects lack "natural" mechanisms of learning. Therefore, the transfer of knowledge from one project to the other or from one project to the permanent part of the organization is difficult. This shortage of learning mechanism is even more serious in geographically dispersed projects and intercultural project teams (Fong 2005; Boh 2007).
4. Projects and other forms of temporary organization usually have a rather short-term orientation with a focus on immediate deliverables. In contrast, knowledge management requires a long-term perspective as there is often a time-lag between the initial investment in knowledge management systems and the return on investment. This conflict of goals may result in an insufficient transfer of knowledge between projects (DeFillippi and Arthur, 1998; Love et al. 2005).

Although the distinction between permanent and temporary organizations is not always clear-cut (Koskinen and Pihlanto, 2008) and permanent organization usually entail temporary elements, we believe that the specific characteristic of projects and programs justify studying knowledge management in a temporary organizational setting. KM in temporary organizations includes different kinds of knowledge which are related to specific knowledge transfers between the temporary organization as well as the permanent organization (Fig. 1). First, knowledge about projects denotes an overview of the project landscape (the projects being conducted or those that have been conducted) in an organization. Intra-project knowledge (2) is closely linked to the project management methodology and the communication practices within projects. Knowledge transfer between upstream projects and downstream projects (3) as well as knowledge transfer between projects in parallel (4) comprises expert knowledge, methodological knowledge, procedural knowledge, and experience knowledge. Finally, most temporary organizations co-exist with a permanent organization. In this case, a transfer from the temporary to the permanent organization (5) may contribute to the organizational knowledge base.

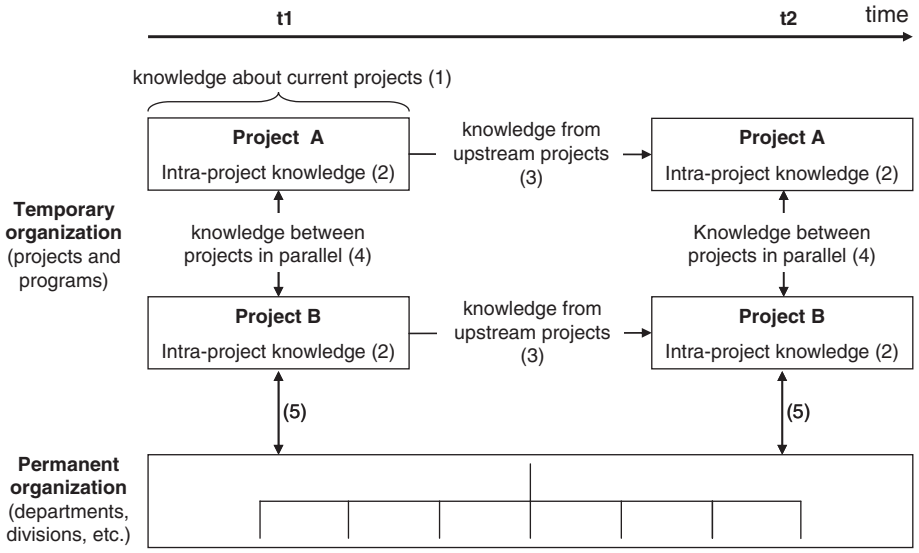

Fig. 1. Knowledge management in temporary organizations.

3. Research on KM in temporary organizations

Several studies consider mechanisms of learning and knowledge-sharing in temporary organizations. Prencipe and Tell (2001) developed a first concept of learning mechanisms in project-based firms. Providing an empirical basis for learning practices in projects, Keegan and Turner (2001) investigated nineteen companies across Europe. In their interviews, they identified time pressure, centralization and deferral as key factors influencing learning from and through projects. The role of tacit knowledge versus explicit knowledge in a project context is the subject of Koskinen (2004). He concludes that language, mutual trust and proximity play an important role in KM but also stresses that the relevance of different types of KM-processes, i.e. codification versus personalization, varies depending on the type of the project. Similarly, Kasvi et al. (2003) introduced the concept of a project memory system and point out that it should not only handle codified knowledge like databases and documents but also the contexts and (social) processes behind these documents. To retrieve and store this kind of personalized knowledge, different procedures like personal interaction and dialogues workshops are required. The dependence of knowledge-sharing mechanisms on context factors is underlined by Boh (2007) who developed four knowledge-sharing mechanisms for distributed knowledge in temporary organizations. He claims that the selection of the mechanisms depends on two context factors: nature of the problem (unique, standard) and the size and geographical dispersion of the project. Fong (2003) studied knowledge creation processes in multidisciplinary teams and described knowledge creation as an interwoven and boundary-crossing process of knowledge-sharing, knowledge-integration and knowledge generation.

A second stream of papers more explicitly deals with the success factors for KM in temporary organizations. In several studies, dimensions like information and communication technology (ICT) or formal procedures, structures and methods are considered along with "softer" factors like culture or social capital. Conducting case studies and action research, Schindler (2002) identified a number of success factors for KM in projects. He grouped the determinants in the following categories: culture, ICT, project management methodology, learning, and organization. Adenfeld and Lagerström (2006) investigated the role of different enablers of knowledge creation and sharing in a transnational project. Considering structure, culture, and ICT as major factors they found that culture is the most important enabler. Culture plays a particular role during the early phases of a project while in later phases the established cultural basis allows a higher degree of impersonal communication via ICT. The importance of ICT, systems and procedures, and culture is subject of three case studies in consulting firms and research institutions conducted by Karlsen and Gottschalk (2004). They analyzed how the three factors affect knowledge transfer on project outcomes in ICT projects. Both culture and systems and procedures are related to project outcomes, while ICT did not show significant influence. Bresnen et al. (2003) studied the role of social processes for KM based on case studies in new product development projects. Again, the limitations of ICT-systems to support knowledge management are one of the major findings. Focusing on the more formalized aspects of KM, Schindler and Eppler (2003) described the practice and success factors of post project reviews to "harvest" project knowledge. They stressed the importance of a formalized lessons-learned process integrated in the project methodology and project goals. Desouza and Evaristo (2006) considered the roles and tasks of project management offices (PMO) in KM and conducted a survey in 32 ICT organizations. PMOs as part of the permanent organization are set up for facilitating and coordinating the activities of the temporary organization. They derive two different knowledge-archetypes for PMOs: administrative and knowledge-intensive. Newell et al. (2004) applied the theory of social capital to KM in a project context and claim that both bonding and bridging aspects play an important role for knowledge integration in

projects. Brookes et al. (2006) introduce the concept of project social capital to explain access to project knowledge.

As preparatory work for the study presented in the paper at hand we conducted an exploratory qualitative study (Hanisch et al. 2009). We interviewed 27 managers responsible for project management and for knowledge management. The interviews were conducted in organizations from different industries such a transportation, automotive, construction, and insurance. As the result of a content analysis, we identified culture and communication, ICT, methods, and organization as major categories of success factors for PKM (for more details on the pilot-study see Hanisch et al. 2009). In the following section we use the findings of this study along with the literature on PKM and on KM in general to derive our hypothesis and to develop a research model.

4. Hypothesis and research model

For the development of the research model we build on the categorization of our pilot-study (Hanisch et al. 2009) and other studies described above. We assign all formalized processes and structures of KM to the category "Organization and Processes." "ICT-systems" comprises all systems (particularly ICT) for supporting KM. The third category of factors covers the more informal aspects such as organizational culture, informal communication, leadership and social capital. These categories are in line with more general research on KM which identified similar dimensions (Gold et al. 2001; Cepeda and Vera, 2007). We assume that the factors directly affect the success of KM in projects but also interdependencies among the factors to exist. Our model aims at explaining the effectiveness of project knowledge management (PKM) as the dependent variable. PKM-effectiveness represents the perceived adequacy of the generation, storage, retrieval and transfer of project knowledge.

4.1. Organization and processes

In the category organization and processes we assume five main factors to be important: "processes of PKM," "organization of PKM," "maturity of project management methodology," "institutionalization of PM/KM in a multi-project environment," and "controlling of PKM activities." The generation, storage, dissemination and retrieval of project knowledge can be facilitated by systematic processes. Tools like lessons-learned workshops, project reviews or de-briefing meetings are usually elements of these processes (Prencipe and Tell, 2001; Koners and Goffin, 2005). We predict a positive relationship between PK processes and PKM-effectiveness.

HO 1. Systematic PK processes have a positive effect on PKM-effectiveness.

In addition to systematic processes, a coherent organization of project knowledge can be assumed to facilitate the knowledge transfer within and across projects but also between the temporary and the permanent part of organization. An important part of the organization of PK is quality assurance with regard to the usefulness, accurateness and timeliness of knowledge (Havens and Knapp, 1999; Holsapple and Joshi, 2000; Du Plessis 2007).

HO 2. The organization of PK has a positive effect on PKM-effectiveness.

The maturity of the project organization describes the scope of the project management methodology and the consistency of its deployment. A stringent application of PM-methodology serves as the storage of knowledge as routines (Bresnen et al. 2003; Schindler and Eppler, 2003). While Adenfelt and Lagerström (2006) argue that formalization hinders knowledge management in projects environments, we suppose that a certain degree of formalization is necessary to overcome the inertia of people to make an effort in knowledge management (Schindler and Eppler, 2003). More advanced PM methods may also stimulate the definition of organizational responsibilities and systematic PK processes.

HO 3.1. The maturity of the PM-methodology has a positive effect on PKM-effectiveness.

HO 3.2. The maturity of the PM-methodology has a positive effect on the organization of PKM.

HO 3.3. The maturity of the PM-methodology has a positive effect on PKM-processes.

In many permanent organizations we find central responsibilities for the temporary organization comprising several programs and a variety of projects (multi-project environment). Desouza and Evaristo (2006) conceptualize project management offices (PMO) as knowledge-based archetypes and Walker and Christenson (2005) propose a project management center of excellence as a central coordination unit of knowledge networks between project teams. Similarly, a central unit for coordinating KM activities across the organization is a form of institutionalizing KM in permanent organizations (Liebowitz 1999). We assume that a central responsibility for and support of PKM in a multi-project environment is positively related with the success of PKM. Likewise, a central unit like a PMO may affect PKM-processes and the organization of PKM.

HO 4.1. The institutionalization of multi-PM/KM has a positive effect on PKM-effectiveness.

HO 4.2. The institutionalization of multi-PM/KM has a positive effect on the organization of PKM.

HO 4.3. The institutionalization of multi-PM/KM has a positive effect on PKM-processes.

Knowledge is often considered a soft factor and related KM activities and their success seem hard to measure and to evaluate. Nonetheless, for coordinating KM activities and for signaling its importance to the employees, the evaluation and control of PKM activities is essential. Also team performance

measurement has to be linked with knowledge objectives to provide coherent incentive schemes (Schindler and Eppler, 2003). The controlling of PKM activities embraces the measurement and steering of participation, quality and improvement of PKM. We assume that controlling of PKM is important for the effectiveness and the quality of PKM.

HO 5. Evaluation and controlling of KM activities positively affects PKM-effectiveness.

4.2. Systems and ICT

Extant research showed mixed findings regarding systems and ICT for supporting PKM. We include it in the model for explaining PKM-effectiveness by suggesting two indirect factors "Use of systems to support communication" and "Use of systems to support storage" influencing a direct factor "ICT support." The general literature on KM accentuated that the existence of an advanced ICT infrastructure is a necessary precondition for successful knowledge exchange (Gupta and Govindarajan, 2000; Karlsen and Gottschalk, 2004). Regarding KM in a project environment we treat standard communication systems like e-mail or telephone as given and focus on more advanced and specific technology for supporting multi-directional communication like team-rooms, net-meetings, web-portals, web-based platforms, and videoconferences. In addition to systems facilitating communication, systems for storage and retrieval of relevant knowledge are essential (Bresnen et al. 2003; Leseure et al. 2004; Sapsed et al. 2005).

Prior research showed, that the mere existence and appropriation of ICT system does not guarantee an effective support of KM activities. Therefore, we propose that the use of systems to support communication and storage of knowledge has a positive impact on the support of ICT for PKM. The later directly influences PKM-effectiveness.

HS 1.1. ICT support has a positive effect on PKM-effectiveness.

HS 1.2. The use of systems to support communication has a positive effect on ICT support.

HS 1.3. The use of systems to support storage has a positive effect on ICT support.

4.3. Culture and leadership

The role of culture and leadership has been discussed in a number of publications on PKM (Bresnen et al. 2003; Karlsen and Gottschalk 2004; Adenfelt and Lagerström, 2006; Ajmal and Koskinen, 2008). Likewise, the more general literature on knowledge management identified culture to be the most significant enabling factor of knowledge creation and sharing (Szulansky 1996; Demarest 1997; Gupta and Govindarajan, 2000). We distinguish five major cultural factors affecting PKM-effectiveness: "knowledge culture" and "management commitment" having a direct influence on PKM-effectiveness and "project culture," "mistake tolerance," and "informal networks" with an indirect influence.

Knowledge culture is related to an open knowledge transfer within and between projects. It depends on the individuals' willingness to share knowledge and on mutual trust. A culture of mutual trust and understanding of personal and organizational advantages of PKM is considered as a precondition to facilitate the activity of potential PKM users (Eppler and Sukowski, 2000; Koskinen 2004; Newell et al. 2004). We hypothesize that the PKM-effectivenes strongly depends on knowledge culture.

HC 1. Knowledge culture has a positive effect on PKM-effectiveness.

In several studies on project management support from top management turned out as crucial factor of success. Top management has to create a supportive atmosphere and to ensure an adequate resource endowment for facilitating and fostering PKM. Top management commitment and the communication of common advantages ensure participation in knowledge-sharing activities (Eppler and Sukowski, 2000; Fong 2003; Liebowitz and Megbolugbe, 2003). Top management commitment may not only directly influence PKM-effectiveness but also have an impact in the knowledge culture.

HC 2.1. Management commitment has a positive effect on PKM-effectiveness.

HC 2.2. Management commitment has a positive effect on knowledge culture.

Learning from experience as a major aim of KM is only possible in an environment with a positive attitude towards mistakes. A culture of tolerance towards mistakes shapes an environment of openness and cooperation (Ajmal and Koskinen, 2008). In addition, project team members need a supportive project culture with a reasonable amount of autonomy regarding the performance of their task and sufficient time for participating in PKM activities (Fong 2003; Carrillo et al. 2004). Finally, research on social networks and knowledge exchange in project environments stressed the important role of informal networks for the integration of dispersed and knowledge into projects (Newell et al. 2004; Brookes et al. 2006). We thus assume that mistake tolerance, project culture, and informal networks have an impact on the knowledge culture.

HC 3.1. Mistake tolerance has a positive effect on knowledge culture.

HC 3.2. Project culture has a positive effect on knowledge culture.

HC 3.3. Informal networks have a positive effect on knowledge culture.

We integrate the hypothesis on the factors organization and structure, systems and ICT, and culture and leadership in a model aiming at explaining PKM-effectiveness (Fig. 2).

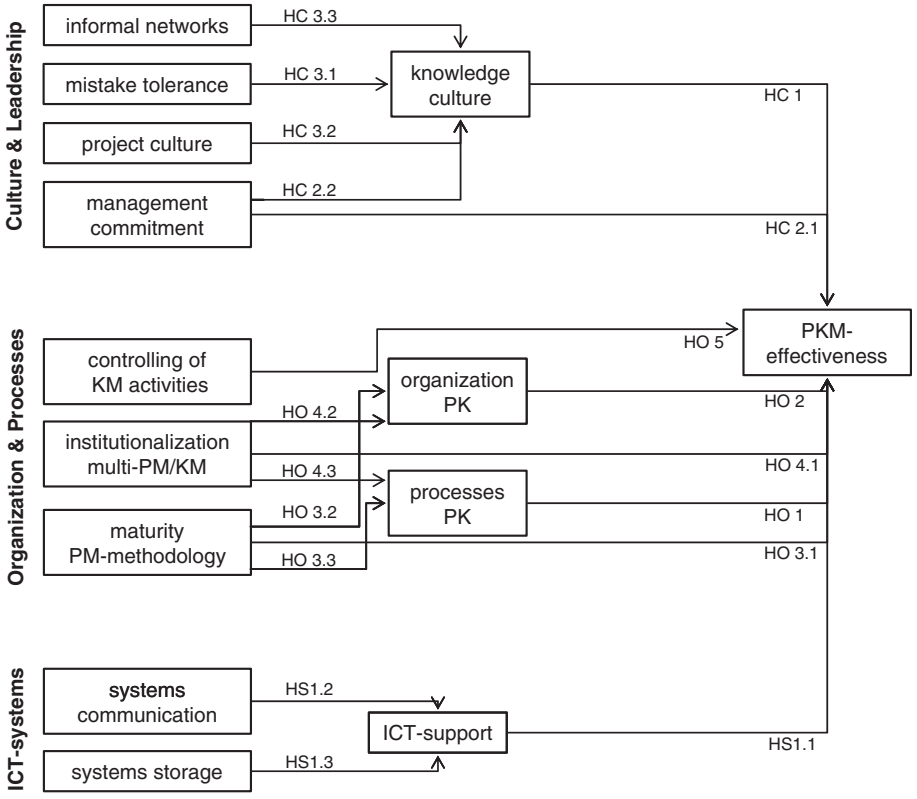

Fig. 2. Research model for explaining PKM-effectiveness.

5. Data and methods

We conducted a survey among 8000 members and other affiliated persons of the German Association for Project Management (GPM), a member organization of the International Project Management Association (IPMA). The target group consisted of project managers, project leaders, project workers and staff of project management offices. We sent out a paper based questionnaire but also provided the option for filling out an online questionnaire. The response rate was 6.2% corresponding to a sample size of n=496 cases. Of the responses n=414 (5.2%) were completely answered and related to companies with more than 20 employees which we defined as the lower limit of company size to be analyzed in the sample. We applied a Mann–Whitney-U-Test for checking for a possible non-response-bias. We split the sample into three groups and compared the early responses to the late responses. The underlying assumption is that the group of late responses is similar to the group of non-responses (Armstrong and Overton, 1977). Likewise we compared the paper based responses with the responses of the online version. For both tests, we found no significant differences of the means of the sub-samples.

The sample comprises organizations of different size and different industries. As Table 1 shows, small enterprises (<100 employees) account for 14% of the sample whereas large enterprises (more than 5000 employees) represent 24% of all cases. The most prevalent industries are Software/IT (15%) and automotive (13%), but also public enterprises (9%) or the construction industry (5%) account for important parts of the sample.

Likewise, the sample represents a broad variety of different projects types (Table 2). External projects, i.e. projects which are carried out for an external customer, amount for 51% of the cases in the sample. Internal projects, i.e. projects which are carried out within the organization constitute 49%. Table 2 also shows that for both kinds of projects (internal and external) IT-related projects are the most prevalent ones. In the sample there is a roughly equal share of small projects with less than five project members (33%) and large projects with ten and more members (37%). Medium-size projects (6–9 persons) account for 26%.

With very few exceptions we measured all scale items with five-point Likert scale. The selection of the items is based on the literature and discussion with the interviewees in the

Table 1
Composition of the sample (company size and industry).

Company size	Share	Industry	Share
> 5000	24%	IT/software	15%
2001–5000	12%	Automotive	13%
1001–2000	10%	Plant construction	11%
501–1000	9%	Manufacturing	10%
101–500	20%	Consulting	10%
≤100	14%	Public enterprises	9%
n.a.	10%	Transportation/logistics	7%
		Other services	5%
		Construction	5%
		Pharmaceutical/chemical	5%
		Financial services	5%
		Telecommunication	4%

Table 2
Composition of the sample (project types and project size).

Internal projects (49%)		External projects (51%)		Project size	
Project type	Share	Project type	Share	Project members	Share
IT	35%	IT	17%	>9	37%
R&D	31%	Consulting	17%	6–9	26%
Organization	19%	Plant construction	16%	<5	33%
Investment	14%	Automotive	14%	not specified	3%
		Manufacturing industry	11%		
		Construction	8%		
		Other	18%		

preparatory qualitative study (Hanisch et al. 2009). When available, we used established scale items previously used in empirical studies. For some of the constructs, existing item scales had to be refined or developed a new. A first version of the questionnaire was pre-tested for reliability and validity with ten persons from different corporations. After a second pre-test with a revised version of the questionnaire with eight managers only minor changes were necessary to develop the final version.

As a possible limitation we have to point that our data is based on the subjective assessment of key informants which may lead to a common method bias (Doty and Glick, 1988). As the database only comprised individual memberships in the GPM we could not purposefully select two or more persons in every organization and collect the independent and the dependent variables separately. This may reduce construct validity. However, we took the possible statistical precautions as will be explained below. As suggested by Podsakoff et al. (2003), we also clearly separated dependent and independent variables in the questionnaire, reduced ambiguity in the item construction, and tried to keep the questions as simple as possible.

5.1. Dependent variable

For measuring PKM-effectiveness we use the constructs of knowledge management effectiveness (Sabherwal and Becerra-Fernandez, 2003), perceived knowledge management effectiveness (Kulkarni et al. 2006/7), and user satisfaction with knowledge management systems (Wu and Wang, 2006). For enhancing validity and reliability, we specify PKM-effectiveness as a reflective second order construct. The construct is reflected by three dimensions each composed of three items.

5.2. Independent variables

To operationalize the constructs in the category "organization and processes" we built on several studies on PKM (Eppler and Sukowski, 2000; Kotnour, 2000; Prencipe and Tell, 2001; Fedor et al. 2003; Kasvi et al. 2003; Liebowitz and Megbolugbe, 2003; Lee and Choi, 2003; Koners and Goffin, 2005; Ruuska and Vartiainen, 2005; Hanisch et al. 2009). The constructs "controlling of KM activities," "maturity PM-methodology" and "organization PK" were measured with three scale items each. For "institutionalization multi-PM/KM" four scale items and for "processes PK" six scale items served to operationalize the constructs. Also for the constructs in the category ICT-Systems, we used existing items in literature, our expert interviews and results of qualitative studies (Kulkarni et al. 2006/7; Chong 2006; Eppler and Sukowski, 2000; Sapsed et al. 2005; Hanisch et al. 2009). The construct "ICT support" is measured with five scale items, "systems communication" with four scale items and "systems storage" with three scale items. The category "culture and leadership" is composed of constructs which we operationalized with six items for "knowledge culture" and four items for the construct "project culture" and "management commitment." Three scale items were used to measure "informal networks" and two scale items for "mistake tolerance" (Eppler and Sukowski, 2000; Choi and Lee, 2003; Lee and Choi, 2003; Sapsed et al. 2005; Hanisch et al. 2009).

5.3. Control variables

We consider five control variables as possible factors influencing the explanatory factors of the model. We account for the size of the projects, the complexity of the project and for the size of the multi-project environment. The underlying assumption is that larger and more complex projects and a huge number of simultaneous projects may require different forms of organizing, processes, ICT-systems and cultural factors (Fong 2003; Boh 2007). We also distinguish between internal projects (directed to internal customers) and external projects (directed to external customers). Finally, the project organization may have an influence on our explanatory factors and therefore is considered as a control variable (Hobday, 2000).

5.4. Statistical approach and measurement validation

The cause and effect chains are tested with structural equation models. We apply the PLS (Partial Least Square) which uses a principal component-based approach for estimation. Compared to LISREL as an alternative approach, PLS is less demanding in terms of sample size, multicollinearity between indicators of a latent constructs, and missing values. Furthermore in case of complex models, newly developed scales and rather small samples — in case of multi group analysis for testing control variables — PLS ought to be applied. Also does it not require a multivariate normal distribution of the data (Fornell and Brookstein, 1982; Chin and Newsted, 1999).

The constructs have been tested for construct validity and reliability according to the common criteria. As first order criteria we applied Cronbach's Alpha, item-to-item-correlation, and exploratory factor analysis. Indicator reliability, factor reliability, convergent validity, and discriminant validity (Fornell–Larcker-criteria) were checked as second order criteria. All values are within acceptable boundaries. Table 3 shows the correlations among the constructs along with the average variance extracted (AVE). As a measure for construct validity, the square root of AVE (printed in bold) of a construct should be greater than the standardized correlation coefficients of the given construct with any construct in the model. This criterion is clearly fulfilled by the data. The assessment of the

Table 3
Correlations among constructs.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Controlling of KM activities	**0.88**													
2 Processes PK	0.50	**0.72**												
3 Mistake tolerance	0.17	0.35	**0.91**											
4 Informal networks	0.32	0.46	0.36	**0.77**										
5 Institutionalization multi-PM	0.40	0.49	0.34	0.31	**0.73**									
6 ICT support	0.34	0.54	0.27	0.32	0.43	**0.83**								
7 Management commitment	0.55	0.60	0.43	0.59	0.58	0.50	**0.77**							
8 Organization PK	0.32	0.42	0.25	0.26	0.50	0.49	0.50	**0.79**						
9 Maturity PM-methodology	0.22	0.46	0.31	0.30	0.41	0.33	0.42	0.23	**0.82**					
10 Project culture	0.18	0.32	0.61	0.44	0.31	0.20	0.42	0.20	0.34	**0.76**				
11 PKM-effectiveness	0.46	0.61	0.40	0.41	0.52	0.57	0.64	0.49	0.40	0.34	**0.72**			
12 Systems communication	0.46	0.61	0.26	0.45	0.42	0.55	0.57	0.40	0.42	0.29	0.5	**0.72**		
13 Systems storage	0.35	0.60	0.29	0.31	0.48	0.54	0.47	0.41	0.46	0.30	0.47	0.57	**0.76**	
14 Knowledge culture	0.30	0.45	0.58	0.60	0.38	0.38	0.61	0.28	0.31	0.57	0.55	0.37	0.32	**0.73**

Bold values are the square root of AVE and the other values are standardized correlation coefficients.

predictive validity with the blindfolding-procedure of PLS delivered only values greater zero.

6. Results

We used the software package Smart PLS 2.0 for calculating the model. Table 4 shows the path-coefficients, t-values, total effects and levels of significance.

The model explains 57.8% of the variance of PKM-effectiveness, 57.5% of knowledge culture, 37.7% of ICT support, 32.3% of organization PK, and 25.2% of processes PK. Of the 18 determinant constructs of the model only one has no significant effect. The effect of one construct is only weekly significant ($p>0.1$) and one construct is significant on the 5%-level. All other constructs show significant effects on the 1%-level at one-tailed t-test. Given the relatively large number of exogenous (independent) variables, effects larger than 0.02 can be considered as relevant and important (Cohen 1988). All endogenous variables considered in the model directly or indirectly contribute to the explanation of PKM-effectiveness. For evaluating the relative importance of the different variables, Table 5 shows the effect size (f^2) for the direct and indirect effects on PKM-effectiveness. The most important factors influencing PKM-effectiveness are knowledge culture, the institutionalization of multi-project management/PMO, ICT support, management support and processes of PK.

We checked for possible moderating effects by splitting the sample into two subgroups (multi group comparison) for each of the control variables (Bollen 1989; Jöreskog and Sörborn, 1989). For instance, we estimated a model for the sub-sample comprising internal projects and another model for the sub-sample with external projects. As a next step, we compared the differences in the significance-levels of the paths of the models for both sub-samples. We also compared the explained

Table 4
Results of the model.

Exogenous variable	Endogenous variable	Path-coefficient	t-value	Level of significance
ICT support	PKM-effectiveness	0.19	3.47	***
Controlling of KM activities		0.09	2.32	***
Institutionalization multi-PM/KM		0.08	1.86	**
Organization PK		0.12	2.49	***
Processes PK	$R^2=57.8\%$	0.17	3.48	***
Management commitment		0.13	2.41	***
Knowledge culture		0.21	4.69	***
Maturity PM-methodology		0.06	1.5	*
Project culture	Knowledge culture	0.19	4.11	***
Informal networks		0.28	7.32	***
Mistake tolerance	$R^2=57.5\%$	0.25	6.05	***
Management commitment		0.26	6.27	***
Systems communication	ICT-support	0.35	8.1	***
Systems storage	$R^2=37.7\%$	0.34	6.74	***
Maturity PM-methodology	Organization PK	0.03	0.57	ns
Institutionalization multi-PM/KM	$R^2=32.3\%$	0.49	9.43	***
Maturity PM-methodology	Processes PK	0.31	6.37	***
Institutionalization multi-PM/KM	$R^2=25.2\%$	0.37	8.03	***

* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

Table 5
Effect size.

Exogenous variable	Effect size (f^2)
Controlling of KM activities	0.088
Processes PK	0.170
Institutionalization multi-PM–PMO	0.201
Organization PK	0.117
Maturity PM-methodology	0.116
Mistake tolerance	0.053
Informal networks	0.059
Management commitment	0.184
Project culture	0.040
Knowledge culture	0.213
ICT support	0.193
Systems communication	0.068
Systems storage	0.065

variances and the effect sizes of the models. As a result we found differences for some of the effects. The effects of the factors in the leadership and culture-dimension and in the ICT-systems dimension are hardly affected by any of the control variables. The effects of organization and processes to some extend are influenced by the size of the multi-project environment. However, none of the control variables has a huge impact or distorts the general structure of the model and therefore needs not to be considered more detailed.

In summary, we find support for 17 of the 18 hypotheses in our model (Table 6) even though two on a rather weak level of significance. A substantial part of PKM-effectiveness can be explained by the constructs. Only hypothesis HO3.2 which predicted a positive effect of the maturity of the PM-methodology on the organization of PKM must be rejected as the effect is non-significant.

7. Discussion

Knowledge is a critical resource in advanced economies. For many organizations, the effective management of knowledge is one of the main factors of success. KM is not even a trivial task in permanent organizations with established organizational routines, processes and a relatively stable organizational culture. In temporary organizations successful KM becomes even more difficult due to the specific traits of projects and programs. Our principal aim was therefore to identify success factors for KM in temporary organizations. As prior work on PKM was mainly based on case studies and qualitative studies, we searched for statistical evidence on the basis of a large sample comprising different industries and different project types. The sample size allows for a broader generalization of the results and for considering several context factors as control variables.

7.1. Knowledge management processes

The main obstacle for KM in projects is the temporariness as the organization is resolved after the task execution and knowledge generated in the project may get lost. The study showed that systematic processes to generate, store and retrieve knowledge positively affect PKM-effectiveness (HO1). In permanent organizations many of these activities are covered by routines which cannot form in temporary organizations. Processes take over tasks of routines as means of knowledge integration (Grant 1996). Processes help to transform temporary knowledge into permanent knowledge by turning tacit into codified knowledge. This knowledge can later be retrieved and used in subsequent projects. A prevalent tool supporting this transformation is dedicated lesson-learned procedures like regular workshops. The documentation of personalized and tacit knowledge has also positive effects for individuals as it stimulates and amplifies processes of learning (Hansen 1999).

7.2. Organization of PKM and the institutionalization of multi-PM

The model confirmed that a coherent organization of PK is essential for PKM-effectiveness (HO2). It has to ensure that knowledge is up-to-date, useful and accurate. Defined standards

Table 6
Support and rejection of hypotheses.

Dimension	Hypothesis	Result
Culture and leadership	HC 1 Knowledge culture has a positive effect on PKM-effectiveness.	Support
	HC 2.1 Management commitment has a positive effect on PKM-effectiveness.	Support
	HC 2.2 Management commitment has a positive effect on knowledge culture.	Support
	HC 3.1 Mistake tolerance has a positive effect on knowledge culture.	Support
	HC 3.2 Project culture has a positive effect on knowledge culture	Support
	HC 3.3 Informal networks have a positive effect on knowledge culture.	Support
Organization and processes	HO 1 Systematic PK processes have a positive effect on PKM-effectiveness.	Support
	HO 2 The organization of PKM has a positive effect on PKM-effectiveness.	Support
	HO 3.1 The maturity of the PM-methodology has a positive effect on PKM-effectiveness.	Support
	HO 3.2 The maturity of the PM-methodology has a positive effect on the organization of PKM.	Reject
	HO 3.3 The maturity of the PM-methodology has a positive effect on PKM-processes.	Support
	HO 4.1 The institutionalization of multi-PM/KM has a positive effect on PKM-effectiveness.	Support
	HO 4.2 The institutionalization of multi-PM/KM has a positive effect on the organization of PKM.	Support
	HO 4.3 The institutionalization of multi-PM/KM has a positive effect on PKM-processes.	Support
	HO 5 Evaluation and controlling of KM activities positively affects PKM-effectiveness	Support
ICT-systems	HS 1.1 ICT support has a positive effect on PKM-effectiveness.	Support
	HS 1.2 The use of systems to support communication has a positive effect on ICT support.	Support
	HS 1.3 The use of systems to support storage has a positive effect on ICT support.	Support

and quality requirements for knowledge management help to circumvent the pitfalls of discontinuous and turbulent project environments. This goes hand in hand with the definition of responsibilities for PKM in a multi-project landscape (HO4.1). This factor showed direct effects on PKM-effectiveness but also positively influenced the organization and processes of PKM (HO4.2 and HO4.3). The institutionalization of responsibilities, especially in the form of centralized project management office (PMO), ensures a high degree of continuity and professionalism and contributes to the willingness of the user to participate in PKM activities. A central PMO also is able to form a link between the temporary and the permanent parts of the organization. Solid institutions to facilitate knowledge transfer in project environments bridge the gap and missing awareness between projects in terms of time, location and responsible people. This factor has the second largest effect on PKM-effectiveness following close behind knowledge culture.

7.3. Project management methodology

The postulated positive effect of the maturity of the PM-methodology on the organization of PM (HO3.2) is the only hypothesis not supported by our results. A potential reason for this finding may be the argument put forward by Adenfelt and Lagerström (2006) that a high formalization of knowledge management and an implementation in the project management methodology prevents people from exchanging, storing, and retrieving knowledge effectively. Moreover, there is only a weak direct influence of PM-methodology on PKM-effectiveness (HO3.1) which contradicts the findings of our previous qualitative study where PM-methodology was identified as an important frame of reference for PKM (Hanisch et al. 2009). Nonetheless, PM-methodology has an additional indirect impact via KM-processes (HO3.3 and HO1). It may also provide routines for the integration of PK in project work. Based on our findings and on previous studies, there is a need for more research on the role of PM-methodology and knowledge management in temporary organizations which explicitly investigates the degree of integration of PKM activities into the methodology.

7.4. Controlling of PKM activities

In general, investment in knowledge management-activities and the outcome of KM is difficult to quantify and to evaluate. This may explain why PKM-controlling is often neglected in project management practice. Likewise, this factor has not been considered extensively in the literature. In our model, the effect of controlling on PKM-effectiveness (HO5) was relevant but compared to the other factors relatively weak. Nonetheless, PKM-controlling can contribute to advocate the acceptance of PM-activities in the organization and to justify the investment of setting up a KM-system.

7.5. ICT support

Existing research on the effects of ICT on the success of KM in temporary organizations generated mixed results. Whereas some studies concluded that ICT plays only a minor role and is far less important than structural and cultural factors (Karlsen and Gottschalk, 2004; Newell 2004, Adenfelt and Lagerström, 2006) other research identified ICT as a necessary precondition for any kind of KM activities (Bresnen et al. 2003; Leseure et al. 2004). Our results support the second position on the role ICT as it has the third largest effect on PKM-effectiveness in our model (HS1.1). Here it is both, systems that facilitate communication between persons (HS1.2) and systems for storage, search and retrieval of knowledge (HS1.3) that are important. This finding can be explained by the fact that in many organizations project work takes place across different locations and a variety of projects are carried out simultaneously. In such a dispersed multi-project environment an organizational memory can hardly be created and maintained and ICT-systems serve as a substitute for permanent structures. The combination of ICT-systems for communication and for storage can also facilitate the transformation of tacit into explicit knowledge when it is accompanied by an adequate knowledge culture as discussed below. Thus we conclude that the ICT infrastructure is a key factor of knowledge management effectiveness in project environments and has in some cases been underestimated in previous research.

7.6. Knowledge culture

Technical ICT-systems alone are not sufficient for ensuring the exchange of knowledge which very often is tacit and personalized. A positive set of values, attitudes, and expectations towards knowledge facilitates the willingness of people to share knowledge and to trust in knowledge from other persons. In our model, knowledge culture is the most important factor for explaining PKM-effectiveness (HC1). The support of informal communication (HC3.3), a tolerance towards mistakes (HC3.1), a positive project culture (HC3.2), and the commitment of top management (HC2.2) contribute to the knowledge culture. In temporary organizations culture can compensate for the lack of organizational routines and organizational memory. Although we find knowledge culture as the most important factor, it needs to be mentioned that in contrast to other studies (Bresnen et al. 2003; Kasvi et al. 2003; Brookes et al. 2006) PKM-effectiveness cannot be explained on this basis only.

7.7. Management commitment

The commitment of top management for PKM activities has a direct impact on PKM-effectiveness (HC2.1) but also indirectly influences the success of KM via the knowledge culture (HC2.2). Management commitment implies an appropriate resource endowment for KM but also the motivation of employees to participate in PKM. Management commitment also has a symbolical value for project team members as it legitimates the time and other resources devoted to KM. Literature has also emphasized the important role of the project leader (Barber and Warn, 2005; Akgün et al. 2007). Management commitment involves setup of a supportive project organization and the delegation of responsibilities and authorities for PKM to the project leader.

7.8. Limitations

The aim of our study was to simultaneously analyze the different success factors for knowledge management in temporary organizations identified in literature. In contrast to prior studies on that subject, we seek for empirical evidence using large sample and controlling for possible industry-effects and project-characteristics. This allowed us to determine the relative strength of the different factors influencing PKM-effectiveness and to generalize our findings. However, generalization of the results may be limited due to the fact that we used a sample composed of members and affiliated persons of the German Association for Project Management. This limitation might be mitigated to some extend as there are several cases of international corporations and subsidiaries of foreign firms. Nonetheless, the results may not be completely culture-free and a major avenue for further research lies in similar investigations in different cultural and national settings.

8. Conclusion

The increasing knowledge-intensity of work contents and the projectification of businesses give rise to a need for the management of knowledge in and between temporary organizations. Although existing studies identified several potential success factors for PKM, the focus on single cases and/or project types limited the generalizability of the results and the relative importance of the different factors and their interrelationships has not been analyzed sufficiently. In our study we therefore simultaneously considered the main factors influencing PKM-effectiveness in a large sample comprising different industries and different project types.

We were able to confirm a number of factors influencing PKM derived from prior studies in different research settings. Some of those factors can be found in general research on knowledge management (in permanent organizations). However, a number of factors are of particular importance for temporary organizations. They mainly serve for compensating for lacking routines and for bridging the gap between different projects regarding time, location and the allocation of project tasks and people. In particular, the influence of cultural factors on PKM success is in line with former research findings. We were able to expand the understanding on KM in project environments by showing that knowledge culture is by far the most important factor of success. However, not only "soft" factors like culture and top management commitment are essential for a successful transfer of knowledge between and across temporary organizations. They must be complemented by ICT-systems effectively supporting communication and the storage and retrieval of knowledge in a temporary project environment. It is not the mere availability of systems but their quality and usefulness which are essential. As a third major factor of success, we found the organization of multi-PM and especially the role and setup of project management offices. In addition to this, several other factors, like the PK processes and the organization of PK have positive impact on PKM-effectiveness. All in all, it is the interplay of several factors which lead to a successful transfer of knowledge within and between projects, and from the temporary to the permanent organization. Our research shows on a broad empirical basis that the effectiveness of handling knowledge relies on a set of project management practices and dedicated activities which might be related to extra effort in project work. Based on previous research in can be assumed that a positive relation between the effectiveness of managing knowledge and the success of managing projects exists (Love et al. 2005).

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