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Different dimensions of knowledge in cooperative R&D projects of university scientists

Benjamin Niedergassel *, Jens Leker

Institute of Business Administration, Department of Chemistry and Pharmacy, University of Münster, Leonardo-Campus 1, 48149 Münster, Germany

A R T I C L E I N F O

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A B S T R A C T

An increasing speed of new knowledge generation and a growing specialization of individuals in specific fields make cooperative R&D projects indispensable to stay abreast of the latest technological developments. However, studies targeting this field of research have almost exclusively focused on industrial cooperation projects, neglecting the importance of academic R&D collaboration.

We attempt to address this research gap by investigating completed R&D cooperation projects of 376 German professors of the chemical and biological sciences. Based on their evaluation, we can distinguish between successful and less successful projects mainly involving explicit or tacit knowledge. We further characterize these groups by identifying significant group differences regarding trust, the interdependency between partners, the frequency of communication and the closeness of partners. Overall, our study presents new empirical evidence that the codification of knowledge plays an important role for the success of cooperative R&D projects.

1. Introduction

An increasing speed of new knowledge generation leads to a growing specialization of individuals in specific fields and subfields of knowledge (Berends et al., 2006). This development makes cooperative R&D projects an indispensable instrument to stay abreast of the latest technological trends—especially in R&D intensive fields, such as the chemical or biotechnological sector (Carayannopoulos and Auster, 2010). Against this background, cooperation represents an important way of sourcing external knowledge. While industrial R&D often emphasizes the "D" and focuses on incremental innovations (e.g. improving the efficiency of production facilities), academic institutions emphasize the "R", concentrating on basic research. Looking at the innovation process, academic research can thus be placed in front of the front end. While the front end usually starts with the first consideration of an opportunity (Kim and Wilemon, 2002), basic research is not performed with a specific opportunity or application in mind (Bade et al., 2007). Cooperation with academia can thus aid in the search for new inventions and provide important stimuli for developing radical innovations (Fabrizio, 2009; Todtling et al., 2009), especially when a broad range of external sources is taken into consideration (Chiang and Hung, 2010).

In line with this reasoning, empirical studies could show that the number of R&D partnerships increased over the last decades (Hagedoorn, 1996; Hagedoorn, 2002; Roijakkers and Hagedoorn, 2006). Responding to the growing importance of cooperation, an extensive amount of literature on cooperative projects in general, and corresponding success factors in particular, has emerged. Many studies have put a special emphasis on structural and organizational factors. These included, for instance, the size of the organization (Rothaermel and Deeds, 2004), complementarity in resources of the cooperating organizations (Yang et al., 1999), the alliance experience of the partners (Hoang and Rothaermel, 2005) or alliance scope and governance (Jiang and Li, 2009), and their respective influence on performance or success. Other studies have focused on personal aspects and interpersonal connections, such as teamwork (Hoegl et al., 2004; Mudambi et al., 2007), the role of promotors (Hauschildt and Kirchmann, 2001) leadership (Curran et al., 2009; Faerman et al., 2001; Kleyn et al., 2007) or cultural aspects (Kanzler, 2010).

In contrast, comparatively few studies have addressed the role different dimensions of knowledge (i.e. tacit and explicit) play in cooperation. This holds all the more true for the context of academic cooperation projects. As Chompalov et al. (2002, p. 750) note: "[…] organizational studies have largely ignored scientific interorganizational collaborations as objects of inquiry […]". Almost all existing studies that analyze tacit and explicit knowledge in cooperative R&D projects rely solely on industrial sources for their data acquisition. In our opinion, this represents a major shortcoming, as the work environment of academic and industrial scientists substantially differs (e.g. Bruneel et al., 2010). Universities and companies have

* Corresponding author.
E-mail addresses: niedergassel@uni-muenster.de (B. Niedergassel), leker@uni-muenster.de (J. Leker).

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fundamentally different cultures and are perceived to have distinct social, cultural and economic roles (Cyert and Goodman, 1997; Meyer-Krahmer and Schmoch, 1998; Van Dierdonck and Debackere, 1988). While the primary goal of universities is the creation and dissemination of knowledge, companies provide products and services within a highly competitive environment (Cyert and Goodman, 1997). As a consequence, time horizons and the methods of validation and reward differ considerably (Lopez-Martinez et al., 1994). Acting under strong competitive pressure, companies mostly need to consider time in terms of meeting short-term goals. In contrast, the time horizons in the academic world are often much longer and less well defined (Cyert and Goodman, 1997). Not surprisingly, academic scientists perceive the short-term orientation of their industrial counterparts to be a major barrier for successful interaction (Meyer-Krahmer and Schmoch, 1998; Schmoch, 1997). In addition, the cultural differences between universities and industry can manifest themselves in deviating goals, languages and assumptions. For instance, many university scientists are driven by recognition and reputation in the scientific community. In contrast, the hierarchical superior often represents the critical constituent for managers (Cyert and Goodman, 1997). Furthermore, university scientists usually aim at making research results accessible to the public, while companies try to capture and exclusively use the intellectual property (Hall et al., 2001). Additionally, the nature and content of the partners' work differs substantially (Cyert and Goodman, 1997; Hurmelinna, 2004). According to Pavitt, "one of the main purposes of academic research is to produce codified theories and models that explain and predict natural reality" (Pavitt, 1998). On the other hand, industrial research mostly aims at concrete applications in the form of products, processes or services (Cyert and Goodman, 1997). Consequently, companies might have to face complex, ambiguous and abstract knowledge where they look for simple and concrete solutions to problems. In light of these differences between industry and academia, it seems to be a worthwhile endeavor to expand the scope of existing research beyond industry's perspective and assess the point of view of academic scientists. They might have different perceptions of the importance of factors potentially relevant for knowledge sharing. As recently demonstrated by a meta-analysis of van Wijk et al. (2008), it is very important to consider contextual characteristics when analyzing organizational knowledge. Accordingly, our study contributes to the existing literature by focusing on the so far under-researched context of academic cooperation projects, explicitly focusing on the role of different knowledge dimensions. To this end, we analyze academic cooperation projects with regard to the associated knowledge and factors relevant for sharing this knowledge. Our main objective is to identify differences between successful and less successful projects involving either predominantly tacit or explicit knowledge.

In the next section, the distinction between tacit and explicit knowledge will be illustrated and studies drawing on this distinction in analyzing cooperation projects will be highlighted. Building on these, hypotheses on the factors of relational trust, dependency of partners and tie strength will be derived. Followed by a description of the research design, results of our survey will be presented and analyzed. The paper concludes with a critical discussion of the results and points at future research opportunities.

2. Knowledge dimensions and their role in cooperation

2.1. Tacit and explicit knowledge

Although literature lacks a clear consensus about the definition of knowledge, many researchers from the field of innovation management follow the classical philosophical definition that views knowledge as justified true belief. However, as the truth of beliefs might be difficult to assess or prove, this work defines knowledge less strictly as justified belief. Although often used interchangeably, knowledge should be delineated from information to allow for a clear understanding of the terms. First, knowledge is always subjective and thus related to an individual's experiences, values, beliefs and commitment (Alavi and Leidner, 2001; Davenport and Prusak, 2000). Second, knowledge is associated with a specific purpose and is related to human action. It has been processed with a certain goal and is often of limited use when applied to differing goals (Cook and Brown, 1999). Third, knowledge is a synthesis of multiple sources of information over time and is always bound to a specific context (Rowley, 2007). These aspects emphasize the subjective nature of knowledge and support the idea of a tacit dimension—first introduced by Michael Polanyi as early as 1958 (Polanyi, 1958). The concept of tacit knowledge was later complemented by the explicit dimension to form the widely accepted distinction between tacit and explicit knowledge.

Building on the notion that individuals seem to know more than they can explain (Polanyi, 1966), tacit knowledge is characterized by a personal quality that makes it hard to formalize or communicate. It is rooted in an individual's values, beliefs, experiences and involvement in a specific context (Nonaka, 1994). The nature of tacit knowledge impedes its processing, sharing and storage in a systematic and logical way (Rehäuser and Krcmar, 1996). However, the same nature makes tacit knowledge more valuable and likely to yield a sustainable competitive advantage, as it is not easily imitated by competitors (Zander and Kogut, 1995). The value of tacit knowledge for high-tech industries, such as biotechnology, could be demonstrated (Zucker and Darby, 1996; Zucker and Darby, 2001; Zucker et al., 2002). In contrast, explicit knowledge refers to knowledge that can be articulated and transmitted in a formal, systematic language. It can be easily processed, transmitted and stored using (electronic) media. This characteristic allows for capturing the knowledge in records of the past, such as libraries or archives (Rehäuser and Krcmar, 1996). Explicit knowledge can thus be regarded as sequential knowledge (*then and there*), contrasting the simultaneous character (*here and now*) of tacit knowledge (Nonaka and Takeuchi, 1997). While the codification of knowledge facilitates its sharing, it simultaneously increases the risk of encouraging imitation (Kogut and Zander, 1992).

2.2. Knowledge in R&D cooperation projects

A literature review reveals that comparatively few studies specifically address the role of tacit and explicit knowledge in cooperation projects. Most of these studies target the impact on knowledge transfer or sharing, as it is closely associated with the overall performance of cooperation projects (Dhanaraj et al., 2004).

Analyzing 137 alliance cases in high-tech industries, Chen (2004) finds that knowledge transfer performance is positively affected by explicitness and a firm's absorptive capacity. Furthermore, the author can show that trust has a positive effect on knowledge transfer performance. In a survey involving firms from more than 15 industries, Cummings and Teng (2003) could show that articulability, embeddedness, knowledge and norm distance (i.e. the degree of shared organizational culture and value systems) as well as transfer activities affect knowledge transfer success. Dhanaraj et al. (2004) examine the influence of tacit and explicit knowledge on the performance of international joint ventures (IJVs). Their results show a positive effect of tie strength, trust, and shared values and systems on the transfer of tacit knowledge. Furthermore, they can demonstrate a positive relationship between explicit knowledge and IJV performance. Reagans and McEvily (2003) studied how different features of networks affect knowledge transfer using data from a contract R&D firm. They could find that social cohesion and network range facilitate