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Complex technological knowledge and value creation in science-to-industry technology transfer projects: The moderating effect of absorptive capacity

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ABSTRACT

This study seeks to enhance the understanding of the interplay between complex knowledge, absorptive capacity in terms of both absorptive capabilities and prior knowledge, and value creation. Drawing on a database of 127 science-to-industry R&D projects in technology-based markets, our study results show the inherent relevance of complexity and absorptive capabilities for value creation. Contrary to expectations, prior knowledge has no significant effect on value creation per se. Instead, the impact of complex technological knowledge on value creation is enhanced at high levels of both prior knowledge and absorptive capabilities. The findings suggest that following a well-worn path leads to competence traps, whereas knowledge-related learning capabilities enable a firm to deal with dynamic environments. The findings have implications for managerial decisions and theory regarding how value can be created from complex knowledge in technology transfer settings.

1. Introduction

Firms' innovation processes have become increasingly open to revitalization of their internal innovation development and to gaining advantages through external knowledge (Chesbrough, 2003; Grant, 1996). Joint R&D collaborations are an important means of gaining access to technological knowledge that fosters innovation success (e.g., Grant & Baden-Fuller, 2004; Un, Cuervo-Cazurra, & Asakawa, 2010). Previous studies have argued that complex technological knowledge fosters comparative advantages and has high value potential for firms owing to a wide range of application opportunities and imitation barriers resulting from ambiguity. Simultaneously, these arguments possibly suggest the opposite for technology transfer projects, since ambiguity often hampers knowledge transfer (e.g., Reed & DeFillippi, 1990; Simonin, 1999; Winter, 1987). However, research to date has shown little and, sometimes, counterintuitive evidence for the complexity–performance relationship. Zander and Kogut (1995) and McEvily and Chakravarthy (2002) both analyzed the effects of complexity on imitation advantages. Contrary to expectations, only McEvily and Chakravarthy's (2002) study revealed a significant complexity–performance relationship. According to their results, complex technological knowledge protects product advantages from imitation. Consequently, the purpose of our study is to examine whether and how complex knowledge contributes to value creation in technology transfer projects. Current conditions underscore the importance of this research question. Drawing on a sample of patent filings between 1980 to 2003, von Graevenitz, Wagner, and Harhoff (2011) show a sustained increase in technological complexity.

To address the complexity–performance relationship in some detail, we build on previous studies on knowledge attributes, knowledge transfer, and value creation, and we present our arguments within the *absorptive capacity* framework. Cohen and Levinthal's (1990) concept of absorptive capacity (AC) suggests that value creation and competitive advantages depend on firms' ability to apply new external knowledge to commercial ends. Inkpen and Dinur (1998), for instance, note that research on the 'out-come' of different forms of knowledge should emphasize learning processes. Simonin's (1999) study shows that prior knowledge diminishes the ambiguity within knowledge transfers. In contrast, at least in low learning capacity settings, complex knowledge enhances ambiguity. However, given steady technological progress, knowledge-related learning capabilities, as opposed to prior knowledge, seem important when it comes to profiting from external knowledge and technology transfer value creation (Teece, Pisano, & Shuen, 1997; Zahra & George, 2002). To investigate the two factors' relative importance, our article addresses the AC concept in terms of prior knowledge and knowledge-related learning capabilities (e.g., Cohen & Levinthal, 1990; Jansen, Van Den Bosch, & Volberda, 2005; Zahra & George, 2002).

Notwithstanding the present investigation, our understanding of how AC moderates the interplay between complex knowledge and value creation remains underdeveloped. Although the influence of AC on value creation has already been examined in connection with knowledge transfer performance and firm success (e.g., Lane & Lubatkin, 1998; Wales, Parida, & Patel, 2013), the potential of AC to optimize

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value from new external knowledge remains a matter of speculation. More recent literature has called for examination of this effect, but so far the influence of AC on tacitness is all that has been analyzed (e.g., Abecassis-Moedas & Mahmoud-Jouini, 2008; Chen, 2004; Jansen et al., 2005; Schmidt, 2010; Volberda, Foss, & Lyles, 2010).

To fill this gap and examine the basic precepts within this relationship, we propose a contingency approach. The predicted importance of this approach derives from the fact that complex knowledge hinders knowledge transfer, while AC is important in creating value from new external knowledge (e.g., Cohen & Levinthal, 1990; Reed & DeFillippi, 1990). Not all firms can learn equally well from third parties, since the specific attributes of the available knowledge differ (Lane & Lubatkin, 1998). As a result, fully utilizing the potential of complex knowledge for value creation necessitates AC (e.g., Volberda et al., 2010).

This paper contributes in several ways. Following the recommendation by Ireland, Hitt, and Vaidyanath (2002), our approach utilizes multiple theoretical roots to explain how value can effectively be created. We seek to deepen the understanding of inter-organizational technology transfer by examining the interplay between complex knowledge, absorptive capacity, and value creation. Implications for the knowledge-based theory emerge from this approach. In light of ambiguous previous findings and the predominant focus on tacit knowledge, it should enhance awareness about *how* and *when* complex knowledge can be transferred and value thereby created. Increasing technological complexity and the steady shortening of technology life cycles highlight the necessity of our investigation (Teece et al., 1997; von Graevenitz et al., 2011).

Finally, we highlight the importance of relational factors in complex technology transfer settings (e.g., Hansen, 1999). This emphasizes the meaning of utilizing integrative concepts in dyad research and provides success factors for practice. We analyze these aspects by proposing a survey of 127 joint R&D projects with public research organizations.

This paper's discussion is organized into five sections beginning with the introduction. In the second, we define central concepts, show theoretical and conceptual backgrounds, and derive hypotheses. Then we introduce the study's central research design and methodology. The fourth section discusses results on the basis of the obtained design. Last, we provide a summary, implications for theory and managerial practice, and limitations including an outlook for future research.

2. Theoretical background

2.1. Value creation of science-to-industry technology transfer

The concept of value creation is defined as the "[…] *trade-off between benefits and sacrifices*" and represents the idea of receiving benefits despite expenditures (Walter, Ritter, & Gemünden, 2001, p. 366). Since it reflects the economic principle, this concept has gained attention in several research areas, particularly the area of dyads such as buyer–seller relationships and alliances (e.g., Gulati, Lavie, & Singh, 2009; Tsai & Ghoshal, 1998). Generally, value can be ascertained from monetary (e.g., Anderson & Narus, 1999) and nonmonetary revenues (e.g., Tsai & Ghoshal, 1998). Firms are inherently interested in remaining competitive in technology-based industrial markets, mostly through innovations and new technological knowledge (Grant, 1996). Research done at public research organizations (PROs) possesses an especially high value-creation potential for the firms' financial performance and industrial innovations (e.g., Salter & Martin, 2001). The firms' R&D collaborations with PROs were found to have the most significant impact on sales growth and product innovation success as compared to other forms of innovation cooperation (Belderbos, Carree, & Lokshin, 2004; Un et al., 2010).

2.2. Complexity of technological knowledge and value creation

Knowledge can be characterized along several dimensions including tacitness, specificity, and complexity (e.g., Reed & DeFillippi, 1990; Winter, 1987). Simon (1962) suggests that complex items are an aggregate of many interrelated elements (see also, e.g., Teece, 1986; Winter, 1987; Zander & Kogut, 1995). Similarly, Simonin (1999, p. 600) defines complexity as the "[…] *number of interdependent routines, individuals, technologies, and resources linked to a particular knowledge or asset*." Mitchell and Singh (1996) elaborate on the systemic and indecomposable characteristics of complex products. Where it is not possible to separate components, each component's performance contributes to the overall performance and thus requires the same amount of observation.

Several studies on knowledge literature have claimed that complexity has a negative effect on learning and thus also on knowledge transfer (e.g., Simonin, 1999). Higher complexity increases fragmentation of knowledge among the individuals involved. This muddies the interplay of cause and effect (leads to *ambiguity*), and this is indicative in turn of demands placed upon numerous resources for integration of knowledge understanding. Owing to this, complex knowledge restrains (both intra-organizational and inter-organizational) knowledge transfer (*stickiness*) (Szulanski, 1996; von Hippel, 1994). These findings suggest that complex knowledge transfer is possibly cost-intensive and, thus, that complexity may decrease the transfer value (cf., Teece, 1986).

Nevertheless, because it is a source of ambiguity, complex knowledge can be highly beneficial to firms such that the benefits presumably will exceed any sacrifices. Previous research mostly proposed and documented a linear relationships between complexity and potential performance effects such as imitation barriers (e.g., McEvily & Chakravarthy, 2002; Simonin, 1999; Zander & Kogut, 1995). Three arguments support the idea that the negative effects of complexity inherently underlie its (also inherent, but predominant) value creation potential in technology transfer projects. First, the difficulty of transfer also affects imitation barriers to potential competitors. Because complex knowledge is fragmented across individuals and business units, little risk is incurred that this knowledge will be lost to external firms, and reverse engineering of commercial applications is hampered as well (e.g., Reed & DeFillippi, 1990; Simonin, 1999; Szulanski, 1996; Zander & Kogut, 1995). McEvily and Chakravarthy's (2002) findings are relevant in this context; they show that complex technological knowledge helps to protect a firm's product improvements from imitation by outside firms. Rivkin (2000) demonstrates this relationship using an example of complex strategies. Even when would-be imitators are aware of most of the per se knowledge components, imitation is nearly ruled out because they fail to understand the overall context; they "[…] *still fail to grasp the recipe*" (Rivkin, 2000, p. 825). Accordingly, an idiosyncratic complex knowledge base might foster competitive advantages (Barney, 1991).

Second, complex technologies naturally refer to a wide range of knowledge domains (e.g., Simon, 1962). From this, many assume that complex knowledge would harbor more commercial application possibilities than less complex knowledge. Besides greater protection from would-be imitators, complexity in terms of broader patent scope also points toward a greater number of commercial ends in technical areas across the board. In the end, wasting resources during the integration and research phase constitutes only a small risk compared to the likelihood that at least one successful commercial application will result (e.g., Merges & Nelson, 1990; Nerkar & Shane, 2007; Sorenson, Rivkin, & Fleming, 2006). Lerner's (1994) study in light of these aspects suggests that the complexity of a firm's patents positively impacts that firm's value.

Third, the transfer of complex knowledge might simultaneously increase learning experiences in several areas and thereby lead to a broader, diversified knowledge base allowing for economies of scope. This will enhance both the firm performance and innovation performance (e.g., Grant & Baden-Fuller, 2004; Henderson & Cockburn, 1996). Since complexity is an inherent characteristic, the more complex the transferred technology is, the more accumulated knowledge it entails (Simonin, 1999). In the end, where knowledge has become the most strategic resource, one that determines firms'

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