Doctoral Thesis

Essays on organizational knowledge and its impact on performance towards an integrative view of ontological levels

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ESSAYS ON ORGANIZATIONAL KNOWLEDGE AND ITS IMPACT ON PERFORMANCE:

TOWARDS AN INTEGRATIVE VIEW OF ONTOLOGICAL LEVELS

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Abstract

Knowledge is one of the most strategically important sources for sustained competitive advantage. It is created by individuals but does not necessarily reside exclusively at the individual level. The enlargement of knowledge from individual to the other ontological levels occurs as a result of social interactions. With respect to organizational knowledge creation, ontological levels (individual, group, organizational, and inter-organizational levels) indicate the extent of social interaction between individuals that take part in knowledge sharing and creation. This dissertation consisting of an introductory chapter and four separate research papers contributes to the knowledge based theory of the firm by filling gaps in the theory related to the ontological levels. It emphasizes the importance of different ontological levels and their interactions for knowledge creation and firm performance. It shows how firms can benefit from paying attention to different ontological facts, discusses managerial implications, and outlines suggestions for future theory building and empirical research.

Zusammenfassung

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1. Knowledge creation as an interactive process of different ontological levels

Over the last 20 years knowledge has been accepted as one of the most strategically important resources of a firm as it is socially complex and difficult to imitate (Grant, 1996; Nonaka and Toyama, 2003). For sustained competitive advantage firms should not only process information and leverage existing knowledge but also enable new knowledge creation that allows the firm to respond quickly to the requirements of the near and more distant future (Handerson and Cockburn, 1994; Nelson, 1991; Nonaka and Takeuchi, 1995; Kogut and Zander, 1996; Teece et al., 1997). Organizational knowledge creation is defined by Nonaka, von Krogh, and Voelpel (2006) as the process of making available and amplifying knowledge created by individuals as well as crystallizing and connecting it with an organization’s knowledge system. While new knowledge is developed by individuals, knowledge remains personal unless articulated and amplified through social interactions. Hence, interactions between individuals play a critical role in organizations.

Nonaka and Takeuchi (1995) explain knowledge creation as a process of continual dialogue between explicit and tacit knowledge along epistemological and ontological dimensions. Epistemology as a branch of philosophy studies the theory of knowledge. Organizational epistemology tries to explain what knowledge is and how and under which conditions it develops (Koskinen et al., 2003). The epistemological dimension in organizational knowledge creation is concerned with the nature and origin of knowledge and distinguishes between tacit and explicit knowledge (Nonaka and Takeuchi, 1995). On the other hand, ontology as another branch of philosophy is the field of study that questions the categories and nature of existence (Milton and Kazmierczak, 2006). Although ontology and
epistemology are related to each other and some epistemological questions arise from
enquiries in ontology they are separate fields of enquiry (Milton and Kazmierczak, 2006;
propose alternative categorial schemes. A categorial scheme typically exhibits a hierarchical
structure, with ‘being’ or ‘entity’ as the topmost category, embracing everything that exists”.
Thus, ontology defines the categories of what exists and describes the nature of these
categories and how these categories are related (Milton and Kazmierczak, 2006). The
importance of ontology lies in bringing clarity and directionality in research by providing
taxonomy of categories (Lawson, 2004). With respect to organizational knowledge creation,
ontology is concerned with the levels of knowledge creating entities (Nonaka and Takeuchi,
1998). The extent of social interaction between individuals that take part in knowledge
sharing and creation is referred as the "ontological" dimension of knowledge creation
(Nonaka, 1994). Hedlund (1994) name the same concept as the “levels of carriers, or agents
of knowledge”. Both authors distinguish between four different ontological levels: the
individual, the group, the organization, and the inter-organizational domains. For the sake of
consistency Nonoka’s terminology will be used in this dissertation thesis.

1.1. Collectivist versus individualist approaches to knowledge

A critical epistemological debate in management and organization science is the locus of
knowledge (Felin and Hesterly, 2007; von Krogh, 2009). This debate has epistemological as
well as ontological implications for positioning of theoretical and empirical studies that deal
with knowledge. The individualist perspective assumes that locus of knowledge is the
individual and it should be the basis for understanding new value creation and organizational
outcomes. Methodological individualists (e.g. Nagel, 1961; Popper 1968) argue that as
collectives are made up of individuals the basic unit of analysis in research should be
individuals (Felin and Hesterly, 2007). The individualist perspective in management and
organization science can be traced back to Herbert A. Simon (von Krogh, 2009). In his paper Simon (1991) suggested that learning takes place inside human heads and organizations learn through the learning of its members or newcomers. Simon’s contribution is important for the knowledge based view of the firm (KBV). Building on Simon’s assumption, Grant (1996), one of the pioneers of KBV, suggested that knowledge creation is an individual activity and the primary objective of the firm is applying this knowledge to the production of goods and services. A recent contribution to the individualist perspective is the paper by Felin and Hesterly (2007). The authors provide supportive arguments for individualistic perspective building their explanations on cognitive revolution in linguistics (Chomsky, 1986, 2000), cognitive psychology (Bouchard and McGue, 2003; Lubinski, 2000) and philosophy (e.g. Peter Carruthers, Jerry Fodor).

On the other hand, as Felin and Hesterly (2007) also show, the collectivist perspective builds on a Durkheimian sociological tradition and assumes that the locus of knowledge is the collective (e.g. groups, communities, networks, organizational units, etc.). This tradition provides the basis for much of knowledge based work (e.g. Kogut and Zander, 1996). The collectivist perspective argues that collectives should be studied on their own right as it is the collective facts that largely determine the organizational outcomes (Felin and Hesterly, 2007). According to Felin and Hesterly the collectivist perspective assumes a downward causation from collective to individual whereas individualist perspective assumes an upward causation from individual to collective. The downward causation of collectivists assumes that individuals are homogeneous and malleable and suggests that collective level facts such as routines determine differential individual and organizational outcomes. The upward causation assumes that it is only the composition of the collective i.e. the individuals and their specifications that define the outcome of the collective.
Von Krogh (2009) criticizes Felin and Hesterly (2007)’s extreme statement of the collectivist view and argues that collectivist approaches are indeed concerned with both individual and collective knowledge and their interactions. The individualist scholars tend to overemphasize the collective knowledge in collectivist studies ignoring their contributions dealing with individual and collective levels (von Krogh, 2009). He provides examples from collectivist research that also consider individual influence (e.g. Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Tsoukas, 2005). Yet, he also indicates that the collectivists may fail to pay enough attention to individual heterogeneity and its impact on organizational knowledge outcomes. As an alternative approach he suggests a combined view including both individual and collective perspectives.

The two approaches are important to understand because their basic assumptions guide and shape how research is designed. Research questions, constructs, unit of analysis, data collection, and implications are all defined according to the position taken between the two perspectives. It has also consequences for the choice of ontological levels in focus. For example, most of the collective theorists (e.g. Nelson and Winter, 1982) argue that organizational level aspects such as routines are independent of the individual and collective cannot be understood by reducing it into its parts (Felin and Hesterly, 2007). They assume that, collective is ontologically independent. On the other hand, individualists are concerned with individual heterogeneity and its impact on the overall outcome. Therefore, they mainly focus on individual differences and their consequences.

There is a thin line between the concerns about the locus of knowledge and the ontological dimension in knowledge creation. The individualist/collectivist distinction in epistemology is particularly concerned with at what level knowledge is created and whether knowledge is fundamentally a social phenomenon which is different from the aggregation of individuals or it is rooted more in the attributes and abilities of the individuals involved (Felin
and Hesterly, 2007). The ontological dimension is concerned with the categories (levels) of social interactions taking part in knowledge creation without referring to the superiority of any level. Thus, for example, a researcher might be proponent of individualist perspective and at the same time focus on organizational level processes regulating interactions of individuals taking part in knowledge creation (e.g. Grant, 1996).

1.2. A combined view on different ontological levels

This dissertation follows a compound approach as suggested by von Krogh (2009) and considers the individual and the collective levels, as well as the interactions between them in explaining organizational knowledge creation. This approach is based on the premise that individuals shape organizations and they are also impacted by organizational level aspects (e.g. routines, culture). Individuals contribute their knowledge to the organization and organizational processes integrate individual knowledge through rules, directives, sequencing of tasks, and organizational routines, as well as group problem solving and decision making (Grant, 1996).

In addition, this dissertation assumes that each ontological level has its own dynamics and knowledge at a level is not reducible to its parts although its parts have a certain influence on it. The interaction within and between different ontological levels helps us understand organizational knowledge creation. Actions of a group of individuals cannot always be epistemologically reduced to a collection of individual actions within the focal group. Therefore, groups, organizations, and even inter-organizational networks can be considered on their own right with respect to knowledge they create and possess (Cook and Brown, 1999). Knowledge is created by individuals but does not necessarily reside only at the individual level (Hedlund, 1994). The enlargement of knowledge from individual to the other ontological levels occurs as a result of social interactions (Nonaka, 1994; Sabherwal and
Sabherwal, 2005). The notion that knowledge can also reside outside the individual has been assumed and emphasized by various literature streams such as research on organizational routines and organizational capabilities (e.g. Cohen, 1991; Teece at al., 1997). Groups as an intermediate level between the individual and the organization allow a finer-grained view on organizational knowledge. The significance of small groups in innovation and product development indicates that this is the level at which much of knowledge creation and learning takes place (Hedlund, 1994). Social interactions spanning organizational boundaries can also occur through informal (e.g. friend-networks) or formal connections (e.g. business partners or alliances). The literature on open innovation (e.g. Chesbrough, 2003) and strategic alliances (Rothaermel and Deeds, 2006) evidence that inter-organizational level is also critical for organizational knowledge creation.

Previous research has identified various features of the ontological dimensions that affect or enable knowledge creation. The individual level features characterize individual differences that take part in knowledge creation process. Some of these characteristics are open-mindedness (Mitchell et al., 2006; von Krogh, 1998), commitment (Nonaka et al., 2000; Ron et al., 2006, Koskinen (2001), and credibility (Akgün et al., 2005). The group level characteristics include group size, knowledge diversity, and demographic variables (Nonaka, 1994; Cohen and Bailey, 1997; von Krogh, 2005; Saks and Ashforth, 1997). A number of “organizational characteristics” such as organizational norms and culture (Maanen and Schein, 1979), reward systems linked to knowledge sharing (Zarraga and Bonache, 2005), context (Ba) (Nonaka et al., 2000), organizational slack (Lawson, 2001; Nohria and Gulati, 1996), and communication means present in the organization (von Krogh, 1998, Nonaka et al., 2000) are also likely to affect knowledge creation. Last, inter-organizational features such as alliances (Deeds and Hill, 1996; DeCarolis and Deeds, 1999) and interactions of firms within a geographical cluster (Porter, 1998; Jaffe et al., 1993; DeCarolis and Deeds, 1999)
influence knowledge outcomes. Hence, research so far has shown that ontological levels and their features impact on organizational knowledge creation. Yet, there are still some theoretical and empirical gaps in the knowledge based theory related to the dynamics within and between different ontological levels and their impact on knowledge creation. The objective of this doctoral thesis is to identify and fill some of these gaps in the literature and to provide theoretical, empirical, as well as methodological contributions to the knowledge based theory of the firm by focusing on different ontological levels and their interactions.

The present doctoral thesis consists of an opening chapter and four independent research papers co-authored by the author of this thesis. This opening chapter highlights the positioning of the four dissertation papers, a literature overview on the knowledge based theory of the firm, the research framework and the interactions of the four contributing papers, and a synthesis of the findings. Each of the four dissertation papers in the appendix fills a research gap in the knowledge based view of the firm and elaborates a different perspective on the interaction between different ontological levels regarding knowledge creation. The first paper “Exploration of Knowledge Sharing In An Online Community Of Volunteers: The Role Of Community Munificence” provides insights about how group level characteristics impact on knowledge sharing intentions of the individuals. This paper presents a model of knowledge-sharing intention and tests it using survey data collected from an online community. The second paper “The Quality of Group Tacit Knowledge” focuses on the individual and group levels. It develops the concept of “quality of group tacit knowledge” and a comprehensive model explaining different quality levels of tacit knowledge that a group can achieve. In addition, it identifies some of the individual characteristics necessary for achieving high quality tacit knowledge in a group. The third paper “Analyzing for Clusters in the biopharmaceutical industry: A review and method” is a review and method paper focusing on the interaction between inter-organizational and organizational levels. It unpacks some
advantages and disadvantages of cluster participation for organizations, and proposes a simple new method for managers to identify geographical clusters. The fourth paper “Filling the Tub at the Right Pace: How Stocks and Flows of Knowledge Impact on Firm Performance in the Biopharmaceutical Industry” deals with inter-organizational and organizational levels and demonstrates the relative impact of knowledge stocks and flows on firm performance over time.

As mentioned before, this doctoral thesis aims to contribute to the knowledge based view of the firm. Next, a review of the literature on knowledge based view of the firm will be presented. Given the vast literature in this field, the dissertation does not include all the knowledge based literature but rather focuses on key foundational contributions. Thus, the scope of the review will be limited to the pioneers of the theory and their contributions with regard to different ontological levels.

2. Knowledge based view of the firm and organization

Theories of the firm conceptualize and predict the structure and behavior of business enterprises. Alternative theories such as economic theories of the firm (Williamson, 1979), organization theory (Astley et al., 1983), behavioral theory of the firm (Cyert and March, 1963), and evolutionary theory of the firm (Nelson and Winter, 1982) offer rival and complementary explanations and models of the real world enterprises. The main objective of strategic management is to explain how and why strategic choices of firms impact on their performance. Strategic management scholars draw their theories upon both economics and the organization theory (Grant 1996). An important contribution of strategic management to the theory of the firm is the “resource-based view of the firm”. The resource based approach suggests that in order to gain competitive advantage firms need to possess idiosyncratic resources, competencies, and capabilities which are scarce, valuable, and durable (Barney,
According to this view the management should optimally deploy the resources and capabilities in order to maximize value and develop new resources for sustained competitive advantage (Grant, 1996).

After Simon’s (1947) critique of economic theory and Polanyi’s (1962) work on the epistemology of human knowledge economists, organizational theorists, and strategists began to focus on intangible assets, especially on knowledge. Since the seminal work by David Teece (1981, 1982) and Nelson and Winter (1982), knowledge has become increasingly important in strategic management. The neo-classical economics underestimated firm differences and treated them as “black boxes” with an objective of allocating resources optimally given preferences and technologies (Nelson, 1991). Breaking with the established assumptions about the firm in neo-classical economics knowledge was increasingly seen as a factor to explain the idiosyncrasies of firms (Nonaka and von Krogh, 2009). The resource-based theory of the firm showed the importance of costly-to-imitate resources that a firm possesses for competitive advantage (Barney 1991; Reed and DeFillippi 1990).

After Sid Winter argued that tacit knowledge is a source of competitive advantage for firms (Winter, 1987) researchers became more interested in knowledge in organizations. In their seminal work Kogut and Zander (1992) distinguished between codified and tacit knowledge and suggested organizations as social communities serving to share, transfer, and create knowledge. The authors introduced the concept of a “combinative capability” to explain the capability of a firm to create new knowledge by exploiting its existing knowledge and unexplored potential of the technology. Winter, Kogut, and Zander's work initiated a line of inquiry in strategic management referred to as the “knowledge-based view of the firm” (Nonaka and von Krogh, 2009; Spender and Grant, 1996; Tsoukas, 1996; Spender, 1996; Szulanski, 1996; Gupta and Govindarajan, 2000). Knowledge based theory builds upon the resource-based theory of the firm and epistemology. In addition, it synthesizes a number of
literature streams such as organizational learning (e.g. March, 1991; Argyris, 1977; 1993); evolutionary economics (e.g. Nelson and Winter, 1982); organizational capabilities and competences (e.g. Prahalad and Hamel, 1990); dynamic capabilities (Teece et al., 1997), and innovation and new product development (e.g. David Teece, 1986; Clark and Fujimoto, 1991). The knowledge-based theory assumes that markets are reasonably efficient and competitive advantage cannot result from asymmetric information about the markets. Since the origin of all the tangible resources lies outside the firm, the competitive advantage is more likely to originate from the firm specific knowledge and its ability to create new knowledge (Spender, 1996).

The knowledge based theory deals with additional concerns beyond the concerns of strategic management (Grant, 1996). It sheds light on the relationship between abstract knowledge, individual, and organizational practices. In addition to conceptualizing organizational knowledge, the knowledge-based view deals with strategies for managing a firm's knowledge assets, organizational structure, leadership within the firm, boundaries of the firm, and the theory of innovation (Spender and Grant, 1996; Grant 1996; Boisot, 1998; Chou and He, 2004; Nonaka et al., 2000, 2005b; Teece, 1998, 2000; Bowonder and Miyake, 2000; Chen and Edgington, 2005). In addition to the theoretical contributions various empirical studies tested the implications of knowledge for firm performance in various industries (Bierly and Chakrabarti, 1996; Dröge et al., 2003; Poppo and Zenger, 1998; Sabherwal and Sabherwal, 2005; Choi and Lee, 2002).

Pioneers of the knowledge-based view include Bruce Kogut, Udo Zander, Robert M. Grant, J.-C. Spender, Ikujiro Nonaka, Hirotaka Takeuchi, Georg Von Krogh, Julia P.
Liebeskind, Johan Roos, Donna M. Decarolis, and David L. Deeds. In the following sections, seminal contributions of these scholars to the knowledge based theory will be reviewed. These scholars have been selected according to four criteria. First, their contributions have emphasized “knowledge” as the fundamental construct in their theorizing about the firm. Second, their studies have contributed to further theory building in the area of knowledge based view of the firm. Third, the significance of their contributions has been evidenced by citations. Fourth, they have been suggested as main contributors to the knowledge based view of the firm by well known scholars working in research fields related to “knowledge” (e.g. Grant, 1997; Kaplan et al., 2001). As Kogut and Zander co-authored most of their articles related to knowledge based theory their contributions will be explained together. After mentioning Grant`s, Spender`s, Liebeskind`s, and Roos`s contributions separately the contributions of Nonaka, Takeuchi, and von Krogh will be summarized together under the title of “organizational knowledge creation theory”. Lastly, the theory of knowledge stocks and flows will be explained by referring to the contributions of Decarolis and Deeds. The main focus of the dissertation papers (see in the Appendix) is on the organizational knowledge creation theory and the theory of knowledge stocks and flows. Therefore the two theories will be explained in more detail.

2.1. Kogut and Zander

Kogut and Zander are among the researchers who established the foundations of knowledge-based theory of the firm. The core idea in their theorizing is that “what firms do better than markets is the sharing and transfer of the knowledge of individuals and groups within an

There are also other scholars from different streams of thinking that underlie KBV such as March, Levintal, Cohen, Teece etc. Although their contributions have provided significant impact on the foundation of KBV, their contributions have not been targeted to build a knowledge based theory of the firm but instead targeted to different research streams (e.g. March, Levintal, and Cohen mainly contribute to organizational learning). Therefore, this dissertation has not stated such scholars as pioneers of KBV although they have influenced the thinking of scholars who targeted to develop knowledge based view of the firm.
organization” (Kogut and Zander, 1992). According to the authors, knowledge is held by individuals but created in social settings. Organizational knowledge is embedded in the organizing principles and cannot be reduced to individuals. In their work, they consider different ontological levels by examining personal expertise, social knowledge, the capabilities of the firm, and inter-organizational networks. However, their approach is fundamentally collectivistic with a focus on organizations as social collectives. The organizing principles, which they consider as an organizational level aspect, structure the relationships among individuals, within and between groups, and among organizations. Thus, they also implicitly point to the link between individual and collective knowledge (von Krogh, 2009). They suggest that individuals possess know-how and information. Interactions within groups enable groups to develop unique language and common stock of knowledge through which individual knowledge can be shared. What the group knows is the information about who knows what and how activities are to be organized (Kogut and Zander, 1992). What the firm knows is the information about other actors and processes in the network and the organizing principles that establish how groups are coordinated and, individual and collective expertise are transformed into products or services.

The authors introduced the concept of “combinative capabilities” to explain how firms can generate new applications from the existing knowledge (Kogut and Zander, 1992). These capabilities are what provide the firm its unique competitive advantage. The authors applied the organizational capabilities idea to knowledge transfer in multinational corporations and found that firms can transfer idiosyncratic technologies which are difficult to codify at a lower cost to wholly owned subsidiaries than to third parties (Kogut and Zander, 1993). In another empirical study, they showed that the degree of codification and how easily the capabilities are taught has a significant influence on the speed of horizontal transfer of knowledge to other sites (Kogut and Zander, 1995). The authors argued that firm identity
enhances coordination, communication, and learning and permits an understanding of the evolution of a firm’s knowledge and its extension across firm boundaries (Kogut and Zander, 1996; 2003).

In sum, the authors’ contribution to knowledge based theory is seminal. Although they consider all ontological levels in their theory building, their main focus is on the organizational and inter-organizational levels. They especially deal with organizing principles of work in explaining what organizations know and how organizational knowledge can be transferred across boundaries.

2.2. Grant
Grant is one of the founders of the knowledge based theory of the firm. In the 1970s Grant’s research interest lay in industrial economics and his interest in knowledge based theory grew out of work on the resource-based theory (Spender and Grant, 1996). Spender and Grant edited a special issue in Strategic Management Journal in 1996 on “Knowledge and the Firm”. In this special issue Grant (1996) theorized on the foundations of the knowledge based view of the firm. In his theory building he emphasized the nature of coordination within the firm and conceptualized the firm as an institution for knowledge application. Grant (1996) suggests that learning takes place within individuals and the primary task of firm is integrating the specialized knowledge of individuals. He identifies four mechanisms for integrating the knowledge possessed by individuals in an organization: 1) rules and directives, 2) sequencing, 3) routines, and 4) group problem solving and decision-making (Grant, 1996, 1996a; Grant, 1997). These mechanisms depend upon the existence of common knowledge such as language, symbolic communication, commonality in specialized knowledge, shared meaning, and mutual recognition of individual knowledge domains.
Grant follows an individualist approach and emphasizes the locus of knowledge as individual. However, his theorizing includes different ontological levels in order to understand the organizational processes by which a firm can access the knowledge of individuals. Particularly, he focuses on the organizational level facts by introducing the integrating mechanisms.

2.3. Spender

Spender (1994) suggested firm as a dynamic body of knowledge in action. Unlike Grant (1996) who focuses on the role of firm in knowledge application Spender emphasizes the role of the firm as a dynamic, evolving, quasi-autonomous system of knowledge production and application (Spender, 1996). Spender follows a collectivist perspective and assumes that “the firm has an ability to know independently of its employees, or at least independently of their conscious reasoning” (1996: 51). Building on previous literature (Durkheim, 1964; Weick and Roberts, 1993; Nelson and Winter, 1982) the author distinguishes between collective and individual knowledge:

“…collective knowledge is probably unlike that of individuals. It is not merely shared individual knowledge. It is likely to be embedded in the organization’s institutionalized collective practices and thus deals with the interaction between the individuals’ practice rather than with what they can report explicitly. It is likely to be emergent and arise after the individuals begin to engage in collective practice. It is likely to be implicit and become evident through practice rather than through explicit analysis.”(Spender, 1994: p. 359)

Spender (1996, 1996a) focuses particularly on the epistemology of knowledge. He criticizes the positivist approaches to knowledge which objectifies knowledge and separates knower from the known (Spender, 1998). He argues that knowledge based theory should shift the focus from the firm’s intangible knowledge assets on to the processes that generate, distribute and apply them. He suggests a four-fold pluralistic epistemology including tacit/explicit and individual/social interactions. According to Spender (1998) a four-fold
pluralistic epistemology is more extensive than Nonaka and Takeuchi’s (1995) two fold pluralistic epistemology including tacit/explicit interactions. He criticizes Nonaka and Takeuchi’s epistemology and argues that it dismisses the individual/organizational dichotomy assuming that only individuals think.

Spender suggests that based on the dynamic interaction between tacit, explicit, individual, and social knowledge the firm comprises four different types of knowledge: conscious (explicit-individual), objectified (explicit-social), automatic (implicit-individual), and collective (implicit-social) (Spender 1996, 1996a; 1998). Each type of knowledge implies different learning and memory processes (Spender, 1996b). Thus, his core theoretical contributions incorporate two ontological dimensions: the individual and the organizational level. While an individual's knowledge is inherently transferable, moving with the person, collective (organizational) knowledge is either publicly available or embedded in the firm's routines, norms and culture. He argues that organizations learn to the extent that their members are “malleable beings whose sense of self is influenced by the organization's evolving social identity” (Spender, 1996).

2.4. Liebeskind

Liebeskind (1996) criticizes traditional transaction cost theory for its weakness in explaining heterogeneous firm performance and extends the rationale offered by transaction cost economics to accommodate the notion of knowledge. The author contributes to the KBV by offering a new theory about how knowledge relates to the existence of firms. She argues that firms have institutional capabilities that allow them to protect knowledge from expropriation and imitation better than the legal protection mechanisms available in markets such as patents, copyrights, and trade secrets. Following an individualist perspective she suggests that since knowledge resides in individuals it is inherently mobile, which makes it easy to leak to competitors in case mobility cannot be avoided. She argues that firms can overcome this
mobility problem through their protection capabilities. These capabilities result from three types of advantages relative to markets for managing knowledge transactions. First, firms can align the incentives of the contracting parties and decrease opportunistic behavior because they unify the ownership of knowledge. Second, through employment contracts a firm increases its scope of control over knowledge workers’ actions. Third, a firm can protect its knowledge by reordering rewards over time such as by offering rendered rewards or deferring the timing at which an individual receives payments for her knowledge. She suggests that these protective capabilities give a firm competitive advantage (Liebeskind 1996). Yet, Liebeskind also suggests that it is costly for a firm to protect its knowledge. Protective capabilities lead to increase sunk costs, administrative costs, and costs of loss of communication. Therefore, firms should think carefully about what knowledge to protects and what mechanisms to use to protect valuable knowledge.

In another study Liebeskind and her colleagues (Liebeskind et al., 1996) focus on the biotechnology industry where patents play a crucial role and firms need to appropriate scientific knowledge that is not already protected by patent laws in order to gain competitive advantage. They argue that most of the new ideas in the biotechnology industry come from “star” scientists in universities. They identify three organizational options for sourcing scientific knowledge: internal sourcing through the use of hierarchy, external sourcing through market exchanges, and external sourcing through social networks. They argue that, in a knowledge intensive industry boundary-spanning social networks provide opportunities for sourcing external scientific knowledge. Providing evidence from a detailed analysis of the publication and patent records of two highly successful biotechnology firms they show that social networks promote organizational learning by extending the scope of firm knowledge and fostering organizational flexibility. Their findings state that external knowledge can be effectively integrated into the organizational routines through research collaboration between
individuals whereas very few of inter-organizational market arrangements provide external knowledge sourcing. Besides emphasizing the importance of boundary spanning social networks, the authors also point to the importance of hierarchical governance structures of the two companies which promoted “university like” organizational context and long term employment for organizational learning. Consequently, the core theoretical and empirical contributions of Liebeskind are related to three ontological levels: individual, organizational, and inter organizational levels. Her studies deal with individual level scientific collaborations as well as inter-organizational level market and quasi-market arrangements for sourcing scientific knowledge and organizational level protective capabilities for deterring knowledge imitation and organizational governance mechanisms for creating new scientific knowledge.

2.5. Johan Roos

In the beginning of the 1990s Johan Roos’s research started focusing on “knowledge”. He co-authored most of his articles and book chapters on “knowledge” with Georg von Krogh. He and his co-authors suggested knowledge as the basis for competitive advantage and provided three main contributions to KBV. First, they argued that the intellectual capital of a firm is the most important source for sustainable competitive advantage. They defined intellectual capital as both what is in the heads of employees (human capital) and what is left in the organization when people go home (structural capital) and argued that intellectual performance of a firm, that is the growth/decline of the intellectual capital, can be measured and is important for organizational success. They suggested a process model of intellectual capital and an IC-index to measure intellectual capital in a firm (Roos and Roos, 1998, Roos et al., 1997). Second, Roos and his colleagues developed a new theory of organizational knowledge, namely “corporate epistemology” (von Krogh et al., 1994). This theory was developed as a synthesis of the cognitive perspective and the autopoiesis theory and explained how and why organizations know. It suggested organizations as a stream of knowledge. In their theory the
authors emphasized the importance of the role of experiences for forming knowledge structures, organizational language for developing knowledge, and availability of relationships for enabling knowledge connections (von Krogh et al., 1994). Third, based on the concept of fitness landscapes (see Kauffman 1993 for more details) he introduced the concept of knowledge landscapes to organization theory and discussed its implications (Roos and Oliver, 1999). The authors defined knowledge landscapes as “a metaphor describing the ever-changing potential knowledge peaks and valleys that surround each one of us.” The authors suggested that the peaks of an individual’s, community’s, or organization’s landscape represent potential knowledge instead of “fitness” whereas the “valleys” can correspond to obsolete data. Therefore, landscapes are suggested to be unique and private to each actor.

Evidenced by the following quote Roos follows a collectivist approach in his theorizing:

“…since knowledge of the social system is shared knowledge, it is no longer entirely dependent on specific individuals ... Individuals may leave the group ... but the knowledge of the group does not ... vanish.” (von Krogh et al, 1994, p: 60)

Although he considers different ontological levels (individual, group, and organizational) in his studies (for example he indicates organizational landscapes might exist on different ontological levels (Roos and Oliver, 1999)) his main contributions e.g. intellectual capital in an organization, and corporate epistemology are mainly related to the organizational level.

2.6. Organizational knowledge creation theory

Organizational knowledge creation theory is recognized for a) having contributed a concept of tacit knowledge to organization science (Tsoukas, 2003), b) emphasizing the importance of socialization for knowledge creation (e.g., Kluge et al., 2001), and c) explaining the process of knowledge creation with the SECI model (Nonaka, 1994). Next the foundations of the theory and its contributions to the knowledge based theory of the firm will be summarized.
In this theory, knowledge is: a) justified true belief, meaning that individuals justify the truthfulness of their observations based on their observations of the world. Justification, therefore, hinges on unique viewpoints, personal sensibility, and experience (Nonaka, and Takeuchi, 1995). Knowledge is also: b) the capacity to define a situation and act accordingly (Stehr, 1992; Stehr 1994; von Krogh et al., 2000). Here, knowledge is oriented towards defining a situation so as to act on it, rather than the solving of depicted and manipulated pre-given problems (e.g., Newell and Simon 1972). Finally, knowledge is: c) explicit and tacit (Nonaka, 1991). According to this dual epistemology knowledge that can be uttered, formulated in sentences, captured in drawings and writing is explicit. Knowledge tied to the senses, movement skills, physical experiences, intuition, or implicit rules of thumb, is tacit (Polanyi, 1967). This definition transcends the Western epistemology with its strong focus on explicit knowledge to cover elements of perception, skills, experience, and history. It underscores that knowledge is never free from human values and ideas. Tacit knowledge is a comprehensive justification of beliefs that are embedded in the human body and mind leading to “gut-feelings” and intuitions (Varela et al., 1991). It is bound to people, deeply rooted in action, commitment, and involvement (Nonaka, 1994). Tacit knowledge, therefore, cannot be encoded or documented easily and sharing it necessitates the “here and now” interaction of people.

The theory categorizes knowledge into four ontological dimensions: individual, group, organizational, and inter organizational levels (Hedlund and Nonaka, 1993; Nonaka, 1994, Hedlund 1994). It assumes the origin of tacit knowledge as individual intuition and experience. The individual tacit knowledge is communicated and converted in the course of social interactions. The interactions between tacit and explicit knowledge becomes larger in scale as more actors become involved. Thus, organizational knowledge creation is suggested as an upward spiral process of interaction between tacit and explicit knowledge, starting at the
individual level moving up to the group, organizational, and even sometimes to the inter-organizational level (Nonaka, 1994). Thus, the theory follows a combined perspective of individualist and collectivist perspectives and assumes that knowledge is created at each ontological level with an expanding community of individuals. As will be explained in section 3, the second dissertation paper (Erden et al., 2008) points to a research gap related to the definition and features of knowledge in the group level.

The theory of organizational knowledge creation proposes that knowledge is created through processes of conversion between tacit and explicit knowledge (Nonaka, 1994). There are four modes of knowledge conversion, the so-called SECI process: socialization (from tacit knowledge to tacit knowledge), externalization (from tacit knowledge to explicit knowledge), combination (from explicit knowledge to explicit knowledge), and internalization (from explicit knowledge to tacit knowledge) (Nonaka et al., 2000). Socialization is defined as the process of converting new tacit knowledge through shared experience. Socialization occurs, for example, in a traditional apprenticeship where the apprentice learns through hands-on experience or in informal meetings outside the workplace where tacit knowledge such as intuitions, worldviews, mental models, and mutual trust can be created and shared (Nonaka et al. 2000). Externalization is the process of articulating tacit knowledge into explicit knowledge. Metaphors, analogies, and models are temporary aids applied by individuals to convey meaning to others. The use of them has an important effect on the outcome of conversion. It is often difficult, if not impossible, for individuals to state precisely what they know, or as Michael Polanyi (1967) puts it “We know more than we can tell.” Combination is the process of converting and combining explicit knowledge held by individuals into more complex and systematic sets of explicit knowledge. The reconfiguration and combination of existing information can be done through computer systems, meetings, or written documents.
Finally, through internalization, which is closely related to ‘learning by doing’, explicit knowledge is converted into tacit knowledge and becomes embodied in the individual.

Empirical and theoretical work has shown that knowledge creation cannot be separated from the context in which it is created. Knowledge creation and sharing is embedded in temporal contexts which include situations, conditions, and social circumstances (Reinmoeller, 2001). In the theory, “context” is often referred to as “Ba” (Nonaka et al., 2000; von Krogh et al., 2000; see also Nonaka et al., 2006, for a review) - a shared space for emerging relationships that can be physical, virtual, mental, or any combination of these (Nonaka and Konno, 1998). Social interaction plays a key role in Ba because tacit knowledge is created through the interactions amongst individuals or between individuals and their environments, rather than by an individual operating in isolation (Nonaka et al., 2000).

Yet, knowledge conversion is a fragile process due to the need for individuals to establish the quality relationships, trust, and care that enable them to socially justify their knowledge. In addition, knowledge sharing in organizations often breaks down due to under-contribution by the members. Reasons for this inefficiency are, for example, that some knowledge, e.g. tacit knowledge, is costly to externalize and share, or that members take limited interest in the outcome of sharing (Davenport and Prusak 1998, Nonaka et al. 2006). Ling et al. (2005) reported that under-contribution of knowledge by community members is a frequently observed problem. Von Krogh (1998) suggested that knowledge sharing hinges on strong caring among group members. An important issue for researchers is how members’ experience of communities shapes their intention to share knowledge. First dissertation paper (von Krogh et al., 2010) develops and tests a model of intention to share knowledge using survey data collected from a community in which members voluntarily exchange their experiences, ideas, and questions on photographic equipment via online platforms.
2.7. The theory of knowledge stocks and flows

A seminal advancement of the knowledge-based view of the firm was DeCarolis and Deeds (1999). This paper conceptualized organizational knowledge as stock and flows in the firm, and tested their relationship with firm performance. The authors used the metaphor of a “bathtub” to illustrate the difference between the stocks and flows of firm knowledge, likening the flow of knowledge to the amount of water that flows into or out of the tub, while the stock of knowledge is the amount of water stored in the bathtub at any point in time. Knowledge stocks - knowledge on record and in the minds of people - and their dynamics constitute the basis for knowledge creation and innovation. These accumulate through knowledge flows from individual and organizational learning. Knowledge flows may further be integrated and converted into knowledge stocks.

Their work made three important contributions to the literature. First, drawing on Diericx and Cool’s (1989) work on the role of asset accumulation for competitive advantage, they operationalized the core knowledge flow and stock constructs. Knowledge stocks were operationalized by products in the pipeline, patents, and firm citations whereas knowledge flows were operationalized by geographical membership, R&D intensity, and number of alliances (DeCarolis and Deeds, 1999). Second, DeCarolis and Deed’s work provided a nuanced view on location (geographical cluster) variables in the knowledge based view of the firm, and examined the impact of these variables on firm performance. Third, testing a comprehensive model, their findings demonstrate that a biotechnology firm's performance is predicted by location, the products available in the research pipeline, and citations to research performed by the firms' research team.

The work on knowledge stock and flow is seminal because it complemented the “static” understanding of organizational knowledge assets (stock) prevalent in the early theorizing, with a more dynamic view of knowledge as process (flow). This distinction is
particularly relevant when knowledge assets and their accumulation are valuable to the firm relative to other assets, such as physical or financial assets (Nonaka and von Krogh, 2009). Therefore, it is also evident that the knowledge stock and flow model was mainly adopted in research on high technology- and science-based firms (pharmaceutical, biotechnology, research and development organizations) as well as scientific publishing.

The model of knowledge stocks and flows (KSF) includes knowledge variables stemming from different ontological levels, namely organizational (e.g. patents) and inter-organizational (e.g. alliances) levels. Rather than outlining the isolated impact of single knowledge variables, e.g. alliances (flow) or scientific publications (stock), KSF assesses the relative impact of several knowledge-related firm characteristics on performance in one industry. Thus, KSF has also significant value for management since it provides concrete insights regarding a profile of investment in knowledge stocks and flows to succeed in a particular industry (e.g. focus on basic contract research versus developing new pharmaceutical products).

In addition to DeCarolis and Deeds (1999) there are a few more studies that empirically tested the impact of KSF on firm performance (Bontis et al., 2002, Kyriakopoulos and de Ruyter, 2004, Zucker et al., 2007). The model has also been adapted to measure knowledge stocks and flows of different industries (Park and Park, 2003). KSF was also used to assess scientific performance of academic journals where stock was conceptualized as the content and number of journal articles, and flow was conceptualized as the sources of ideas and researchers who publish in the journal (Biemans, et al. 2007).

However, the original model (DeCarolis and Deeds, 1999) was developed in the mid 1990's where the knowledge based view of the firm was still in its infancy. It was tested drawing on a sample of biotechnology firms compiled and published in Ernst & Young’s
biotechnology report by Burrill and Lee (1993). Thus, developments in the knowledge-based view of the firm call for a modification and extension of the stock and flow model. Moreover, the biotechnology industry has become increasingly diversified in terms of technology, products, and services, and an extended stock and flow model needs to be tested in these refined industry segments. The fourth dissertation paper (von Krogh et al., 2010) addresses these challenges.

2.8. Comparison of the contributions

In this section, the contributions of the scholars explained in the previous sections are summarized and compared according to their positioning in individualist/collectivist perspectives and according to their focus on ontological levels in their theory building. The comparisons are made by the author’s self-judgment based on the literature reviews in the previous sections. In order to compare the assumptions with regard to the locus of knowledge three different approaches are considered: individualist, collectivist, and combined. The ratings are done as follows. If a scholar or theory assumes individual or collective as the locus of knowledge it is rated as “Individualist” or “Collectivist”, and if it considers both as the locus of knowledge it is rated as “Combined”. The rating results and the proving quotes can be seen in Table 1.
### Table 1 The comparison of scholars/theories according to their position regarding the locus of knowledge.

<table>
<thead>
<tr>
<th>Scholar/Theory</th>
<th>Individualist</th>
<th>Collectivist</th>
<th>Combined</th>
<th>Exemplary Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kogut and Zander</td>
<td></td>
<td>+</td>
<td></td>
<td>“Because we know that hiring new workers is not equivalent to changing the skills of a firm, an analysis of what firms can do must understand knowledge as embedded in the organizing principles by which people cooperate within organizations.” (Kogut and Zander, 1992: p383)</td>
</tr>
<tr>
<td>Grant</td>
<td>+</td>
<td></td>
<td></td>
<td>“Grant emphasizes the role of the individual as the key knowledge locus.” (Felin and Hesterley, 2007: p197)</td>
</tr>
<tr>
<td>Spender</td>
<td></td>
<td>+</td>
<td></td>
<td>“The firm has an ability to know independently of its employees, or at least independently of their conscious reasoning” (Spender, 1996: p51).</td>
</tr>
<tr>
<td>Liebeskind</td>
<td>+</td>
<td></td>
<td></td>
<td>“Although ultimately all exchanges of knowledge take place between individuals (Grant 1996), individual-level exchanges can be supported by organization-level arrangements.” (Liebeskind et al., 1996: p433)</td>
</tr>
<tr>
<td>Roos</td>
<td>+</td>
<td></td>
<td></td>
<td>“…since knowledge of the social system is shared knowledge, it is no longer entirely dependent on specific individuals … Individuals may leave the group … but the knowledge of the group does not … vanish.” (Von Krogh et al, 1994, p: 60)</td>
</tr>
<tr>
<td>Organizational knowledge creation theory</td>
<td></td>
<td></td>
<td>+</td>
<td>“Here, it is important to mention that groups of people do not just learn individually from each other; they also engage in a creative process of enhancing collective knowledge, enabling the group to perform better through coordinated individual behavior. Collective (explicit and tacit) knowledge, in turn, also affects individuals, who increase their repertoire of action, problem formulation, and decision making.” (von Krogh, 2009; p:121)</td>
</tr>
<tr>
<td>The theory of knowledge stocks and flows</td>
<td></td>
<td>+</td>
<td></td>
<td>“Organizational knowledge is a firm specific asset which is not easily imitated and nontradeable (Barney, 1986). Nontradeable assets cannot be bought and sold in factor markets (Dierickx and Cool, 1989)” (DeCarolis and Deeds, 1999; p: 954)</td>
</tr>
</tbody>
</table>

The summary of the contributions of the scholars according to their focus on the ontological levels in their theory building can be seen in Table 2. The comparison regarding the ontological dimensions considers four levels: individual, group, organizational, and inter-organizational. The ratings of contributions are done as follows. If a scholar or theory is very much focused on an ontological level, comprehensively explaining the features and dynamics...
within that level the corresponding rating is three plusses. If an ontological level is mentioned but shallowly explained by a scholar/theory it is rated with two plusses and if it is mentioned but not explained it is rated with one plus. In the last column of the table the reasons for the ratings are indicated briefly by pointing to the main or important contributing concepts/constructs of each scholar/theory and the corresponding ontological levels and references.

<table>
<thead>
<tr>
<th>Scholar/Theory</th>
<th>Individual level</th>
<th>Group level</th>
<th>Organizational level</th>
<th>Inter-organizational level</th>
<th>Exemplary main concepts/constructs related to ontological levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kogut and Zander</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>Organizational level: Organizing principles of work, combinative capabilities (Kogut and Zander, 1992) Inter-organizational level: Transfer and Imitation of Organizational Capabilities (Kogut and Zander, 1995)</td>
</tr>
<tr>
<td>Grant</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>Individual level: Specialization in knowledge acquisition, recognition of individual knowledge domains (Grant, 1996) Organizational level: Mechanisms for integrating specialized knowledge (Grant, 1996)</td>
</tr>
<tr>
<td>Spender</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>Individual level: Conscious knowledge, automatic knowledge (Spender, 1996) Organizational level: Objectified knowledge, collective knowledge (Spender, 1996)</td>
</tr>
<tr>
<td>Liebeskind</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>Organizational level: Protection capabilities (Liebeskind 1996) Inter-organizational level: Boundary spanning social networks (Liebeskind et al., 1996)</td>
</tr>
</tbody>
</table>
Table 2 The comparison of scholars/theories according to the ontological levels they consider.

<table>
<thead>
<tr>
<th>Organizational knowledge creation theory</th>
<th>++</th>
<th>+++</th>
<th>+++</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual level: Individual tacit knowledge, externalization, learning by doing (Nonaka et al., 2000; Nonaka, 1994)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group level: Socialization (Nonaka, 1994)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizational level: Ba (Nonaka et al., 2000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The theory of knowledge stocks and flows</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Organizational level: Organizational knowledge stocks and flows (DeCarolis and Deeds, 1999)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-organizational level: Geographic munificence (DeCarolis and Deeds, 1999)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Research Framework

As stated in section 1, ontological dimensions and their interactions are crucial for organizational knowledge creation. This dissertation thesis seeks to fill in the research gaps related to different ontological levels in the knowledge based theory of the firm. Although new ideas are developed by individuals, social groups play an important role in justification of beliefs and expansion of knowledge. In a group new knowledge can be created only if the members are willing to socialize and share their knowledge with other group members. The first dissertation paper emphasizes the interaction between the group and individual levels. It investigates how perceived benefits and favorable conditions in a group (community) impact on individual intentions to share knowledge. Yet, even if individuals share their knowledge it is not definite that high quality knowledge can be created. How can we judge whether a group possesses high quality knowledge or not? Explicit knowledge is relatively easy to conceptualize and measure. For example specialists can review and control the written documents and accordingly judge its quality with respect to different criteria. On a broader level, firms can hire auditors e.g. financial auditors to check their explicit statements. However, what does the quality of group tacit knowledge refer to? Although organizational knowledge creation theory assumes that knowledge can be created on each ontological level,
it does not provide a satisfactory definition of the "quality of group tacit knowledge (QGTK)." The second dissertation paper develops a conceptual model that explains the levels in QGTK. Thus, it considers two ontological levels and sheds light on how individuals can form groups with high quality tacit knowledge. The groups, or with Nonaka’s (1994) terminology the "communities of interaction", constitute the fundamental structure of an organization. What matters at the end of the day is the overall performance of an organization. According to the knowledge based view of the firm, sustained performance of an organization is mainly predicted by its existing knowledge stocks and future knowledge flows. One of the knowledge flow channels for firms is the geographical clusters where the firms are located. The third paper is a methodology and review paper. It reviews the advantages and disadvantages of clusters and develops a method to identify the clusters in an industry. This method is further used in the fourth dissertation paper for identifying the clusters in the biopharmaceutical industry. The fourth dissertation paper investigates the impact of different knowledge stocks and flows of a firm on its performance. It considers both knowledge flows originating within the organization as well as from the outside world through inter-organizational interactions (e.g. cluster participation and alliances). Figure 1 shows the scope of the papers regarding the ontological levels. The dashed shapes indicate the main focus of the research question. The papers might also deal with other ontological levels which are not indicated by the depicted shapes in the figure. That is, this figure only considers the basic ontological levels under investigation. The position of the shapes indicates which level is touched upon in more detail compared to the other level in focus.
Figure 1 The positioning of the dissertation papers according to the ontological levels. (First paper: Exploration of Knowledge Sharing In An Online Community Of Volunteers: The Role Of Community Munificence, Second paper: The Quality of Group Tacit Knowledge, Third paper: Analyzing for Clusters in the biopharmaceutical industry: A review and method. Fourth paper: Filling the Tub at the Right Pace: How Stocks and Flows of Knowledge Impact on Firm Performance in the Biopharmaceutical Industry.)

The strength of these independent research papers lies in their focus on different ontological levels (individual, group, organizational, and inter-organizational), diverse selection of methods (panel data analysis, conceptual model building, cluster analysis, and structured equation modeling) and unique datasets (quantitative longitudinal data, online survey) providing a holistic view on knowledge creation in different ontological levels and their interactions. A summary of the salient futures of the dissertation papers can be seen in Table 3.
Next the research gaps and the contributions of each dissertation paper will be summarized.

3.1. An exploration of how communities can shape knowledge sharing intentions

3.1.1. Abstract

This study examines how individual and collective benefits, and context, provided in online communities, shape members’ intentions to share their knowledge. We build a model of
knowledge-sharing intention and test it using survey data collected from a community in which members voluntarily exchange their experiences, ideas, and questions on photographic equipment via online platforms. We find the benefits and favorable conditions provided by a community (community munificence)—which consists of collective knowledge, experienced interdependence, opportunity structures, and psychological safety— influence individuals’ motivation to contribute knowledge. We discuss managerial implications and outline suggestions for future theory building and empirical research.

3.1.2. Research gap

A community is a social entity where members come together based on a mutual obligation and/or for a shared purpose. Interactions between the members and knowledge sharing are preconditions for a community to achieve its purpose (Rothaermel and Sugiyama 2001, Wenger 1998, Wenger et al. 2002). The availability of new communication technologies has influenced the way people form social communities (Miller et al, 2009). Online communities, consisting of people who exchange ideas via online platforms facilitate the collective action of members needed to create knowledge through asynchronous, immediate, interactive, and low-cost communication (Wiertz and Ruyter 2007; Miller et al, 2009).

The term ‘online community’ may refer to a wide range of Internet forums including markets and auction sites, electronic bulletin boards, list servers, social networking sites, blog hosts or sites, gaming communities, and shared-interest Web sites (Miller et al, 2009). In online communities geographically dispersed people with different interests, holding different perspectives, and accessing different experiences often voluntarily help others they hardly know. Motivated by this interesting feature an increasing number of scholars have been investigating different types of online communities such as open source software (OSS) communities (O'Mahony and Ferraro 2007, Roberts et al. 2006), customer communities
(Wiertz and Ruyter 2007, Nambisan 2002), and user communities (Jeppesen and Frederiksen 2006).

Of paramount importance to communities, knowledge sharing often breaks down due to under-contribution by the community’s members. Reasons for this inefficiency are, for example, that some knowledge, e.g. tacit knowledge, is costly to externalize and share, or that members take limited interest in the outcome of sharing (Davenport and Prusak 1998, Nonaka et al. 2006). Online communities of volunteers, spanning organizational boundaries, represent a particular challenge to knowledge sharing; as a special form of organization, they often exist outside a formal hierarchy and control mechanisms, and members are frequently not exposed to formal incentives, such as performance-related pay or career opportunities (Ellis et al. 2004).

Although there is a growing stream of research on knowledge sharing in online communities (Wasko and Faraj 2005, Jeppesen and Frederiksen 2006, Hsu et al. 2007) the impact of online community on people’s intention to share knowledge is absent from this research. This paper seeks to fill this research gap by identifying the characteristics of an online community of volunteers that shape individual perceptions and impact on individual members’ experience and intention to share knowledge. Building on research and theory on knowledge sharing, and the theory of planned behavior from motivational psychology, the paper develops the construct of “community munificence,” which captures perceived benefits and favorable conditions in a community, and a full model of intention to share knowledge in a community.

3.1.3. Methodology

The model is tested on an online community in which members voluntarily exchange their experiences, ideas, and questions based on a common practice or interest in photography. To
test the model, a web-based survey was conducted. As all the constructs deal with individual perceptions and motives, the unit of analysis was chosen as the member. The data was analyzed using structural equation modeling (SEM). The results revealed that the perceived benefits and context in a community have a significant impact on members’ motivation to share their knowledge.

3.1.4. Contributions

The paper is a first attempt to explain how community munificence can shape intention to share knowledge and contributes to our understanding of the motivational aspects that give rise to knowledge-sharing behaviors in a social context. It helps to better understanding of what is needed to build and sustain successful online communities. It makes three contributions to the existing literature. First, by introducing the concept of “community munificence” and showing its high empirical relevance for predicting knowledge-sharing intention, the paper contributes to the existing body of research on knowledge sharing (e.g., Bock et al. 2005, Wiertz and Ruyter 2007, Nonaka 1994, Quigley et al. 2007, Yang and Chen 2007, Zarraga and Bonache 2005). Second, the study contributes to the emerging literature on online communities. This is the first study to provide a holistic explanation of why people’s perception of being a member of an online community shapes their intention to share knowledge. Finally, our study contributes to the literature on motivational psychology, by lending support to the theory of planned behavior (Ajzen 1991). The results demonstrate that people’s perception of what the community has to offer-community munificence- matters for the dimensions of planned behavior. It is important to examine the application of motivations across contexts in which individuals work, live, and play, as demonstrated in our study. Perceptions of these contexts and their impact on motivation represent interesting areas of research, with strong implications for organizational and management research and practice.
3.2. A need for defining group level tacit knowledge and its quality

3.2.1. Abstract

Organizational knowledge creation theory explains the process of making available and amplifying knowledge created by individuals as well as crystallizing and connecting it to an organization’s knowledge system. What individuals get to know in their (working) lives benefits their colleagues and, eventually, the wider organization. In this article, we briefly review central elements in organizational knowledge creation theory and show a research gap related to the quality of tacit knowledge in a group. We advance organizational knowledge creation theory by developing the concept of “quality of group tacit knowledge.” Based on this concept, we further develop a comprehensive model explaining different levels of tacit knowledge quality that a group can achieve. Finally, we discuss managerial implications resulting from our model and outline imperatives for future theory building and empirical research.

3.2.2. Research gap

Knowledge creation is often seen as the “front-end” of product development where tacit knowledge plays a great role in achieving innovation success. Yet, in most cases, knowledge creation is not the product of a single person but a collective work of a group of people or a team which draws the attention to “group tacit knowledge (GTK).” GTK is socially complex and difficult to imitate, and therefore constitutes a part of a firm’s intangible resources that give rise to competitive advantage. Spender (1996) argues that collective knowledge is the most reliable and strategically significant type of organizational knowledge. Given its centrality to organizational competitiveness understanding knowledge on group level and its features is of critical importance.
Although much theory and research exist on “individual tacit knowledge” (Gourlay, 2004; Nonaka et al., 2000; Nonaka, 1994; Polanyi, 1967; Tsoukas, 2003) and some scholars emphasize the quality of individual tacit knowledge (Doran, 2004; Koskinen, 2001; Nonaka, 1994; Noh et al., 2000; Nonaka and Toyama, 2007; Sanders, 2004), so far, academic work on organizational knowledge creation have rarely focused on GTK, nor has it systematically identified the “quality of group tacit knowledge (QGTK)” and how one can distinguish between groups with different quality levels in their collective tacit knowledge. This paper argues that GTK has a meaning in itself and that it also is associated with various levels of quality. The goal of this paper is to fill a gap in the organizational knowledge creation theory and identify what “group tacit knowledge” and its “quality” mean.

3.2.3. Contributions

This conceptual paper advances organizational knowledge creation theory by developing the concept of “quality of group tacit knowledge” and a model for identifying its levels. It defines group tacit knowledge (GTK) as capacity of a group to coordinate and act as a collective body in the absence of explicit rules or directions and identifies four different quality levels associated with GTK: group as assemblages, collective action, phronesis, and collective improvisation. The SECI model from organizational knowledge creation theory (Nonaka, 1994), Aristotle’s concept of “phronesis” (Aristotle, 1999; Nonaka and Toyama, 2007), theories of organizational improvisation (Crossan, 1998; Moorman and Miner, 1998; Vera and Crossan, 2005), and organizational aesthetics (Baumgarten, 1950; Strati, 2003, 1996, 1992) were used as the basis for the model development.

The paper provides implications for practice as well. When managers bring people together for a project, the challenge for everyone is how to use the potential and to leverage it to be more than just the sum of what the individual members know. Group tacit knowledge
with high quality is a resource that organizations can rely on when confronted with unexpected and unfamiliar situations which require intuition and spontaneous collective action. The model developed in the paper enables researchers and managers to understand the role of different quality levels in group outcomes. Managers concerned about knowledge creation, innovation, and creativity in organizations should pay close attention to the factors that provide a group with high quality tacit knowledge. Regarding the QGTK, the responsibility of the leadership is to mobilize tacit knowledge that is unevenly distributed and create the context necessary for collective action, while finding ways to enhance the quality of tacit knowledge on all levels (Nonaka and Toyama, 2007).

3.3. Development of a new methodology for identifying clusters

3.3.1. Abstract

Clusters are groups of co-located and interconnected firms and institutions linked by commonalities and complementarities. There are several reasons for the geographical concentration in the biopharmaceutical industry. This paper unpacks some advantages and disadvantages of cluster participation, and proposes a simple new method for managers to identify clusters in the biopharmaceutical industry.

3.3.2. Research Gap

The importance of agglomeration has been noted by many scholars in many disciplines including economic geography, management, and organization science (e.g. Krugman, 1991; DeCarolis and Deeds, 1999; Gittelman, 2007). Although some empirical studies of clusters in the biotechnology industry are available, to our knowledge there is no study on clusters in the biopharmaceutical industry (a sub-field of the biotechnology industry). Previous literature defined the cluster boundaries with different proxies, such as states, districts, provinces,
MSAs, and specific regions in countries such as UK Central Statistical office regions (Prevezer, 1997; Wennberg and Lindqvist, 2010; Baptista and Swann, 1999; Globerman et al., 2005). Such pre-defined cluster boundaries provide static boundaries with certain other limitations. For example, previous studies mainly used metropolitan statistical areas (MSA) to identify cluster boundaries (Folta et al., 2006; Decarolis and Deeds, 1999; Zucker et al., 1998; Audretsch and Stephan, 1996). This approach is problematic because clusters defined according to MSA do not necessarily provide accurate information on the clusters in a specific industry. A cluster might consist of more than one MSA, or one MSA might be too large to capture knowledge spillovers due to clustering. Moreover, pre-defined boundaries, such as MSAs, cannot be used globally as there is no worldwide unit of area that can account for comparable clusters.

3.3.3. Contributions

Taking into account the limitations of the previous methods discussed, the paper introduces a new method to identify the clusters in the biopharmaceutical industry. The method finds a configuration in which the distance between the firms in a cluster is minimized while the distance between the clusters is maximized. The proposed method has two advantages; first, it is flexible and can be used to determine clusters on different levels (e.g., state, country, or worldwide). Second, as it is not limited to static boundaries such as MSAs it can be used to observe the evolution of clusters over time.

Managers should keep in mind that the ability of the firm to benefit from knowledge spillovers might be contingent on certain factors, such as the technological proximity of firms in the cluster (Autant-Bernard, 2001); industry structure (e.g., bargaining power of suppliers, or monopolistic competition versus pure monopoly); the culture in the cluster; the diversity of firm strategy, etc. (see for example Audretsch, 1998). In addition, innovation is contingent on
different interrelated factors, such as demand conditions, related and supporting industries, and firm structure and strategy (Porter, 1998). Therefore, when choosing locations for their firms, managers should first investigate cluster boundaries, cluster characteristics, and afterwards find the most appropriate cluster for their goals, expectations, and capabilities.

3.4. The impact of knowledge stocks and flows on firm performance

3.4.1. Abstract

The model of knowledge stocks and -flows (KSF) is a key advancement of the knowledge-based theory of the firm. The model hypothesizes a relative impact of stocks and flows of a firm's knowledge on the firm's performance (DeCarolis and Deeds, 1999, Dierickx and Cool, 1989). Until now, empirical examination of KSF has been strictly limited to a cross-sectional study of a small sample of biotechnology firms based in the United States, demonstrating linear relationships between some stocks and flow variables and firm performance. Thus, little is know about the non-linear and dynamic impact of knowledge stocks and flows on firm performance. Based on recent research on the knowledge-based view of the firm, we extend KSF towards a non-linear knowledge-based model. Using new extensive panel data and new refined measures, we test this model on a global sample of biopharmaceutical firms (2003–2007). We demonstrate the relative impact of knowledge stocks and flows on firm performance over time. We find that firms’ performance does not depend solely on their existing knowledge but also on their search for new knowledge opportunities, through in-house creation or from the outside.

3.4.2. Research Gap

An important contribution to the knowledge-based view was the knowledge stocks and -flows model (KSF) (DeCarolis and Deeds, 1999, Dierickx and Cool, 1989) as explained in section
2.7. To this date, the empirical examination of KSF has been limited. There are few studies that empirically tested the impact of KSF on firm performance (Bontis et al., 2002, DeCarolis and Deeds, 1999, Kyriakopoulos and de Ruyter, 2004, Zucker et al., 2007). Previous research used a cross-sectional research design to test the impact of KSF on firm performance. Since stocks and flows of firm knowledge are dynamic and will change across firms and time, the cross-sectional research design found in prior work is limited in terms of making statistically valid inferences (Bierly and Chakrabarti, 1996, Bowen and Wiersema, 1999, Hill and Hansen, 1991). Thus, little is known about the longitudinal impact of knowledge stocks and flows on firm performance. In addition, the stock and flow variables suggested by the previous research (DeCarolis and Deeds, 1999) should be reconsidered. For example, to measure knowledge flows stemming from a firm’s geographical location previous research used a single score composed of different measures such as the number of high technology employees, and the number of medical schools per MSA (DeCarolis and Deeds, 1999). However, this approach neglects the individual impact of each measure of the compound variable, leading to a coarse-grained view of the mechanism between knowledge flows and firm performance. Moreover, Previous literature used Metropolitan Statistical Areas (MSA) to identify cluster boundaries (DeCarolis and Deeds, 1999, Folta, et al., 2006). Clusters defined according to MSA do not necessarily provide accurate information on the clusters in a specific industry, so this approach is conceptually problematic; a cluster might consist of more than one MSA, or one MSA might be too large to capture knowledge spillovers due to clustering (Wallsten, 2001). In terms of the interaction mechanism, previous research assumed a positive linear relationship between flows of knowledge and firm performance (DeCarolis and Deeds, 1999). Although redundancy of knowledge is often thought to benefit creativity (Nonaka, 1994), too much knowledge incurs excessive integration and coordination costs (Tiwana, 2008). Recent work specifically questions the assumed linear relationship
between knowledge flow variables and firm performance (Folta et al., 2006, Rothaermel and Deeds, 2006). This paper attempts to resolve this issue by extending KSF by proposing a non-linear (inverted U-shaped) impact of flows of knowledge on firm performance.

3.4.3. Methodology

The model was tested with a sample of public biopharmaceutical firms. The Bloomberg® database was used to develop a list of all public biopharmaceutical companies worldwide and the resulting list of firms was coded according to the definition of a biopharmaceutical firm based on Rader (2008). The final sample included 167 firms, representing 13.3% of the initial population. The stock and flow model was tested using a longitudinal panel research design over five years (2003-7).

3.4.4. Contributions

Drawing upon work on knowledge stocks and flows by Dierickx and Cool (1989) and DeCarolis and Deeds (1999) the forth dissertation paper develops a dynamic model of knowledge stocks and flows. Based on recent research on the knowledge-based view of the firm, the paper extends KSF towards a dynamic knowledge-based model portraying non-linear mechanisms. Using new extensive panel data and new refined measures, the paper tests this dynamic model on a global sample of biopharmaceutical firms (2003-2007). More specifically, this study contributes to the work on KSF in three ways. First, it advances the measurement of how stocks and flows of firm knowledge impact on firm performance by advancing the variables suggested by the previous research are advanced (DeCarolis and Deeds, 1999) and introducing new variables. For example, to measure knowledge flows stemming from a firm’s geographical location new measures that capture the density of participants in a cluster as well as the specialization of clusters around a certain industry group (biopharmaceuticals) were developed. In order to identify the clusters in the
biopharmaceutical industry the method suggested by the third dissertation paper was used (see section 3.3). Second, the paper introduces a new interaction mechanism between the firm performance and stocks and flows of firm knowledge. Previous research assumed a positive linear relationship between flows of knowledge and firm performance (DeCarolis and Deeds, 1999). This paper extends KSF by proposing a non-linear (inverted U-shaped) impact of flows of knowledge on firm performance. Third, the paper provides a dynamic model of knowledge stocks and flows using panel data statistics.

In conclusion, the results of the full model show that of all the flow variables, only R&D intensity has an inverted U-shaped impact on firm performance. However, all other flow variables except cluster specialization and personnel growth show a significant impact. In addition, all stock variables show a significant impact on firm performance. The results show that firms’ performance does not depend solely on their existing knowledge but also on their search for new knowledge opportunities, through in-house creation or from the outside.

4. Conclusion and Implications

Starting from the assumptions about the locus of knowledge and the ontological levels in knowledge creation this dissertation has reviewed the basic contributions to the knowledge based view of the firm, identified the research gaps related to different ontological levels in the theory, and introduced the contributions of four dissertation papers. Arguing for a combined view of individualist and collectivist approaches the dissertation highlights that each ontological level has specific dynamics and interactions within and between the ontological levels matter for how organizations share, create, apply, and transform knowledge. Each of four dissertation papers deals with interaction between knowledge related aspects on different ontological levels and provides explanations and evidence about this interaction and their impact on overall knowledge outcomes.
Individual as origin of all knowledge is supposed to contribute to the collective knowledge of the organization (Spender, 1996; Erden et al., 2008; Grant, 1996; Nonaka, 1994). Studies from various fields such as organizational learning (e.g. March, 1991), managerial cognition and skills (e.g. Kaplan et al., 2003), science and technology (e.g. Zucker et al., 2002), organizational knowledge creation (Nonaka, 1994), and entrepreneurship (Kakati, 2003) emphasize the importance of individuals for organizational performance. Since tacit knowledge tends to be highly personal (Polyani, 1962) idiosyncratic knowledge and capabilities of individuals make crucial difference for the collective outcome. For example, Zucker and Darby (1998) showed that star scientists play central roles in the creation of new knowledge and its successful commercialization in the biotechnology firms. Supporting this line of argumentation, the second dissertation paper indicates that group outcomes depend on individual knowledge and characteristics. It suggests that group level tacit knowledge exists and individual credibility is decisive in achieving a high quality group tacit knowledge. Yet, in most cases new knowledge is socially constructed through the interactions amongst individuals from different specialization areas. Thus, teams, groups, and communities are the main sources of new ideas and innovation in organizations (Nonaka et al., 2000). Social interactions in groups enable transfer of individual tacit knowledge to other members and give rise to a synergy between individuals with different backgrounds. As the theory of symbolic interactionism argues, humans are socially constructed and have the mental capacity to learn and modify the meanings of symbols and signs during the action and interaction with other people (Blumer, 1969). Thus, the social interactions and context in a group influence the construction of individuals’ reality and meaning. The first dissertation paper suggests that there is great value in focusing on group level characteristics such as the benefits and context provided in a community in order to understand individual knowledge sharing behavior. The empirical results suggest that what community provides impact on members’ knowledge
sharing motivations. Hence the first and second dissertation papers together point to a two-way interaction between the individual and group level factors related to knowledge creation.

Eventually, individuals and their interactions within and across groups constitute a crucial part of what organizations know. That is, human capital within an organization is an important source of its knowledge. Another source of organizational knowledge is the connections to other organizations. Previous literature on alliances (Rothaermel and Deeds, 2006), strategic groups (Erden et al., 2009), open innovation (Chesbrough, 2003), and geographical agglomeration (Gittelman, 2007) emphasized the importance of boundary spanning interactions for firm performance. Focusing on the geographic clusters, the third paper shows that there are both advantages and disadvantages of geographical agglomeration and suggests a method for identifying clusters in an industry. Due to the stickiness of tacit knowledge firms can only access this type of knowledge residing outside firm boundaries through close interrelations. Geographical clusters enable firms to access to knowledge that spillovers from the co-located organizations. Using the method suggested by the third dissertation paper the fourth dissertation paper identifies the worldwide clusters in the biopharmaceutical industry and suggests that membership to a cluster provides inflow of knowledge for a firm. The paper provides empirical evidence from the biopharmaceutical industry for the impact of stocks and flows of knowledge on firm performance. Hence, dealing with organizational and inter-organizational levels, the third and fourth papers highlight the importance of knowledge stocks within the organizations and sources of knowledge stemming from inter-organizational connections for organizational performance.

4.1. Impact on theory and practice

On a theoretical level this dissertation contributes to the knowledge based view of the firm. It emphasizes the importance of different ontological levels and their interactions for knowledge
creation and firm performance. Hence, it fills some gaps in the theory related to different ontological levels. First, building on work on knowledge sharing, online communities, and motivational psychology this dissertation thesis identifies how voluntary members’ perception of an online community motivates them to share their knowledge. It contributes to the existing body of research on knowledge sharing (e.g., Bock et al. 2005, Wiertz and Ruyter 2007, Nonaka 1994, Quigley et al. 2007, Yang and Chen 2007, Zarraga and Bonache 2005) by developing the concept of “community munificence”, which explains exclusive benefits and favorable conditions as perceived by members of a community, and showing its high empirical relevance for predicting knowledge-sharing intentions. It also contributes to the emerging literature on online communities by providing the first study with a holistic explanation of why people’s perception of being a member of an online community shapes their intention to share knowledge. These findings have implications for community members, as well as for the firms that host or sponsor online communities. There is a great value in paying close attention to the mechanisms that motivate members to contribute. First of all, community members should be provided with various opportunities and context to interact. Mailing lists, collaboration platforms such as wikis, bulletin boards, forums, chat rooms, or other types of social software constitute the proper media for this purpose. An important factor that managers of sponsor organizations or leaders of communities should consider is the rewards provided to contributors, which can take the form of reputation, status, or learning opportunities (e.g. Hertel et al 2004). It is important for managers and leaders to understand which type and composition of rewards fit better for communities given specific goals and type of contributors. Although one might expect little peer pressure in online communities, this thesis shows that subjective norms have a relatively strong influence on intentions to share knowledge. Therefore, communities should try to develop a “netiquette” that emphasizes collective outcomes and lets members experience interdependency within the
community. An emotionally safe context where members can trust each other and leadership support might be imperative for achieving community objectives.

Second, this dissertation contributes to organizational knowledge creation theory (Nonaka, 1994; Nonaka and Takeuchi, 1995; Nonaka et al., 2006; von Krogh et al., 2000) by filling a gap related to the group tacit knowledge. It defines group tacit knowledge and proposes a model that explains different levels of QGTK. Suggested levels have implications for the managers. Group tacit knowledge with high quality is a resource that organizations can rely on when confronted with unexpected and unfamiliar situations. Managers concerned about knowledge creation, innovation, and creativity in organizations should pay close attention to the factors that provide a group with high quality tacit knowledge. When managers bring people together for a project, they should mobilize tacit knowledge and create favorable context for collective action. The model of QGTK enables researchers and managers to understand the role of different quality levels. Accordingly managers can identify the level that fits better to certain task requirements. They can provide organizational members with workshops, exercises, and games that can help to develop skills for better group coordination (Vera and Crossan, 2004). Information technologies (IT) may also help developing high QGTK by facilitating knowledge sharing. Although IT can never substitute face-to-face interaction where people can share their tacit as well as their explicit knowledge (Fahey and Prusak, 1998) it can serve as a kind of group memory for knowledge, through which people can access past experiences, in particular overt clues, documented experiences, written reflections.

Third, the dissertation also contributes the theory of knowledge stocks and flows by showing that performance of firms over time depends on the stocks and flows of firm knowledge, which constitute the basis for knowledge creation and innovation. It develops and tests a new model that predicts that flow variables have an inverted U-shaped impact on firm
performance. It advances the knowledge stocks and flows model by introducing new and more accurate measurement variables and by testing their impact on firm performance. Prior work used data from the biotechnology industry to test the stocks and flows model, which dates back to mid-1990s (Burrill and Lee, 1993, DeCarolis and Deeds, 1999). Due to recent developments in the biotechnology industry the dissertation focuses on a sub-group of the biotechnology companies and uses a purer sample of biopharmaceutical firms. The results will help scholars and managers to understand the comparative role of stocks and flows of firm knowledge in the biopharmaceutical industry segment, and ways to exploit them optimally for superior firm performance.

The dissertation also provides methodological contributions for research on geographical clusters. It proposes a simple new method for managers to identify clusters in the biopharmaceutical industry. Managers should keep in mind that the ability of the firm to benefit from knowledge spillovers might be contingent on certain factors, such as the heterogeneity of the firms in the cluster, industry structure (e.g., bargaining power of suppliers, or monopolistic competition versus pure monopoly), and the culture in the cluster. In addition, innovation is contingent on different interrelated factors, such as demand conditions, related and supporting industries, and firm structure and strategy (Porter, 1998). Therefore, when choosing locations for their firms, managers should first investigate cluster boundaries and the specifications of cluster members.

In sum, managers and researchers should understand the nature of knowledge residing on different ontological levels and their interactions. While developing strategies managers should pay attention to integrating knowledge from different levels. Such a strategy should first consider the individuals since they constitute the fundamental parts of an organization. Managers should hire individuals who already possess or have the potential to build up necessary knowledge, skills, and capabilities compatible with the organizational goals. A
challenge for managers is to leverage knowledge of individuals to enable synergy between different specialization fields and groups. There might be different options for overcoming this challenge. Managers can act as knowledge activists who catalyze knowledge activities, connect and coordinate knowledge creation initiatives, and provide overall direction to knowledge exchange and creation (von Krogh et al., 1997). For example, managers might introduce various IT solutions such as online platforms for connecting individuals and groups to foster knowledge sharing. In addition, managers can introduce and make use of boundary objects that help to represent and transform knowledge between individuals, groups, and organizations. Boundary objects are the artifacts that a person or group works with (Carlile, 2002). They help to overcome the problems that deter knowledge exchange at a given boundary. These objects can be physical such as prototypes or electronic such as e-mail and can carry both explicit and tacit knowledge. For example whereas a blueprint could carry explicit knowledge a product could carry tacit knowledge embedded in its design. The responsibility of the managers is to motivate organizational members to use boundary objects and to help them to choose the most appropriate object.

With regard to inter-organizational relations, managers should find appropriate number and type of partners for their organizations. Literature on alliances showed that number of alliances of a firm has an inverted U shape with new product development (Rothearmel and Deeds, 2006). Managers should be careful about when, with whom, and to what extend to form alliances. Especially they should pay attention to the qualifications and compatibility of partners with the firm’s long-term strategies and capabilities. For example, previous research showed that trust and cultural alignment between the partners (Powell et al., 1996; Inkpen, 1998) as well as shared experiences (Gulati, 1995) might have significant effect on alliance performance.
4.2. Future research agenda

So far this dissertation filled some of the research gaps in the knowledge based theory of the firm. By analyzing knowledge creation and sharing on different ontological levels and investigating their interactions with a main focus on individual-group and organizational-inter-organizational interactions, this dissertation hopes to help firms to develop successful knowledge strategies.

Future research should further investigate the interactions within and between the ontological levels such as individual-organization, individual-inter organization, group-organization, and group-inter organization interactions. As Felin and Hesterley (2007) also suggested, a comparative study of different ontological levels would be needed to see their relative impact on firm performance. Future research should study this topic in different knowledge- and science-based industries to assess its overall validity in different contexts.

An interesting research question is related to the interaction effects between stocks and flows of organizational knowledge. What should be the speed of knowledge flow so that the firm can integrate it effectively to its knowledge stocks? Clusters as a source of knowledge flows are also a field where further research is needed. Future research should investigate the compatibility of knowledge structures between the firm and the cluster. To what extend should the knowledge structures be overlapping for a firm to exploit knowledge spillovers in a cluster?

In addition, future research should identify the factors that lead to high quality group tacit knowledge. What should be the composition of the group concerning diversity of individual knowledge, size, characteristics etc.? What type of leadership is needed for achieving a higher quality of group tacit knowledge? What level of group tacit knowledge quality fits better to different tasks (e.g. for creative, innovative, repetitive task)? Regarding
knowledge sharing in groups this dissertation tested the model on knowledge sharing intentions among the members of an online community in Korea. National cultures might impact on the preferences of individuals. Future research should test the model in different online and offline communities across different geographies and cultures with larger samples, to confirm the generalizability of the findings.

There is also great value in focusing on leaders’ role related to knowledge creation in organizations. The impact of a leader mainly relies on the power to motivate members to contribute (Fleming and Waguespack 2007). Future research should investigate how community leaders can foster favorable conditions and benefits provided to the members to motivate knowledge sharing.
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EXPLORATION OF KNOWLEDGE SHARING IN AN ONLINE COMMUNITY OF VOLUNTEERS: THE ROLE OF COMMUNITY MUNIFICENCE

Publication under review,
please do not circulate or quote without the explicit consent of the authors

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Abstract
This study examines how individual and collective benefits, and context, provided in online communities, shape members’ intentions to share their knowledge. We build a model of knowledge-sharing intention and test it using survey data collected from a community in which members voluntarily exchange their experiences, ideas, and questions on photographic equipment via online platforms. We find the benefits and favorable conditions provided by a community (community munificence)-which consists of collective knowledge, experienced interdependence, opportunity structures, and psychological safety-influence individuals’ motivation to contribute knowledge. We discuss managerial implications and outline suggestions for future theory building and empirical research.

INTRODUCTION

Many online community organizations are based on a common practice or interest in which members
participate and contribute voluntarily through online platforms (Ren et al. 2007). Examples include communities of members sharing a hobby, conducting trade, participating in sports, developing software, or discussing health-related issues. The existence and success of these communities depend on willingness of members to engage in sharing their individual knowledge. For example, a recent survey showed that many companies initiate and invest heavily in online communities because they want to access members’ ideas and improve product development (Deloitte 2008). Yet, the same survey also noted that many such communities fail to enlist members. In another study, Ling et al. (2005) reported that under-contribution of knowledge by community members is a frequently observed problem. Under-contribution often stems from members’ negative or unproductive experiences of community participation. An important issue for researchers is how members’ experience of online communities shapes their intention to share knowledge.

Prior research has identified factors that impact on an individual’s intention to share knowledge. For example, Bock, Zmud, Kim, and Lee (2005) showed that such intention is affected by anticipated extrinsic rewards, reciprocal relationships, an individual’s sense of self-worth, and a favorable organizational climate. Most of the research on knowledge sharing intentions has been conducted within organizational boundaries, leaving a research gap on knowledge sharing intentions in online communities. Yet online communities of volunteers, spanning organizational boundaries, represent a particular challenge to knowledge sharing; as a particular form of organization, they often exist outside a formal hierarchy and control mechanisms, and members are frequently not exposed to formal incentives, such as performance-related pay or career opportunities (Ellis et al. 2004). This paper seeks to fill this research gap by identifying the characteristics of an online community of volunteers that impact on individual members’ experience and intention to share knowledge. Building on research and theory on knowledge sharing, and the theory of planned behavior from motivational psychology, we develop the construct of “community munificence,” which captures relevant community characteristics, and a full model of intention to share knowledge in an online community. We test the model on an online community in which members voluntarily exchange their experiences, ideas, and questions based on a common practice or interest in photography. We find that the benefits
and context a community provides to its members have a significant impact on members’ motivation to share their knowledge. Our work helps to better understanding of what is needed to build and sustain successful online communities.

In the next section, we briefly review the relevant literature and go on to build a model of knowledge sharing intentions. In the third section, we present our research design, sample, and results. Finally, we discuss implications for theory and practice.

LITERATURE REVIEW

In the following section we review relevant literature on knowledge sharing, online communities, and the theory of planned behavior, and develop a model of intention to share knowledge in online communities of volunteers that account for community characteristics.

Knowledge Sharing Intentions in Communities

A community is a social entity where members come together based on a mutual obligation and/or for a shared purpose, and where knowledge sharing is a precondition to achieve this purpose (Rothaermel and Sugiyama 2001, Wenger 1998, Wenger et al. 2002). Communities are non-canonical, emergent, and often not restricted by a formal organization (Brown and Duguid 2001). Several authors argue that membership in a social community leads individuals to share more knowledge than they would if they were not members of a community (Wenger 1998, Brown and Duguid 1991). Because community members may become part of a social practice through joint problem solving, they often share explicit as well as tacit knowledge (Brown and Duguid 2001, see also Grant 1996). Communities create social bonds between their members that motivate them to behave according to emerging social norms, shared values, or rules. Bagozzi and Dholakia (2006) define fundamental characteristics of a community as consciousness of kind (us versus them), shared rituals and traditions, and a sense of duty or obligation toward the members.
Of paramount importance to communities, knowledge sharing often breaks down due to under-contribution by the community’s members. Reasons for this inefficiency are, for example, that some knowledge, e.g. tacit knowledge, is costly to externalize and share, or that members take limited interest in the outcome of sharing (Davenport and Prusak 1998, Nonaka et al. 2006). A number of scholars have proposed that, to share their knowledge, members need to establish social relations characterized by experienced opportunities to share knowledge, trust, and care (e.g. Nahapiet and Ghoshal 1998, Hansen 1999, Alavi and Leidner 2001, von Krogh 1998 2002). Communities provide these social relations and allow their members to access other members’ knowledge through practices (Brown and Duguid 1991, Wenger 1998) or online communication (Wasko and Faraj 2005).

Prior work on knowledge sharing has focused on factors explaining the patterns of behavior it entails. According to Yang and Chen (2007), these factors can be categorized along three dimensions: “individual characteristics,” “knowledge characteristics,” and “organizational characteristics. Individual characteristics include motivation (Bock et al. 2005), commitment (Wiertz and Ruyter 2007), and self-efficacy (Quigley et al. 2007). Knowledge characteristics pertain to the tacit-explicit continuum (Nonaka 1994). Lastly, organizational characteristics include organizational culture and policies (Quigley et al. 2007, Yang and Chen 2007), community design (Ren et al. 2007), reward systems linked to knowledge sharing (Zarraga and Bonache 2005, Bock et al. 2005), context (Ba) (Nonaka et al. 2006, Nonaka and Konno 1998), and leadership styles (Nonaka et al. 2000, 2007).

The literature on online communities is recent but fast emerging. Online communities facilitate the collective action of members needed to create knowledge (Wiertz and Ruyter 2007). Research has investigated intra-organizational online communities (Ardichvili et al. 2003), but recently extensive research has also been devoted to online communities of volunteer members. Geographically dispersed people with different interests, holding different perspectives, and accessing different experiences often voluntarily help others they hardly know. Motivated by this interesting feature an increasing number of scholars have been investigating different types of online communities such as open source software (OSS) communities (O’Mahony and Ferraro 2007, Roberts
et al. 2006), customer communities (Wiertz and Ruyter 2007, Nambisan 2002), and user communities (Jeppesen and Frederiksen 2006).

Previous research on online communities identified three main motivations for volunteer members. First, anticipated benefits and rewards, such as approval, status, respect, reputation, and self-enjoyment motivate members to contribute to online communities (Wasko and Faraj 2005, Jeppesen and Frederiksen 2006, Hsu et al. 2007). For example, Wasko and Faraj (2005) conducted a study on an electronic network of practice sponsored by a professional association and found that expectations of personal benefits, for example, enhanced reputation, are a strong motivator for intended knowledge sharing. Ross (2007) made a qualitative discourse analysis of message board transcripts and interviewed the members of an online community of taxi drivers to explain the benefits that accrue to online learning communities. His findings suggest that the online community provides a back-region for the taxi drivers where they can compare themselves, learn from each other, and cultivate friendships. Second, members contribute to online communities out of moral obligation resulting from generalized reciprocity and altruistic behavior (Wasko and Faraj 2000). For example, Peddibhotla and Subramani (2007) reviewed the top 1000 most prolific contributions of reviewers on Amazon.com. Consistent with the first two motivations we mentioned, their study found two different motives for reviewers to contribute: self-oriented motives, which consist of personal development, utilitarian motives, and personal enjoyment; and other-oriented motives, which consist of social affiliation, altruism, and reciprocity. Third, individuals are more motivated to participate in online communities that have an appropriate medium for knowledge sharing in which a high level of trust, sense of obligation, identification, and social control are promoted (Wasko et al. 2004, Hsu et al. 2007). According to McWilliam (2000), successful online communities provide a medium for the pursuit of common interests; a sense of place with shared rules, values, and codes of behavior; promote dialogues and relationships; and encourage active participation. Moreover, Ross (2007) argues that the pseudonyms used in online communities offer a safe context with almost zero risk of damage to members’ reputations in their “real” life.
Prior work faced two important challenges. The first was that the majority of research focused on knowledge that was actually shared, possibly confounding causes and effects. For example, previous work could not capture whether people intended to share their knowledge, whether sharing happened by coincidence (unwanted spillover), or was post-rationalized by respondents. For example, Hsu et al. (2007) studied antecedents of knowledge-sharing behavior in virtual communities and found that whereas self-efficacy, personal outcome expectations, and identification-based trust impact significantly on knowledge-sharing behavior, community-related outcome expectations have no significant impact. In this study, knowledge-sharing behavior was captured using a web-based survey with items such as “I frequently participate in knowledge sharing activities in this online community.” While these items are intended to capture actual knowledge-sharing behavior, they do not distinguish whether respondents were really willing to share or post-rationalized their behavior. Second, while it is argued that community is an appropriate context for studying knowledge-sharing for reasons of efficiency (Wenger 1998), the impact of online community on people’s intention to share knowledge has not been studied. And to date little is known about why and how community might enhance people’s intention to share. To fill this research gap, we study the effect of people’s experience of an online community on their knowledge-sharing intentions. Online communities of volunteers outside formal organizations are an ideal setting for observing “intentions to share knowledge,” because in this context knowledge-sharing depends solely on members’ voluntary commitment and intention (Hsu et al. 2007).

Community Munificence

To analyze underlying community-related mechanisms that shape members’ intentions to share their knowledge in an online community of volunteers, we developed a new construct of “community munificence.” This construct refers to a community characteristic where the community’s members perceive it as “bestowing gifts” on them. Within a community, varied goods and conditions might be provided. The way members perceive these—whether or not they find them beneficial and useful—is a significant factor of their motivation to contribute to the community. Through community munificence, people enjoy a number of benefits that make them want to become a community.
member, continue their membership, and contribute what is necessary to do so. Community munificence is a set of exclusive benefits and favorable conditions perceived by its members.

Four main components constitute the construct: “psychological safety” (Edmondson 1999), “opportunity structures” (von Krogh, 2002), “collective knowledge” (Nonaka 1994, Spender 1996), and “experienced interdependence” (Hertel et al. 2004, Ren et al. 2007). These components are necessary but not sufficient for identifying all the benefits and favorable conditions perceived by members in a community. However, they capture the main and most critical aspects without which a loose affiliation of people cannot become a “community” (Sartre 1978). Psychological safety (PS) is the shared belief that the community is “safe for interpersonal risk taking” (Edmondson 1999). It captures favorable conditions perceived by community members such as trust, care, and sense of belonging, and shared sense of identity (Chiu et al. 2006). Psychologically safe settings enable confidence that individuals will not be embarrassed, rejected, or punished for sharing their knowledge, nor exploited by others’ opportunistic behavior (Edmondson 1999). Opportunity structures (OS) are the means, channels and opportunities members perceive to be available for receiving and sharing knowledge in a community. Virtual collaboration platforms, face-to-face meetings, training or any context that facilitates interaction and communication constitute opportunity structures (von Krogh 2002). Collective knowledge (CK) is the unifying character of the community and makes sense only when the knowledge of different community members is combined or brought together (Kogut and Zander 1992, Nonaka 1994, Spender 1996). Collective knowledge is knowledge created within the community that members perceive as beneficial and useful. It may appear either as the combined explicit knowledge of individuals (e.g. databases, handbooks, codings) or as collective experience (e.g. best practices and knowing how to coordinate as a community) (Erden et al. 2008). Lastly, experienced interdependence (EI) refers to members’ perception of the interdependence of people’s contribution to reaching a goal and the importance of self-contribution to the community. For online communities, the most critical aspect of experienced interdependence is goal interdependence, the degree to which members’ goals are linked to community goals (Hertel et al. 2004). When members contribute, they experience the vitality of connectedness and coordination for expected benefits, and
the benefits accrue to both the community and individual members (Wiertz and Ruyter 2007).

The Theory of Planned Behavior

One explanation for knowledge sharing in communities is the individual’s intention to share knowledge. Members’ intentions can be defined as their specific purpose in acting, the end or goal they aim to accomplish. Desire for an outcome, beliefs about consequences, beliefs about ability to perform and goal-directedness are determinants of intentional action (Malle and Knobe 1997). Intention to share knowledge is goal-directed, toward making one’s knowledge available to others. Whether the resulting action is successful or unsuccessful will depend on whether the intended result is brought about. Other consequences of action are unintentional.

There are at least two reasons why intention is expedient for explaining knowledge sharing. First, previous research in motivational psychology has established a strong correlation between intention to act and realized action (Ajzen 1991). Second, knowledge sharing is a longitudinal phenomenon, partly affected by intended and non-intended behavior and consequences, and is subject to contextual factors, such as the availability of templates for conducting transfer, communication technology, organization structure, location, and organization culture (Szulanski and Jensen 2006, Szulanski 1996). Thus, intentions are a good proxy to capture an individual’s overall tendency toward knowledge sharing. In the following section we introduce and briefly discuss the theory of planned behavior, which we later relate to knowledge-sharing intentions.

Explaining human behavior is crucial in organization research and motivational psychology (e.g. Ajzen 1991). The theory of reasoned action (TRA) is based on the premise that humans are rational and that the behaviors explored depend on personal willingness (Fishbein and Middlestadt 1997). TRA has been applied to a wide range of research fields, including psychology, management, marketing, and healthcare (Chang 1998, Fortin 2000, Sheppard et al. 1988, Wilson et al. 1992). The theory assumes that behavioral intention is a function of one’s attitudes toward the behavior and subjective norms (SN). Attitudes depend on salient belief and evaluation of outcomes of behavior,
whereas subjective norms depend on one’s beliefs about approval of the behavior by the significant others.

The theory of planned behavior (TPB) extends TRA by including perceived behavior control (PBC) as a predictor of the behavioral intention. Madden, Ellen, and Ajzen (1992) and Ryu, Ho, and Han (2003) found that TPB has a better explanatory power than TRA. PBC refers to people’s perception of the ease or difficulty of performing the behavior of interest and is a function of control belief and perceived facilitation (Azjen 1991). Control belief is the perception of the presence or absence of the resources and opportunities needed to carry out the behavior. Perceived facilitation is one’s assessment of the importance of those resources to the achievement of outcomes.

In work on the motivational mechanisms underlying knowledge sharing, scholars have applied both TRA and TPB (Quigley et al. 2007, Bock et al. 2005, Lin 2007). For example Bock et al. (2005) investigated intention to share knowledge in 27 Korean organizations using TRA, and found that intention was affected by anticipated extrinsic rewards, reciprocal relationships, and sense of self-worth. The authors extended TRA by adding the construct “organizational climate,” which includes fairness, innovativeness, and affiliation. One limitation of studies based on TRA is that they do not consider perceived behavioral control. Yet, the performance of most behaviors depends on the availability of requisite opportunities and resources, such as time, money, skill, and the cooperation of others (Ajzen 1991), and these resources represent people’s actual control over behavior. For this reason, TPB is useful for investigating the motivation to share knowledge in online communities.

A MODEL OF INTENTION TO SHARE KNOWLEDGE IN AN ONLINE COMMUNITY OF VOLUNTEERS

In the next sections, we develop a model explaining the factors that affect individuals’ intentions to share knowledge within online communities of volunteers. The model depicted in Figure 1 makes three contributions to the existing literature. First, we include a new construct—“community
munificence”—to identify the set of exclusive benefits and favorable conditions an online community bestows on its members. Second, we investigate the impact of “community munificence” on shaping members’ intentions toward knowledge sharing. Third, adopting TPB as theoretical framing, we investigate factors (attitudes, subjective norms, and perceived behavioral control) that impact on individuals’ intentions to share knowledge within an online community. Here, we extend and improve on Bock et al. (2005) by including the effect of “behavioral control” on “intention to share knowledge.”

![Figure 1 The Model of Intention Shaping Toward Knowledge Sharing](image)

**The Antecedents of Knowledge-Sharing Intentions in TPB**

Attitude (AT) to knowledge sharing arises from an individual’s beliefs about the value of its anticipated consequences. According to TPB, an individual’s intention to perform a behavior such as sharing knowledge increases if the attitude is favorable to the behavior (Ajzen 1991). Previous research has also found supporting empirical findings in intra-organizational settings (Bock et al. 2005). So, we can hypothesize:

*Hypothesis 1: Favorable attitudes of members to knowledge sharing have a positive effect on the intention to share knowledge in online communities of volunteers.*
Subjective norms (SN) refer to the perceived social pressure for or against performing a behavior (Ajzen 1991), such as sharing knowledge. Bock et al.’s (2005) study found that the greater the subjective norm to share knowledge the greater the intention to do so. We expect a similar effect in online communities of volunteers:

*Hypothesis2: Subjective norms of members in favor of knowledge sharing have a positive effect on the intention to share knowledge in online communities of volunteers.*

Perceived behavioral control (PBC) depends on two aspects: (1) perception of the resources and opportunities available (Chang 1998), and (2) self-efficacy, that is the confidence of individuals in their own ability to perform a behavior (Azjen 1991), such as sharing knowledge. Bandura (1977) suggests that people’s behavior is strongly affected by their confidence in their capability for conducting it. The more resources, means, and opportunities members of an online community believe they have to share knowledge, and the fewer obstacles they anticipate, the greater should be their perceived control over knowledge sharing. Thus, we can hypothesize:

*Hypothesis3: PBC related to knowledge sharing has a positive effect on the intention to share knowledge in online communities of volunteers.*

**The Impact of Community Munificence on AT, SN, and, PBC**

Below we explain why and hypothesize how community munificence impacts on AT, SN, and PBC and exemplify these interactions by referring to components of community munificence. Each component of community munificence namely “psychological safety,” “opportunity structures,” “collective knowledge,” and “experienced interdependence” might have some impact on any of AT, SN, and PBC. However, in the examples and explanations we highlight only the most apparent interactions deduced from theory.
**Community munificence and attitudes** In a community, individuals seek opportunities, occasions, and benefits of sharing knowledge and they are more willing to perform behaviors that they expect will lead to favorable consequences (Chiu et al. 2006). Research supports the notion that personal outcome expectations, such as cost-effective learning, self-satisfaction, and social recognition have a positive effect on knowledge sharing among members of online communities (Hsu et al. 2007, Lin 2007, Quigley et al. 2007, Bock and Kim 2002, Kankanhalli et al. 2005, West and O’Mahony 2005). The reason why members develop certain outcome expectations in a community may be explained by a gift culture. The literature on gift culture suggests that gift giving (for example, revealing one’s own knowledge to the community) creates social interdependencies. Giving a gift creates an obligation to return a gift, which can take any form, including power, reputation, or knowledge (Mauss 1967, Bergquist and Ljungberg 2001). The perceived benefits and appropriate conditions provided by the community may show members that the expected outcomes are achievable. This strengthens their belief in the return of making a “gift” to the community. The more benefits and favorable conditions they anticipate receiving in the community, the more they believe that their contributions will be worth the effort. Thus, community munificence impacts on members’ attitudes toward knowledge sharing.

This impact can be experienced through different mechanisms that can be explained by referring to the components of community munificence (PS, OS, CK, EI). For example, members’ interdependence for reaching expected outcomes has a positive impact on their attitudes to the community. Members share knowledge because they expect certain outcomes, consistent with the objectives of the community, from which they benefit. Their attitudes toward contributing to the community are reinforced when members perceive the potential opportunities and benefits can be realized only if they act as a collective entity, and understand the exigency of their own knowledge for collective and individual outcomes.

Second, as many authors on communities have argued, members form social bonds and develop a shared sense of identification (Wenger 1998, Ren et al. 2007, van Maanen and Barley 1984,
Orr 1990). The more members identify with the community, the more they are motivated to contribute to it (Thompson 2005). Different commitment mechanisms, one of which is identification, change attitudes toward behavior (Kelman 1958). Therefore, a shared sense of identification increases members’ willingness to contribute to the community outcome. Prior research on communities also supports the theory that identification with the community creates positive attitudes toward knowledge sharing. Dyer and Nobeoka’s (2000) study on Toyota supplier networks found that creating suppliers’ identification with the network was the first critical step in motivating them to share knowledge. The feeling of belonging and self-identification with the supplier community also motivated members to contribute to community outcomes. Similar results on the link between identification and contribution have also been shown in online communities developing the Linux operating system (Hertel et al. 2003).

Third, community members experience trust and care (von Krogh et al. 2000, Wiertz and Ruyter 2007); members feel psychologically safe in sharing knowledge. Trust and care enable the expectation that individuals’ interests will be protected by others (Hosmer 1995, Pavlou and Fygenson 2006). In a community, trust is facilitated through personal contact and social interactions (Fleming and Waguespack 2007). Prior research confirms the idea that trust is a key factor for knowledge sharing in online communities (Wiertz and Ruyter 2007, Chiu et al. 2006). Knowing that trust and care are mutually valid, and that other members will not take the advantage of the situation, the community can convert “I” intentions to “we” intentions (Bagozzi and Dholakia 2006). “We” intentions create reciprocity among members and a sense of belonging. Bock et al. (2005) found that anticipated reciprocal relationships, in which members respond in similar ways to the actions and intentions of others, have a positive effect on attitudes toward knowledge sharing. Thus, we would expect:

**Hypothesis 4:** Community munificence has a positive effect on the attitudes related to knowledge sharing in online communities of volunteers.

**Community munificence and subjective norms** Community munificence influences subjective norms
toward knowledge sharing by providing the context and conditions in which individuals experience social pressure to contribute and make use of the benefits provided. For example, perceived interdependence in this context may lead to favorable community norms (Bergquist and Ljungberg 2001). Shared goals and objectives give rise to reciprocal interdependencies or mutual obligations and bind community members together (Marwell and Oliver 1993). Because of experienced interdependence, community members feel obliged to contribute and cooperate with others to achieve shared objectives. One of the basic characteristics of a community is “sense of duty or obligation” among its members (Bagozzi and Dholakia 2006). A social norm is a social influence mechanism that impacts on motivational alignment toward behavior (Geen 1991). In a community, social norms are shared behavioral expectations that individuals behave consistently and according to the norms (Quigley et al. 2007), including sharing their knowledge, and are often understood as a social control mechanism (Lee and Cole 2003). However, norms need to be “taken in” by individuals: their influence depends on how individuals assess them and let them shape their behavior (Ajzen 1991). Thus, we can expect:

Hypothesis5: Community munificence has a positive effect on the subjective norms related to knowledge sharing in online communities of volunteers.

Community munificence and perceived behavioral control Community munificence influences perceived behavioral control by providing benefits and favorable conditions, such as resources, opportunity structures, connections between individuals, and a sense of self-efficacy for knowledge sharing. Communities emerge because individuals’ knowledge or capabilities do not make them self-sufficient. Collective knowledge emerges when the knowledge of different community members is combined, embedded within, available through, and derived from the relationships within the community. Community munificence provides the potential means and channels to access and share this collective knowledge through online interactions. Members perceive that whenever they intend to share/receive knowledge they can find means to access other members, for example through personal profiles or discussion forums, or knowledge repositories, such as frequently asked questions (FAQ).
Under these conditions, online community members’ perception of self-control over knowledge sharing increases, and this gives rise to increased perceived behavioral control.

In addition, community munificence may increase the perception of self-efficacy, which is defined as individuals’ belief in their own capabilities to accomplish a goal successfully (Bandura 1977). By accepting individuals as members, the community conveys that their contributions are valuable to the community. Moreover, the community offers members the opportunity to explore their own capabilities and knowledge. For example, members may take for granted experiences or capabilities that may add great value to the community. In time members may realize that their contribution is valuable and indispensable for collective outcomes. This helps them believe in their own capability to accomplish a goal.

Lastly, the psychological safety that trust instills results in a greater controllability of behavior, reducing the social uncertainty caused by unexpected contingencies in relationships (for example, people acting in incomprehensible or unpredictable ways) (Zand 1972, Luhmann 1979). Pavlou and Fygenson (2006) studied the intention toward purchasing behavior of online consumers and found that trust has an impact on perceived behavioral control because it absorbs social uncertainty and enables the individual to cope with it better.

To summarize, the perception of having the required resources, context, connections, self-efficacy and psychological safety provided by community munificence, gives rise to PBC. Therefore, we expect:

Hypothesis 6: Community munificence has a positive effect on the PBC over knowledge sharing in online communities of volunteers.

RESEARCH DESIGN

To test the model, we conducted a web-based survey of a very large online community of volunteers.
As all the constructs deal with individual perceptions and motives, the unit of analysis is the member. There are 12 forums that differ in how members interact, behave, and participate. The perception of what the online community offers is varied enough to provide reliable results on the impact of these perceptions on members’ intention to share knowledge. We analyzed the data using structural equation modeling (SEM). Next, we describe the measures, the sample and the analysis performed.

**Measures**

Multi-item, seven-point Likert scale items were used to measure the latent variables in SEM. We mainly developed the items in the questionnaire by adapting validated measures derived from previously published studies. The items and the literature from which the items were extracted are listed in Appendix A. Items measuring attitudes, subjective norms, PBC, and intention to share knowledge were adapted from Ajzen (1991), Bock and Kim, (2002), and Lin (2007). To measure intention to share knowledge, we used items related to (1) general knowledge sharing intentions, without specifying the knowledge to be shared; (2) intention to share explicit knowledge; and (3) intention to share tacit knowledge. The rationale for this distinction is rooted in theories of organizational knowledge (Grant 1996, Nonaka 1994); members might perceive it as more costly and less rewarding to share tacit knowledge that requires externalization, than explicit knowledge. The construct community munificence was measured using four sub-latent variables (components), namely “psychological safety,” “opportunity structures,” “experienced interdependence,” and “collective knowledge.” These latent variables were used as reflective indicators of the higher-level latent variable “community munificence.”

Opportunity structure items were adapted from previous studies (Chiu et al. 2006, Bock and Kim 2002, Lin 2007, Renzl 2008, Ryu et al. 2003). Some sub-dimensions were identified to measure psychological safety and experienced interdependence. Psychological safety was measured using items that correspond to the sub-dimensions of trust, sense of belonging, reciprocity, and care (Wasko and Faraj 2000, 2005, von Krogh et al. 2000, Renzl 2008); experienced interdependence was measured using items that correspond to goal interdependence derived from prior studies (Chiu et al.
2006). We developed the items for collective knowledge ourselves.

**Sample and Data Collection**

A web-based questionnaire survey was conducted among the members of an online photo community in Korea. The questionnaire was translated into and administered in Korean. The community is known as the SLR club (www.slrclub.com) and mainly focuses on single lens reflex (SLR) digital cameras. The objective of the community is to provide a platform for individuals to share information about digital cameras and to promote interaction among members through online/offline activities. It was launched in March 2001 with 70 members, and has become one of the biggest photo communities in the world, with 10,000 members in 2002, 20,000 in 2003, and 600,000 by the end of 2007. In SLR club, there are 12 forums based on different camera brands (Canon, Contax, FujiFilm, Kodak, Leica, Nikon, Olympus, Panasonic, Pentax, Samsung, Sigma, and Sony/Minolta). Each forum has different web boards, providing general information, Q/A, free board, new product, consumer reports, and friendship forums.

The online survey was posted on the official event board managed by SLR between April 1 and 20, 2009. In total we received 718 responses. As we do not know how many community members read the post about the survey, we cannot estimate a precise response rate. However, we can approximate it with the number of completed surveys per number of unique clicks on the link to the questionnaire, which is a common measure of response rate in prior studies of openly administered questionnaires in online communities (Wiertz and Ruyter 2007). In total we had 5375 clicks by November 1, 2009. As we expect the number of clicks by April 20, 2009 be much less, the response rate is at least 13% but probably much higher. After deleting responses with missing values, we ended up with 531 complete responses, of which 517 respondents were male and 14 female. Table 1 shows the respondents’ characteristics, which we used as control variables.
Demographic Information and Characteristics of Respondents

<table>
<thead>
<tr>
<th>Measure</th>
<th>Items</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
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<tr>
<td></td>
<td>Female</td>
<td>14</td>
<td>2.6</td>
</tr>
<tr>
<td>Age</td>
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<td>14</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>20–30</td>
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<td>36.5</td>
</tr>
<tr>
<td></td>
<td>30–40</td>
<td>274</td>
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</tr>
<tr>
<td></td>
<td>40–50</td>
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<td>7.5</td>
</tr>
<tr>
<td></td>
<td>50–60</td>
<td>7</td>
<td>1.3</td>
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<tr>
<td></td>
<td>&gt;60</td>
<td>2</td>
<td>0.4</td>
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<td>Forum</td>
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<td>Contax</td>
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<td>1.1</td>
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<td></td>
<td>Fujifilm</td>
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</tr>
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<td></td>
<td>Kodak</td>
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<td>1.3</td>
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<tr>
<td></td>
<td>Leica</td>
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<td>Nikon</td>
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<td>Sigma</td>
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</tr>
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<td></td>
<td>Sony/Minolta</td>
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<td>5.8</td>
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<tr>
<td>Experience in SLR Club</td>
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<td>17.7</td>
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<td></td>
<td>1–2 years</td>
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</tr>
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<td></td>
<td>&gt;8 years</td>
<td>14</td>
<td>2.6</td>
</tr>
<tr>
<td>Total</td>
<td>–</td>
<td>531</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1 Respondent Information

ANALYSIS AND RESULTS

We tested the proposed model using structural equation modeling (SEM). For the analysis we used AMOS (analysis of moment structures) software. SEM is based on covariance analysis techniques and is frequently used for the modeling of causal relationships between constructs measured with multiple items (Gefen et al. 2000).

All constructs were measured with reflective indicators. Because of item similarities we put correlation between the error terms of four item pairs: one pair in psychological safety, one pair in subjective norms, and two pairs in attitude. According to the measurement model, standardized loadings of all items in the model are around 0.7 or larger, showing satisfactory indications of the items for the latent variables. The weights and standardized loadings of the measures are listed in
Appendix B.

To examine construct validity, we assessed convergent and discriminant validity. As suggested by Fornell and Larcker (1981) we assessed convergent validity by internal consistency of the constructs (using Cronbach’s alpha) and average variance extracted (AVE). Internal consistency shows the level of correlation between the construct’s items and the accepted cut-off point is 0.6, with 0.7 as recommended threshold for a reliable construct (Gefen et al. 2000). As Table 2 shows, all the internal consistency measures are equal to or larger than 0.7. AVE measures the amount of variance captured by the latent variable in relation to the amount of variance caused by measurement error (see also Wasko and Faraj 2005). To measure AVE of community munificence (CM), we used the loadings of its indicators, namely the sub-latent variables CK, EI, OS, and PS. With the exception of “opportunity structures,” which has an AVE value of 0.47, very close to the suggested cut-off value of 0.5, all other constructs have AVE values greater than 0.5 (Fornell and Larcker 1981). The results validate the convergent validity of the constructs.

<table>
<thead>
<tr>
<th>Construct</th>
<th>No of items</th>
<th>Cronbach’s Alpha</th>
<th>AVE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Behavioral Control (PBC)</td>
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<td>0.80</td>
<td>0.67</td>
</tr>
<tr>
<td>Subjective Norm (SN)</td>
<td>4</td>
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<td>0.60</td>
</tr>
<tr>
<td>Attitude (AT)</td>
<td>5</td>
<td>0.93</td>
<td>0.69</td>
</tr>
<tr>
<td>Intention to Share Knowledge (ISK)</td>
<td>4</td>
<td>0.85</td>
<td>0.60</td>
</tr>
<tr>
<td>Collective Knowledge (CK)</td>
<td>2</td>
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<td>0.54</td>
</tr>
<tr>
<td>Experienced Interdependence (EI)</td>
<td>2</td>
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<td>0.63</td>
</tr>
<tr>
<td>Opportunity Structures (OS)</td>
<td>3</td>
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<td>0.47</td>
</tr>
<tr>
<td>Psychological Safety (PS)</td>
<td>5</td>
<td>0.85</td>
<td>0.51</td>
</tr>
<tr>
<td>Community Munificence (CM)</td>
<td>4</td>
<td>NA</td>
<td>0.69</td>
</tr>
</tbody>
</table>

*Table 2 Convergent Validity Measures*

Discriminant validity indicates to what extent two constructs differ, and we checked this by comparing the square root of the average variance extracted (AVE) for a given construct with the correlation of the given construct with any other construct, as suggested by Fornell and Larcker

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2 Average variance extracted (AVE) = \( \frac{\text{sum of squared standardized loading}}{\text{[(sum of squared standardized loadings) + (sum of indicator measurement error)]}} \).

Indicator measurement error is calculated as \( [1 - (\text{standardized loading})^2] \).
As Table 3 shows, with the exception of OS, the square root of the AVE for each construct is greater than the correlations with other constructs, which confirms satisfactory discriminant validity. The correlation between OS and PS is higher than the square root of AVE for OS. However, it is not so critical to the hypothesis testing since both of the latent variables function as reflective indicators of the same higher level construct “community munificence” and all related hypotheses are formulated on the “community munificence” level. It should be observed that since the sub-constructs of PS, OS, EI, and CK constitute the same construct of community munificence, it is not surprising that the intercorrelations between them are higher than the intercorrelations between other constructs.

<table>
<thead>
<tr>
<th></th>
<th>PBC</th>
<th>SN</th>
<th>AT</th>
<th>ISK</th>
<th>CK</th>
<th>EI</th>
<th>OS</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBC</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SN</td>
<td>0.455</td>
<td>0.772</td>
<td></td>
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<td></td>
<td></td>
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<td>AT</td>
<td>0.417</td>
<td>0.497</td>
<td>0.832</td>
<td></td>
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<tr>
<td>ISK</td>
<td>0.521</td>
<td>0.524</td>
<td>0.444</td>
<td>0.773</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CK</td>
<td>0.483</td>
<td>0.575</td>
<td>0.526</td>
<td>0.411</td>
<td>0.737</td>
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<td></td>
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<tr>
<td>EI</td>
<td>0.483</td>
<td>0.576</td>
<td>0.527</td>
<td>0.411</td>
<td>0.610</td>
<td>0.795</td>
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<td></td>
</tr>
<tr>
<td>OS</td>
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<td>0.607</td>
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<td>0.644</td>
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<td>PS</td>
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<td>0.490</td>
<td>0.727</td>
<td>0.728</td>
<td>0.768</td>
<td>0.715</td>
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</table>

*Table 4 Correlations Between the Constructs vs Square Root of AVEs. (The bold numbers in the diagonal row show the square roots of AVE.)*

Finally, the overall fit of the model was checked using the most common fit indices (Gefen et al. 2000; Browne and Cudeck 1993). The measures confirm a good overall fit of the model (AGFI = 0.863, CFI = 0.936, TLI = 0.927, RMSEA = 0.058).

**Results**

After verifying construct validity and model fit, we tested the proposed hypotheses. Figure 2 depicts the standardized regression weights and the significance measures related to the hypotheses.
Table 4 shows the squared coefficients of the multiple correlations of each latent variable, which correspond to the $R^2$ in linear regression. The squared multiple correlation of community munificence does not exist as it is an exogenous variable.

<table>
<thead>
<tr>
<th>Latent Constructs</th>
<th>Squared Multiple Correlations ($R^2$)</th>
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</thead>
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<tr>
<td>PBC</td>
<td>0.382</td>
</tr>
<tr>
<td>SN</td>
<td>0.543</td>
</tr>
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<td>AT</td>
<td>0.455</td>
</tr>
<tr>
<td>ISK</td>
<td>0.395</td>
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<td>CN</td>
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<tr>
<td>EI</td>
<td>0.611</td>
</tr>
<tr>
<td>OS</td>
<td>0.68</td>
</tr>
<tr>
<td>PS</td>
<td>0.868</td>
</tr>
</tbody>
</table>

*Table 6 Squared Multiple Correlations*

As Figure 2 shows, all the hypotheses are confirmed with high significance levels ($p<0.005$). Consistent with the theory of planned behavior attitudes, subjective norms and PBC turned out to be robust predictors of intention to share knowledge in an online community of volunteers (Adjen 1991).
PBC has the higher standardized regression weight compared to AT and SN. This shows that, at least in context of the Korean online community, the perception of control over individuals’ own knowledge-sharing behavior has relatively stronger influence than AT and SN on their willingness to contribute to the community. SN shows also quite a high impact, which might be due to Korea’s collectivist national culture. AT has the lowest regression weight (0.163) as well as lowest significance level (0.002) compared to the other two predictors of intention to share knowledge.

All indicators of community munificence, CN, EI, OS, and PS, are also significant at a level of 0.001, with very high loadings ranging between 0.78 and 0.93 (see Appendix C). This demonstrates that the four aspects of community munificence proved good indicators of the construct. Moreover, as we hypothesized, community munificence has a positive influence on AT, SN, and PBC, which ultimately impacts on individuals’ intention to share knowledge. Although there is no great difference between the standardized regression weights of community munificence on AT, SN, and PBC, the influence is strongest on SN. To sum up, these results suggest that the benefits and favorable context afforded by the online community (community munificence) are crucial for people’s motivation to contribute their knowledge to the community.

To check for the impact of the control variables (gender, age, forum type, membership duration) on individual intention to share knowledge, we introduced the control variables to the existing model and ran the model once more. The results suggest that whereas gender and duration of membership have significant impact (p<0.001), age and the type of forum in which individuals participate have no significant effect (p>0.05) on people’s intention to share knowledge. Female members are slightly more willing to share their knowledge than men (0.158***). The standardized regression weight of membership duration (−0.148***) suggests that people are more willing to share their knowledge during the early stages of their membership than at later stages.
IMPLICATIONS AND CONCLUSION

As individuals and firms continue to discover the power of online communities, a very relevant and timely challenge for research is to understand what it takes for people to contribute their ideas and knowledge and help such communities succeed. In this paper, we build on work on knowledge sharing, online communities, and motivational psychology (the theory of planned behavior), to identify how voluntary members’ perception of an online community motivates them to share their knowledge. We review theory, and develop and test a model of knowledge-sharing intentions on an online photo community in Korea. In line with our expectations, all our hypotheses are confirmed.

Our review shows that prior work faced the challenge of focusing on knowledge that was actually shared, possibly confounding causes and effects (Hsu et al. 2007). Moreover, while it is often argued that community is an appropriate context for studying knowledge sharing, for efficiency reasons (Wenger 1998, Brown and Duguid 1991), the impact of online community characteristics people’s intention to share knowledge remains weakly understood. By developing the concept of “community munificence” and showing its high empirical relevance for predicting knowledge-sharing intention, we contribute to the existing body of research on knowledge sharing (e.g., Bock et al. 2005, Wiertz and Ruyter 2007, Nonaka 1994, Quigley et al. 2007, Yang and Chen 2007, Zarraga and Bonache 2005). Community munificence explains exclusive benefits and favorable conditions as perceived by members of a community. The level of community munificence is identified by the level of psychological safety, opportunity structures, experienced interdependence, and collective knowledge that reside within a community. Our study is a first attempt to explain how community munificence can shape intention to share knowledge and contributes to our understanding of the motivational aspects that give rise to knowledge-sharing behaviors in a social context. More specifically, we extend the model in Bock et al. (2005) by including the effect of “behavioral control” on “intention to share knowledge.” We test the model on an online community covering volunteer members, instead of an intra-organizational community. The sample provides us with a “pure setting” to test intentions to contribute knowledge to a community, because in this setting, members are not
exposed to formal hierarchy, organizational control mechanisms, and formal incentives, which may force their sharing of knowledge.

Our study contributes to the emerging literature on online communities. When individuals come together in online communities for a shared purpose it is crucial to leverage the knowledge embedded in each member for all to benefit (Erden et al. 2008). Prior work focused on knowledge sharing in different types of online communities, such as open source software (Roberts et al. 2006), customer (Wiertz and Ruyter 2007), and user communities (Jeppesen and Frederiksen 2006). However, none of these studies has focused explicitly on the outcome of people’s community-related experience of knowledge sharing. To our knowledge, this is the first study to provide a holistic explanation of why people’s perception of being a member of an online community shapes their intention to share knowledge.

Finally, our study contributes to the literature on motivational psychology, by lending support to the theory of planned behavior (Ajzen 1991) in predicting the intention to share knowledge. To our knowledge, this is the first study to test these predictions in the context of an online community of volunteer members. Moreover, our results also demonstrate that people’s perception of what the community has to offer—community munificence—matters for the dimensions of planned behavior. It is important to examine the application of motivations across contexts in which individuals work, live, and play, as demonstrated in our study. Perceptions of these contexts and their impact on motivation represent interesting areas of research, with strong implications for organizational and management research and practice.

There are implications for community members, as well as for the firms that host or sponsor online communities aiming to benefit from such external and open knowledge sources. Based on our model, firms and members of such communities should pay close attention to the factors that constitute community munificence. Depending on the availability and type of community, different underlying mechanisms can be used to motivate members to share their knowledge. First of all,
community members should be provided with various opportunities and media to interact. Mailing lists, collaboration platforms such as wikis, bulletin boards, forums, chat rooms, or other types of social software constitute the proper context for this purpose. Another important factor is the rewards provided to the contributors, which can take the form of reputation, status, or learning opportunities (e.g. Hertel et al 2004). Although we might expect little peer pressure in online communities, because of the frequent use pseudonyms, our results suggest that subjective norms have a relatively strong influence on intention to share knowledge. Therefore in a community, it is important to shape a “netiquette” that emphasizes collective outcomes and lets members experience interdependency with others within the community. Moreover, the community should provide an emotionally safe context where members can trust each other and feel they are members of “one big family.” Leadership support, or some form of active moderation of the online community, might be imperative for achieving this community munificence.

Our results should be interpreted in the light of certain limitations. First, because of the web-based questionnaire method, the data might be biased toward members who actively contribute to the community (Hsu et al. 2007). Future research should examine the model in other online communities using alternative types of respondent control. Second, the study is limited to cross-sectional data and, unlike longitudinal data, causal relations can only be inferred from theory, not proved (Bock et al. 2005). Future research should complement this study by investigating how community munificence might change over time in shaping knowledge-sharing intentions. In addition, future work needs to examine how communities are infused with subjective norms, and as well how these norms relate to established social norms in the community. This work would also need to investigate corrective action or punishment in online communities, such as withdrawal of membership when trust is abused or knowledge sharing falls below expectations.

Third, our study cannot differentiate between contributors on the basis of their activity level, for example between passive members or core-contributors or leaders, due to the presentation of members in their community. Yet, as we reasoned earlier, leadership and forms of moderation might
be imperative for the success of online communities. In future work, the research model should be extended to understand the influence of community munificence on different players. For example, in online communities of volunteers, leadership depends on trust, credibility, and occupational authority. The impact of a leader relies on “the power to persuade and motivate,” as members cannot be forced to participate (Fleming and Waguespack 2007). Future research should investigate how community leaders foster community munificence. Finally, in our study the model was tested among the members of an online community in Korea, which, as we speculated, may have a collectivistic national culture compared to other geographies. Given these limitations, we encourage researchers to test the model in different online and offline communities across different geographies and cultures with larger samples, to confirm or disconfirm the generalizability of the findings.

REFERENCES


Nonaka, I., Konno, N. 1998. The concept of ‘Ba’: building a foundation for knowledge creation.


### APPENDIX A

**TABLE A1 Questionnaire Items**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Key References</th>
</tr>
</thead>
</table>
| Intention to Share Knowledge (ISK) | • I try to share knowledge with community members  
• I plan to share knowledge with community members  
• I openly share information that I gained from news, magazines and journals with other community members  
• I openly share my photo and camera related experiences or know-how with community members | Bock and Kim 2002, Lin 2007, Renzl 2008, Ryu et al. 2003                                                                                       |
| Attitude (AT)                       | For me, sharing my knowledge with other members is  
• very unpleasant  very pleasant  
• very unenjoyable very enjoyable  
• very harmful  very beneficial  
• very bad  very good  
• very worthless  very valuable | Ajzen 1991, Carr and Sequeira 2007, Ryu et al. 2003                                                                                       |
| Subjective Norm (SN)                | • Most members who are important to me share knowledge in the community  
• The members whose opinions I value share knowledge in the community  
• Most members who are important to me think that I should share knowledge in the community  
• The people whose opinions I value think that I should share knowledge in the community | Ajzen 1991, Bock and Kim 2002, Ryu et al. 2003, Pavlou and Fygenson 2006                                                                 |
| Perceived Behavioral Control (PBC) | • It is always possible for me to share my knowledge with network members  
• If I want, I always could share knowledge with network members                                                                 | Grafield 2006, Regans and Mcevily 2003, Ryu et al. 2003                                                                 |
| Psychologica l Safety (PS)          | • I feel a sense of belonging to the community  
• I believe in the value of the network.  
• Community members are honest to each other  
• Community members would help me if I need it  
• I proactively seek to understand other community members’ needs and interests | von Krogh et al. 2000, Renzl 2008                                                                                                 |
| Opportunity Structures (OS)        | • I can access updated information in the community  
• I can get various training and seminar in the community  
• The community facilitates the interaction with other members                                                                 | Chiu et al. 2006                                                                                              |
| Experienced Interdependence (EI)    | • Community members share the same goal of learning from each other  
• Community members believe that sharing their knowledge and information will help other members. | Compeau and Higgins 1999, Chiu et al. 2006                                                                 |
| Collective Knowledge (CK)           | • In my network, we collectively develop new ideas  
• In the offline gatherings (photo shooting, casual regional meeting) we discuss and develop new ideas | Bock and Kim 2002, Lin 2007, Renzl 2008, Ryu et al. 2003                                                                 |
### APPENDIX B

**TABLE B1 The Weights and Standardized Loadings of The Measures**

\[ p^{***} < 0.001 \]

<table>
<thead>
<tr>
<th>Construct</th>
<th>Reflector Indicator / Item</th>
<th>Regression Weight</th>
<th>Standardized Reg. Weight</th>
<th>S.E.</th>
<th>C.R.</th>
<th>P</th>
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<tr>
<td><strong>Community Munificence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td></td>
<td>0.997</td>
<td>0.931</td>
<td>0.062</td>
<td>16.108</td>
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<tr>
<td>OS</td>
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<td>0.564</td>
<td>0.825</td>
<td>0.044</td>
<td>12.879</td>
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<tr>
<td>EI</td>
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<td>0.781</td>
<td>0.043</td>
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<tr>
<td>CK</td>
<td></td>
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<td>0.78</td>
<td>0.066</td>
<td>15.006</td>
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<tr>
<td><strong>Psychological Safety (PS)</strong></td>
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<td></td>
<td></td>
<td></td>
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<td>0.811</td>
<td>0.071</td>
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<td>1.088</td>
<td>0.855</td>
<td>0.054</td>
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</table>
### APPENDIX C

**TABLE C1 Regression Weights**


table

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Regression Weight</th>
<th>Standardized Reg. Weight</th>
<th>S.E.</th>
<th>C.R.</th>
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<td>0.512</td>
<td>0.675</td>
<td>0.037</td>
<td>13.988</td>
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</tr>
<tr>
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<td>0.555</td>
<td>0.618</td>
<td>0.046</td>
<td>11.957</td>
<td>***</td>
</tr>
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<td>0.052</td>
<td>15.535</td>
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</tr>
<tr>
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<td>0.434</td>
<td>0.317</td>
<td>0.077</td>
<td>5.616</td>
<td>***</td>
</tr>
<tr>
<td>ISK &lt;--- AT</td>
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<td>0.087</td>
<td>3.043</td>
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<tr>
<td>ISK &lt;--- SN</td>
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<td>0.299</td>
<td>0.065</td>
<td>5.122</td>
<td>***</td>
</tr>
<tr>
<td>PS &lt;--- Community Munificence</td>
<td>0.997</td>
<td>0.931</td>
<td>0.062</td>
<td>16.108</td>
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THE QUALITY OF GROUP TACIT KNOWLEDGE

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Abstract
Organizational knowledge creation theory explains the process of making available and amplifying knowledge created by individuals as well as crystallizing and connecting it to an organization's knowledge system. What individuals get to know in their (working) lives benefits their colleagues and, eventually, the wider organization. In this article, we briefly review central elements in organizational knowledge creation theory and show a research gap related to the quality of tacit knowledge in a group. We advance organizational knowledge creation theory by developing the concept of "quality of group tacit knowledge." Based on this concept, we further develop a comprehensive model explaining different levels of tacit knowledge quality that a group can achieve. Finally, we discuss managerial implications resulting from our model and outline imperatives for future theory building and empirical research.

1. Introduction
Knowledge is one of the most important sources of competitive advantage for firms (Grant, 1996, Nonaka, 1990, Nonaka, 1991, Nonaka, 1994, Nonaka and Takeuchi, 1995 and Nonaka and Toyama, 2003). A critical factor for competitive advantage is enabling new knowledge creation that allows the firm to respond as quickly as possible to the business requirements of the near and more distant future.
Thus, knowledge and the theory of organizational knowledge creation have long been discussed among academics. Organizational knowledge creation is defined by Nonaka et al. (2006, p. 1179) as “the process of making available and amplifying knowledge created by individuals as well as crystallizing and connecting it with an organization’s knowledge system.”

Knowledge creation is of paramount importance to a firm’s strategy (e.g., Bierly and Chakrabarti, 1996). Nonaka et al. (1994) argue that, in dealing dynamically with a changing business environment, firms should not only process information efficiently but also create knowledge. A changing business environment is characterized by increased global competition, rapidly changing technologies and market needs, and shorter product life cycles which all necessitate creativity and innovation (McDonough, 1993). Knowledge creation is often seen as the “front-end” of product development where tacit knowledge plays a great role in achieving innovation success. Yet, in most cases, innovation is not the product of a single person but a collective work of a group of people or a team which draws the attention to “group tacit knowledge (GTK).” GTK is socially complex and difficult to imitate, and therefore constitutes a part of a firm’s intangible resources that give rise to competitive advantage (Leidner, 2000). Given its centrality to organizational competitiveness understanding its features is of critical importance. Although much theory and research exist on “individual tacit knowledge” (Gourlay, 2004, Nonaka et al., 2000, Nonaka, 1994, Polanyi, 1967 and Tsoukas, 2003) and some scholars emphasize the quality of individual tacit knowledge (Doran, 2004, Koskinen, 2001, Nonaka, 1994, Noh et al., 2000, Nonaka and Toyama, 2007 and Sanders, 2004), so far, academic work on organizational knowledge creation have rarely focused on GTK, nor has it systematically identified what the “quality of group tacit knowledge (QGTK)” could refer to and how one can distinguish between groups with different quality levels in their collective tacit knowledge. One might reason, for example, that the tacit knowledge of a group is the aggregation of all individual tacit knowledge and that its quality is a function of individual tacit knowledge. In this paper, we demonstrate that this is not the case, and argue that GTK has a meaning in itself and that it also is associated with various levels of quality.

The goal of this paper is to fill a gap in the literature and identify what “group tacit knowledge” and its “quality” mean. As the basis for our model development, we draw upon the SECI
model from organizational knowledge creation theory (Nonaka, 1994), Aristotle’s concept of “phronesis” (Aristotle, 1999 and Nonaka and Toyama, 2007), theories of organizational improvisation (Crossan, 1998, Moorman and Miner, 1998 and Vera and Crossan, 2005), and organizational aesthetics (Baumgarten, 1950, Strati, 2003, Strati, 1996 and Strati, 1992). In the next section, we identify the existing research gap in organizational knowledge creation theory concerning QGTK. Then we introduce a model that explains the levels in QGTK. Next, we discuss the role of advanced information technology in enabling or constraining group members’ socialization and derive implications for the QGTK. Finally, we discuss managerial implications resulting from our model and outline imperatives for future theory building and empirical research.

2. The quality of group tacit knowledge in organizational knowledge creation theory

In this section, we review basic concepts of organizational knowledge creation theory and point out an important research gap concerning the quality of group tacit knowledge. In organizational knowledge creation theory, knowledge is: (a) justified true belief, meaning that individuals justify the truthfulness of their observations based on their observations of the world. Justification, therefore, hinges on unique viewpoints, personal sensibility, and experience (Nonaka and Takeuchi, 1995). Knowledge is also: (b) the capacity to define a situation and act accordingly (Stehr, 1992, Stehr, 1994 and von Krogh et al., 2000). Here, knowledge is oriented towards defining problems, rather than the solving of depicted and manipulated pre-given problems (e.g., Newel and Simon, 1972). Finally, knowledge is: (c) explicit and tacit (Nonaka, 1991). Knowledge that can be uttered, formulated in sentences, and captured in drawings and writing is explicit. Knowledge tied to the senses, movement skills, physical experiences, intuition, or implicit rules of thumb, is tacit (see also Polanyi, 1967).

The theory of organizational knowledge creation proposes that new knowledge is created through processes of conversion between tacit and explicit knowledge: socialization, externalization, combination, and internalization (Nonaka, 1994 and Nonaka et al., 2000). Empirical and theoretical work has shown that knowledge creation cannot be separated from the context in which it is created. Knowledge creation and sharing is embedded in temporal contexts which include “situations, conditions, social circumstances in the before, now, and after” (Reinmoeller, 2001). In the theory, “context” is often referred to as “Ba” – a shared space for emerging relationships and practices in a
group that can be physical, virtual, mental, or any combination of these (Nonaka and Konno, 1998; see also Nonaka et al., 2006, for a review).

Although organizational knowledge creation theory suggests that the origin of all knowledge is individual, it also focuses on emerging groups for the purpose of knowledge creation and innovation. For example, individual creativity is supposed to contribute to the collective knowledge of the organization (Spender, 1996). Although all four processes of the SECI model play a role in GTK creation, socialization (the process of converting new tacit knowledge through shared experience) is one of the most critical steps. New tacit knowledge is socially constructed through the interactions amongst individuals or between individuals and their groups, rather than by an individual operating in isolation (Nonaka et al., 2000). Socialization occurs, for example, in a traditional apprenticeship where the apprentice learns through hands-on experience, or in informal meetings outside the workplace where tacit knowledge including world views, mental models, and mutual trust can be created and shared (Nonaka et al., 2000). As a result, two kinds of tacit knowledge might emerge: individual level and group (or collective) level (Nonaka, 1994).

Yet much of the literature on management and organization theory has treated tacit knowledge on the “individual” level (Gourlay, 2006). Individual tacit knowledge consists of technical and cognitive skills (Alavi and Leidner, 2001), and because it “resides” in individuals it is hard to externalize along the continuum of knowledge (from tacit to explicit), codify, and document (Grant, 1996). Examples include driving or swimming skills, intuitions, gut feelings, and mental models. Non-individual level tacit knowledge is studied under different names in the literature, such as “group” (Cook and Brown, 1999 and Kogut and Zander, 1992), “collective” (Alavi and Leidner, 2001, Gourlay, 2006, Leonard and Sensiper, 1998, Nonaka, 1994 and Spender, 1996), “social” (Spender, 1996), “communal” (Brown and Duguid, 2001) or even “organizational” (Chou and He, 2004, Kogut and Zander, 1992 and Nonaka and Takeuchi, 1995) tacit knowledge. Although there are some nuance and level differences in their meanings, authors refer to tacit knowledge that is not possessed by one individual but created and possessed collectively by more than one individual. Such group level tacit knowledge is sticky and it cannot be allocated to parts or individuals, which makes it difficult to replicate or imitate (Szulanski, 1996). That is why, for example, some companies transfer and hire not
only one person but a whole team with history of working together on solving very complex tasks (Durisin, 2001).

Grant (1996) suggested that when groups are confronted with complex tasks, such as innovation in products, services, and processes, they need to integrate the knowledge of individuals for problem solving and decision making. Ultimately, shared, integrated knowledge is brought to bear on tasks. Organizational knowledge creation theory posits that through knowledge conversion new tacit knowledge can become collective for the group (Nonaka, 1994). That is, the group members begin to act in a collective and coordinated manner, solving complex tasks, without explicit rules for action such as written procedures, decision rules, formal models, or even without explicit communication. Communities of practice are good examples for such groups (Brown and Duguid, 2001 and Lave and Wenger, 1991). While the existence of GTK is assumed in the theory and described in anecdotes, the process of GTK has not been explained in much detail. How can this new collective and coordinated action be explained? What are the reasons that make a group of people act as a “collective body?” If one of them is the group tacit knowledge, then, what are the dimensions to differentiate between various groups when analyzing the quality of the tacit knowledge they possess?

As an initial step in a major program to develop a theory of group tacit knowledge in organizations, this paper focuses on the “quality” aspect – whether or not GTK enables the group to act in a particular way. There are two reasons for this. First, in the front-end model of innovation, socialization, through which GTK is created, is a necessary, although not sufficient condition for knowledge creation (Kluge et al., 2001, Nonaka and Takeuchi, 1995 and von Krogh et al., 2000). Without it, innovation is likely to fail (Nonaka, 1994). Moreover, Spender (1996) argues that collective knowledge (social tacit knowledge) is the most reliable and strategically significant type of organizational knowledge. Second, organizational knowledge creation theory is recognized for having contributed much to the concept of tacit knowledge to organization science (Tsoukas, 2003). Hence, it is very crucial to understand the contribution of socialization to a group and to identify what constitutes high quality tacit knowledge for a group.

3. Group tacit knowledge
Recently, a lot of studies focused on groups in organizations and their role in knowledge creation and sharing (e.g., Cook and Brown, 1999 and Zárraga and Bonache, 2005). According to this view, organizations and groups are more than a collection of people. In the following, we briefly review previous studies and then reframe the concept of GTK by synthesizing the most relevant aspects.

Our focus of interest for the paper is on “group” level tacit knowledge. “Group” refers to a collection of people in a close relationship taking part in an interrelated activity with the aim of performing a task or achieving a common target (Weick and Roberts, 1993). There are six main characteristics of what we call GTK. First of all it is socially constructed; or simply stated, is a result of social interactions, i.e., socialization. Socialization means that members of a group not only come to understand each other’s definition of shared situations but also agree on a common definition and come to hold justified true belief about how to act in that situation (von Krogh et al., 2000). As a result of socialization, group level knowledge is created which includes collective practical skills, expertise, and cognitions. Second, GTK is deeply rooted in action. Tacit knowledge can not be learnt by reading, talking, or just “seeing.” This implies that GTK hinges on activity in and with the group where members indwell in the practice with their mind and body. It is the knowledge that enables a group to act as a “collective body and mind” without necessarily having the help of explicit rules and procedures. “The collective mind can be conceptualized as a pattern of implicitly coordinated, heedful interrelations of actions in a social system” (Weick and Roberts, 1993). According to Weick and Roberts (1993), heedful performance is a result of thinking, feeling, and creating a shared purpose together.

“ Actors in the system construct their actions (contributions), understanding that the system consists of connected actions by themselves and others (representation), and interrelate their actions within the system (subordination)… As heedful interrelating and mindful comprehension increase, organizational errors decrease…” (Weick and Roberts, 1993)

The authors give the example of flight deck activities on an aircraft carrier focusing on the mindfulness of the collective practice. Taking into account their explanations, one can conclude that
GTK is not likely to emerge before individuals engage in collective practice. GTK does not reside in individuals separately but is found in the interconnected relations and activities of individuals. Thus, the collective performance of a group depends on how heedfully people interrelate in action. The relation between collective action and GTK can be compared to a growing loop: GTK is achieved by collective action and used to act collectively. Madhavan and Grover (1998) explain team interactions in a similar way by using the term “shared mental models.” They argue that teams create a shared understanding of particular situations with the help of prior shared knowledge. Shared mental models represent unconscious assumptions about probable actions of individuals, a shared oral language with its own vocabulary, a shared body language with its own clues, “taken for granted” understanding, and shared memory (Madhavan and Grover, 1998 and Nonaka, 1991). Another important aspect of GTK is that it provides a group with synchronization of action with a common understanding of timing. The way members connect their activities makes the system mindful (Weick and Roberts, 1993). As soon as the group builds a collective mind, members will be able to act as a collective body. Without the mind, the body cannot function, and vice versa! If this kind of mindfulness is maintained, the actions of people can be coordinated and connected even in unfamiliar and complex situations. The spontaneous, unplanned actions of groups in unfamiliar situations are studied in organizational improvisation literature (Crossan, 1998 and Vera and Crossan, 2005). The collective improvisation necessitates collective intuition which is also a kind of GTK. In Section 4, the relevance of collective improvisation to GTK will be explained in more detail.

Third, GTK depends on requisite variety and is more than the “algebraic sum” of individual tacit knowledge. In other words, collective action leads to synergy and the capabilities of the group exceed the “algebraic sum” of individual capabilities (Brown and Duguid, 2001). Kogut and Zander (1992) define “group know-how” as recipes of organizing such as Tayloristic methods or craft production. Although the definition takes a very important aspect of GTK, namely “self-organizing” character, the example of “Tayloristic methods” does not correspond to our understanding of GTK. Tayloristic methods are based upon well-defined procedures and rules. They ignore individual differences and uncertainty by assuming that the optimal way of performing a task is the same for everyone. Contrary to this, organizational knowledge creation theory would suggest that GTK depends
on the variety in capabilities of group members where each individual has specific strengths and weaknesses and the optimal way of doing things, solving problems, and performing tasks may change from person to person. Despite these differences, a group with tacit knowledge may still act as a “collective body and mind” by compensating the weaknesses via dynamic coordination and heedful interrelating (Weick and Roberts, 1993).

Fourth, GTK is embedded in group culture, norms, routines (Spender, 1996) and is rooted in commitment, ideals, values, senses and emotions (Nonaka and Takeuchi, 1995). Group culture, norms, and routines emerge as a result of shared experiences and lead to collective sense making. Witnessing the same situation at the same time is necessary but not sufficient to talk about the shared experience. It asks for “legitimate peripheral participation” (Lave and Wenger, 1991) of members in the practice. Moreover, in order to convert a shared event into a shared experience, it is important that the group pays attention to the same stimuli (D’Eredita and Barreto, 2006) and at the same time shares a common goal orientation. Group culture gives rise to group identity, group language (oral and body), definition of group boundaries, and feeling of shared belonging. As a result, it motivates group members take an active role in the welfare of other group members. One of the most important aspects of group identity is that people are able to interpret clues used within the group and contribute to production of new ones. Such clues allow people to understand what other group members do, what their intentions are, what help they need to solve tasks and problems, as well as opportunities for knowledge sharing. Clues are particularly important for sharing tacit knowledge (for more, see von Krogh, 2002). Routines and norms enable shared understandings, help to coordinate (Feldman and Rafaeli, 2002), and provide a team or group with the activity to reproduce the task over time ensuring continuity in collective performance. Consequently, the members gain a representation of others’ probable actions, interdependencies of these actions, connected relations, and the ability to act intuitively in unknown situations (Cohen and Bailey, 1997 and Weick and Roberts, 1993). It is also important for GTK that each group member understands (implicitly or explicitly) the indispensability of other members for collective action. In order to achieve GTK, the group benefits largely from the mutual insights of members into the reactions of others (von Krogh et al., 2000). Similarly, Cook and Brown (1999) label GTK with “organizational genres.” In the organizational context, “genre” applies
not only to literary artifacts but also to various physical and social artifacts such as technologies and ways of doing certain things, and shows the meaning associated with these artifacts by the group. These organizational genres are acquired in practice as a result of shared experience, held in common, and have meaning in the unique group context. They are a kind of GTK which are not taught or explicitly defined but rather constituted collectively and implicitly by the group.

Fifth, GTK is the capability of a group to agree on the best action for “common goodness” and to find the means to actualize it. In order to be able to act collectively not only should a group have shared understandings and collective sense making mechanisms but also should determine and undertake the best action for “common goodness” in a specific situation. That is, the group should define what “good” for the group is; accordingly what their goal is and which path they should follow to reach their goal. This is related to the concept of “phronesis.” The concept and its relation to GTK are explained in the next section.

Sixth, GTK not only reduces uncertainty, but also allows the group to deal with uncertainty (see also Liebeskind, 1996). In every group (and other social systems), two interacting people face a so-called “double contingency.” We can explain this situation as: “both know that both know that one could also act differently” (Vanderstraeten, 2002). In a group of more than two people where simultaneous action by many is inevitable, this situation is even more complex. In such situations, we can talk of “multiple contingency” which may reduce the group’s ability to act in a coordinated and orchestrated manner. The members of a group with tacit knowledge have the ability to “guess” what the others may act like in different situations. This enables the group to deal with “multiple contingency” which as a result facilitates the collective improvisation. Collective improvisation is the capability of a group to cooperate and act spontaneously even in uncertain and unfamiliar situations.

As seen above, there are different contributions in the literature regarding the meaning of GTK each suggesting particular aspects of the concept. In sum, group level tacit knowledge has very much to do with team coordination in complex work (Hedlund and Nonaka, 1993). It is the capacity of a group to act as a collective body using their collective mind in situations that are familiar as well as unfamiliar and complex in the absence of explicit rules or directions. GTK allows the group to deal with uncertainty, to define new tasks and to solve predefined tasks. While doing this, “group identity”
and “group boundaries” are dynamically reproduced and become key for the recognition of GTK. Yet, GTK does not guarantee that every group manages to perform well in all situations. Why can some groups coordinate and perform better than others although all possess some kind of GTK? What makes the difference? It is possible to speak of the quality of group tacit knowledge. Above, we defined GTK in general without referring to “quality” differences, while mostly referring to work on groups such as deck crews on aircraft carriers that have high quality GTK. So one should not assume that all groups with some tacit knowledge are able to act like a collective body and mind. In the following part, we will propose how to differentiate between different quality levels of GTK and which characteristics a group possesses in each level.

4. Quality of group tacit knowledge: Towards a model

Tacit knowledge is a comprehensive justification of beliefs that are embedded in the human body and mind leading to such characteristics as “gut feelings” and intuitions (Varela et al., 1991). It is deeply rooted in action, commitment, and involvement (Nonaka, 1994). Tacit knowledge, therefore, cannot be easily externalized along the continuum of knowledge (from tacit to explicit), encoded or documented and sharing it necessitates the “here and now” interaction of people. Because it is bound to people, it cannot be judged or measured separately. Speaking of “quality,” therefore, poses a particular challenge because this notion is often not “measurable” (e.g., Mileage before a car breaks down, or the comfort of a coach from the viewpoint of a customer). The perception and recognition, cognition styles, heuristics and biases in judgment, mental models, and the skills of individuals influence the quality of tacit knowledge (Maqsood et al., 2004). This is why two people experiencing the same situation may develop different levels of expertise and tacit knowledge. According to Nonaka (1994), the quality of personal tacit knowledge is affected by two factors: the “variety” of an individual’s experience and the “knowledge of that experience” (also see Sanders, 2004). The knowledge of experience is “an embodiment of knowledge through a deep personal commitment to bodily experience” (Nonaka, 1994) which is very much dependent on the characteristics of the individuals.

Although “quality of personal tacit knowledge” is mentioned in some studies (Doran, 2004, Koskinen, 2001, Nonaka, 1994, Noh et al., 2000, Nonaka and Toyama, 2007 and Sanders, 2004), the
QGTK has so far not been isolated, analyzed and studied in academic research. Given the lack of conceptual work on this subject, this section aims to develop a model of the QGTK. According to the explanations in the previous section, GTK is created by the inherent collective action of a group (Alavi and Leidner, 2001). It is the ability of a group to act or perform with a collective mind as a collective body. How successful these actions are in real situations depends on the quality level of the GTK. Although a group may be very successful in collective action under certain conditions it may fail under unfamiliar ones. In this section, we identify the characteristics of different levels of quality in GTK and argue for a model of four levels ranging from a modest quality level to the highest. The model is depicted in Fig. 1. It resembles a model of “expertise development” (Dreyfus and Dreyfus, 1986), but it applies distinctly to groups. The model shows the levels of developing high quality of tacit knowledge in a group. Groups at a given level do better than groups at previous levels by adding extra capabilities onto it. In the following part, we explain each level separately beginning with the lowest quality level.

Figure 1: Different levels in the quality of group tacit knowledge

4.1. Level 1: Group as assemblages
At this level, the group can be specified as a “collection of people.” Group members are like “foreigners” to each other with nearly no shared experience. There are weak group ties, identities present and there are no shared memory, shared understanding, or shared norms that can be attached to the group. In short, one cannot speak of GTK at this level. As an example, we can think of a newly formed basketball team with members from different colleges, nations, age groups, different experiences in the game and different understandings of its rules and so on, who have never met before. This level corresponds to the team’s very first meetings where there is no shared history and no collective understanding of mutual differences, responsibilities, or skills.

4.2. Level 2: Collective action

The group advances from the first level to this level through gaining exposure to shared events and developing shared experiences. Groups at this level exhibit certain characteristics. First, they develop a shared memory and the members understand the nature and value of “collectively acting.” Shared memory and understanding enable the group to solve familiar tasks automatically by repeating pre-experienced activities. Each member knows how the others will act in certain situations due to previous experiences and coordinates herself accordingly. The group becomes a collective body and mind for certain familiar situations where the function of each component is well defined.

Second, group-based routines are generated and the group acts according to these routines and procedures. Group routines are recurring patterns of behaviors of group members involved in a collective action (Feldman and Rafaeli, 2002). They are embedded experiences and successful solutions to complex tasks, as well as the coordination of solutions to various tasks. These routines are not explicitly defined but stored as “tacit memory” and are bound to customs (Cohen and Bacdayan, 1994). The group tacitly knows how the routines work depending on the interrelated actions of the members. At this level, the group is not capable to act beyond the routines in uncertain and unfamiliar situations.

The third feature of this level is the existence of “group culture.” Through experiencing collective action group-specific languages, clues, and values are developed. Accordingly, group boundaries are defined and “collective identity” is strengthened. At this level, although members
possess a shared culture and a feeling of shared belonging, their conflict resolution mechanisms are still not capable to exploit the individual differences and strive for a negotiated result under unknown situations.

At the collective action level, our basketball team automatically draws upon the previously gained knowledge and plays in a coordinated manner following the tactics they developed during trainings. The players know well how the others act sequentially when they perform a specific tactic and how rival team members could act and react in the match. Yet, the team members are not capable of dealing with uncertainty as a collective body. That is, if the rival acts in a way in which the team’s tactic fails, the team does not have the ability to do something totally different from what has already been practiced before. The team is bound to the planned tactics. In other words, it cannot adapt to the new, unknown situation. During the performance, the team does not need to communicate explicitly which tactic to choose; players use some clues that evoke specific tactics. However, it may fail to choose the best one that could work for a certain context. The team is not qualified enough to play flexibly and change the tactics wisely according to the progress in the game. Therefore, they need to follow the instructions of their coach in order to choose the appropriate tactic. Moreover, some crisis may emerge due to the conflicting interests. For example, some players may avoid passing the ball to other players which may destroy the collective team atmosphere.

4.3. Level 3: Phronesis

The concept of “phronesis” was discussed in organizational knowledge creation theory by (Nonaka and von Krogh, 2007) and (Nonaka and Toyama, 2007). The concept was introduced by Aristotle. In his book Nicomachean Ethics, he defines three different kinds of knowledge namely: episteme, techne, and phronesis. Episteme is universal, context-free, explicit, and objective knowledge that can be interpreted as scientific knowledge. Techne is practical and context-specific technical know-how. It includes tacit knowledge such as skills and crafts. The concept of phronesis can be roughly translated as “prudence,” “practical wisdom,” and “practical rationality.” It describes the ability to determine and undertake the best action for “common goodness” in a specific situation (Nonaka and Toyama, 2007). Spender (1996) defines phronesis as an understanding of social activity and politics. For example
episteme is the knowledge of the scientific fact that a ship can float in water according to Archimedes’ principle, techne is the knowledge how to make a good ship, and phronesis is the knowledge of what a “good” ship is for certain situations and how it can be designed accordingly (a good ship for transportation of passengers differs from one for transportation of oil). Phronesis is mostly studied and mentioned on an individual level. If we adapt the interpretation of phronesis to a group level, phronesis for a group is high quality collective tacit knowledge gained from collective practical experiences that enables the group to decide heedfully and to take appropriate actions for specific situations guided by group values, group culture, and shared goals (Nonaka and Toyama, 2007). Phronesis is “synthesizing glue” between contextual and universal knowledge (ibid.) which provides the capacity to define goals for specific context that are shared and accepted by the group and to figure out the means to reach them (Halverson, 2004).

When it comes to the definition of “good,” one can pose the following question: goodness for whom? In Nonaka and Toyama (2007), it is the “good” for “common goodness” for a particular context that can be defined as a result of a compromise between individual perspectives. The meaning of “good” therefore is parallel to the meaning of “truth” used in the definition of knowledge: a dynamic process of justifying personal belief towards the “truth” (Nonaka and Takeuchi, 1995). “Good” and “truth” are both socially constructed. What is “true” and “good” depend on who decides on it (values) and under which conditions it is decided. In a social setting, individuals have different interests, make diverse contributions to activity, and hold various viewpoints. Robert Bellah (1991) argues that “a good community is one in which there is argument, even conflicts about the meaning of shared values or goals and certainly how they will be actualized in everyday life.” It is impossible to ignore differences in individual interests, egoisms, and “I-intentions” (e.g., see Bagozzi and Dholakia, 2006). However, the group can find ways to exploit the individual differences and strive for a negotiated result. According to Gilbert’s plural subject theory, in collective action people tend to behave and think as jointly through which “we” or “us” is conceptualized (Gilbert, 1989). There are some examples from open source software user communities (Bagozzi and Dholakia, 2006) and product development teams (Nonaka, 1991) showing that people manage to convert “I-intention” to “we-intention.” This result depends on the presence of group identity and boundaries, mutual
understanding, and common goal orientation (Bagozzi and Dholakia, 2006). It can be achieved by synthesizing various subjective interpretations and objective rules into collective knowledge. A group needs to fulfill the following requirements to become a collective entity and to define what “common good” is in specific situations: “mutual responsiveness among members to the intentions and actions of others, collective commitment to the joint activity, and commitment to support others involved in the activity” (Bagozzi and Dholakia, 2006).

Phronesis is not only the ability to identify common goodness and to establish consensus on a common goal. It is also the ability to find the means to reach this goal. Thus, phronesis may also mean that the group members use general, universal, explicit knowledge in a particular situation and make their explicit knowledge inform action (tacit knowledge) in a particular context. Therefore, phronesis necessitates the ability to collectively grasp the essence of particular situations with the help of common sense (Nonaka and Toyama, 2007). In order to find ways to reach the goal, it is necessary for group members to share their perceptions, interpretations, intuitions, and judgments with the group which leads to a collective understanding of the situation. To do this, they also need to communicate their subjective insights to others. At the “phronesis level” group members share their tacit knowledge and allow it to become a resource which all can draw on (von Krogh, 2002). Moreover, there is a collective decision-making mechanism and each member becomes committed to the end decisions. At this level, the group is able to choose the best action for common goodness and in order to accomplish it all members commit to collective decisions, even if they do not necessarily (totally) agree. In addition, group members do not necessarily need the guidance or directives of a leader. The group has autonomy and people collectively sense that its decisions have meaning and impact (Druskat and Wheeler, 2003). Similar to self-managed teams a team at this level is empowered to make its own decisions.

To sum up, a group at this level advances from the “collective action” level by gaining the capability to (1) convert “I” intentions to “we” intentions, (2) decide on and commit to the “common goodness,” (3) grasp the essence of particular situations, (4) take the best action for “common goodness,” and (5) manage itself. Returning to the example of the basketball team – at this level, the players learn about each other’s physical as well as emotional and cognitive strengths and weaknesses.
The meaning of “common goodness” may change depending on the context. For example, whereas in trainings, common goodness may imply the team members learn how to play in different positions, in a match it could refer to beating an opposing team by using the best positioning in a match. At this level, all the members commit to the team’s welfare and play for the common “goodness;” a kind of “one for all, all for one” understanding emerges. The team can use collective “practical wisdom” during the play and choose the best tactic that can be applied in a specific situation. It means the coach does not need to extensively intervene and guide the play. The players avoid egoistic behaviors and do their best to support collective success. Thus, crises due to conflicting interests are more easily overcome compared to the collective action level. The team plays “wisely” because it is capable of choosing the most appropriate tactic within the play. However, it is still not able to come up with totally new tactics within the play itself, i.e., to improvise.

As another example we can give experienced consultancy teams working on a specific subject in a professional services company. These teams can decide on the best action required for a specific problem without the directions of a leader. The function of the leader is not vital for such teams. The leaders do not decide in detail how to solve the problems if it is not a very unfamiliar situation. If the situation is entirely new and unfamiliar, the leader needs to be involved more in the problem solving activities. However, in most cases, the function of the leader is to give ideas in order to improve the chosen solution instead of showing the best action to solve the problem.

4.4. Level 4: Collective improvisation

“Collective improvisation” is the highest level of tacit knowledge quality a group can achieve. In an effort to understand how firms and groups can respond to fast environmental changes, unpredictable events, and the need for continuous innovation, “improvisation” has taken the attention of scholars in management and organization studies (Vera and Crossan, 2004 and Vera and Crossan, 2005). There are different application areas of improvisation of which jazz groups (Organization Science special issue on jazz improvisation, 1998), theater (Crossan, 1998 and Vera and Crossan, 2004), education, team work (Vera and Crossan, 2005), and strategy (Crossan, 1998) are the most well-known. Nonaka and Toyama (2007) suggest that “the social ability to improvise is the ability to react quickly and
appropriately to an unpredictable situation.” Good improvisation is “about negotiation among team members, setting each other up for success, and trusting and respecting others while enacting the ongoing scene” (Vera and Crossan, 2005). The joint action of individuals that are themselves improvising produces “collective improvisation” (Moorman and Miner, 1998) which again is more than the “algebraic sum” of individual improvisations. Therefore, at this level it is important that each member is an expert in what she is expected to do because this enables her to improvise individually. Credibility becomes vital, and is defined as members’ beliefs about the accuracy and reliability of other members’ knowledge (Akgun et al., 2005). Without competent and credible members, a group will not be able to improvise collectively as collective improvisation results from a chain of individual improvisations. If one link breaks, the entire chain breaks.

In improvisation, there are no predetermined roles and rules. The most important dimensions are spontaneity and intuition (Crossan and Sorrenti, 1997). Hence, in order to be able to improvise in unexpected situations, a group should have developed a collective mind which leads not only to coordination in certain situations but also to collective intuition (such as a kind of “gut feeling” in unfamiliar situations). Collective intuition means that each member intuitively acts in a way that is consistent with the actions of others. This demands that each member gives full concentration and attention to others’ actions over time and thereby overcomes multiple contingencies. This level of GTK does not reduce uncertainty but it allows the group to deal with uncertainty. Hutchins (1991) gives the example of how a ship crew whose navigational system has broken down found their way to the harbor with the help of collective improvisation. Although no crewmember understood the complete system, their collective action worked through acting collectively and intuitively in an unknown situation. In our terms, the crew possessed a high quality group tacit knowledge.

There are different levels of improvisation, too (Moorman and Miner, 1998). Whereas in some cases improvisation may lead to an incremental change to existing routines, in others it may turn out to be radical creativity (Vera and Crossan, 2005). In both cases, improvisation is “intuition guiding action in a spontaneous way” (Crossan and Sorrenti, 1997). Vera and Crossan studied collective improvisation and its effect on innovative team performance (Vera and Crossan, 2005). They argue that there are several dimensions that impact on the effectiveness of improvisation: (1) the team’s task
relevant expertise, (2) teamwork quality by which they mean cooperation and trust, (3) the context for effective improvisation such as experimental culture and real-time information and communication, and (4) training. The authors believe that improvisation can be taught through exercises like games. Good improvisation “is a tool that complements planning efforts but, because of its creative and spontaneous nature, it is not necessarily tied to success, the same way planning is not necessarily associated with success” (Vera and Crossan, 2005). For the QGTK, the relevant aspect is not necessarily that improvisation leads to success per se but that the group is able to make sense and improvise collectively even in complex, unfamiliar, uncertain, and urgent situations.

At this level, the basketball team is not only able to act according to the previously exercised tactics and to choose which tactic is the best for specific situations but also create entirely novel tactics while playing. These are coordinated actions of members developed spontaneously within the play. According to the rival’s play members position themselves and each one contributes to the collective “play” in a way that would best fit to the context. The “play” may partly exploit the previously learned tactics but it is not constrained by them. The team adapts itself to the situation and improvises collectively. Another example for the groups at this level could be new product development teams. Some of these teams generate novel action patterns without advance planning, which may decrease time to market especially in a turbulent environment (Akgun and Lynn, 2002).

Finally, we want to emphasize two important points about the model of QGTK. The first one is the fact that not every team/group needs to possess the highest level of tacit knowledge quality in order to be successful. The required quality level for a task depends on the task specifications. Achieving the highest quality level in GTK is a costly process; the group should make investments in the form of time, money, attention, etc. Thus, QGTK has an opportunity cost as well: if the task is not demanding a high QGTK the resources and capabilities that are necessary to achieve a high quality level can be devoted to other productive events.

The second point is the importance of aesthetics for the QGTK. GTK rests on the “subjective feeling of shared belonging” (Strati, 2003) and is acquired through the filter of aesthetic judgment. Strati (ibid.) defines aesthetics as a form of organizational knowledge. It is the “aesthetic knowledge that gives rise to interaction and the construction of social relationships.” At the same time, aesthetic
sentiment is formed by negotiations amongst team members (Strati, 2007). There is a very close relationship between the aesthetic judgment of individuals in a group and the QGTK. For example, in a team, how individuals feel about the team atmosphere, and what they find beautiful or see as unpleasant, all affect their feelings of belonging and contributions to collective action. In an unfamiliar situation, it is the senses, feelings, and aesthetic knowledge that give rise to unconscious and spontaneous action. If each individual has a different aesthetic judgment, collective tacit coordination will be difficult to realize in the course of acting. In a group of no common aesthetic understanding, we cannot expect a high QGTK that enables the group to act as a collective body and collective mind. A feeling of shared belonging moderates the relation between aesthetic knowledge and QGTK. The importance of aesthetics varies for different levels of group tacit knowledge quality. The higher the quality becomes, the more critical the impact is. When the quality level rises, shared aesthetic values become more crucial like the oxygen needed to survive on a mountain summit.

5. Conclusion and discussions

GTK is an important driver for collective creativity and innovation success in organizations. Until now, the QGTK in organizational knowledge creation has not constituted a central research topic. In this paper, we have identified and tried to address a part of this gap. The scope of the paper was restricted to the definition of GTK and the QGTK. We have reviewed some of the central elements in organizational knowledge creation theory and combined these with “collective action,” “phronesis,” and “improvisation” which constitute a theoretical background. We have proposed a model that explains what different levels of QGTK refer to. This model is a contribution to organizational knowledge creation theory (Nonaka, 1994, Nonaka and Takeuchi, 1995, Nonaka et al., 2006 and von Krogh et al., 2000) by filling a gap related to the GTK.

There is great value in focusing on GTK for organizations. When managers bring people together for a project, the challenge for everyone is how to use the potential and to leverage it to be more than just the sum of what the individual members know. Group tacit knowledge with high quality is a resource that organizations can rely on when confronted with unexpected and unfamiliar situations which require intuition and spontaneous collective action. The model developed in the paper
enables researchers and managers to understand the role of different quality levels in group outcomes. Managers concerned about knowledge creation, innovation, and creativity in organizations should pay close attention to factors that provide a group with high quality tacit knowledge. Regarding the QGTK, the responsibility of the leadership is to mobilize tacit knowledge that is unevenly distributed and create the context necessary for collective action, while finding ways to enhance the quality of tacit knowledge on all levels (Nonaka and Toyama, 2007). Love, care, trust, and commitment are crucial to gain high quality group tacit knowledge (Koskinen, 2001, Nonaka et al., 2000, Ron et al., 2006 and von Krogh, 1998). Organizational knowledge creation theory suggests that managers should create a “ba,” which may be “virtual,” “mental,” or “physical,” that directly or indirectly gives rise to such feelings (Nonaka and Konno, 1998). Moreover, leaders’ behavior is very important for peoples’ perceptions of fairness, commitment, and trust (Cohen and Bailey, 1997). In addition, they can provide organizational members with workshops, exercises and games that can help to develop skills for improvisation (Vera and Crossan, 2004).

The major challenges in organizational knowledge creation are to define knowledge sources, make them available to the members, and combine the existing ones. Information technologies (IT) may help to overcome these challenges, especially time and space constraints (Ramarapu et al., 1999). IT is known for its capability to facilitate data and information exchange, that is, to combine, organize, and distribute explicit knowledge (Leidner, 2000). The problem with tacit knowledge is that it is bound to people and, therefore, cannot be externalized along the continuum of knowledge (from tacit to explicit), encoded, or documented easily and sharing it necessitates the “here and now” interaction of people. Thus, some scholars argue that IT can never substitute face-to-face interaction where people can share their tacit as well as their explicit knowledge (Fahey and Prusak, 1998). We definitely support this argument; nevertheless, we still believe that IT may have a major effect in facilitating tacit knowledge sharing which, as a result, affects the QGTK. IT can serve as a kind of group memory for knowledge, through which people can access past experiences, in particular overt clues, documented experiences, written reflections and so on, and thereby recollect an image of past events. This kind of memory may also include a database of best practices, or organizational stories, or the information that guides people to address the right person, such as the Yellow Pages. A good example for this kind of
usage is the customer resource tool developed by Syngenta, called the “Agronomic Brain” (Chin, personal communication 2007). The tool helps to visualize the communal, tacit knowledge of call center people by presenting the contacts and connections they make to respond to questions from customers. It is used to visualize the emerging knowledge of the call center agents as they act and coordinate as a community, and therefore belongs to the community. In this way, the tool also helps leverage the value of tacit knowledge for example in linking together hitherto unrelated thoughts and may provide comprehensive solutions to customer problems. When these solutions are reused on related new problems, and reflected upon by the call center agents, new tacit knowledge may also be created. The tool exemplifies how knowledge flows from individuals to communities, how tacit knowledge can be converted to explicit knowledge on the continuum; and how this in turn stimulates the creation of more knowledge, completing the cycle. The advantage of the Agronomic Brain is that it combines the distributed knowledge of call center agents and as a result increases the efficiency and effectiveness of the call responses and facilitates the training of new agents by mapping the necessary connections to reach a specific knowledge.

von Krogh (2002) suggests that information systems may play a vital role in the formation of a community. Information systems, such as email, chat rooms, collaboration platforms, and bulletin boards, help to develop weak ties (Constant et al., 1996) and from that they may further develop into strong ties. This plays a great role in helping a group to create a GTK, i.e., to pass from the “group as assemblages” level to the collective action level. Moreover, information systems may assist in creating care and trust in a community which are necessary for the sharing of explicit and tacit knowledge amongst group members (Sambamurthy and Jarvenpaa, 2002 and von Krogh, 2002).

The paper is limited to the development of a model based on the concepts of GTK and QGTK. In the future, the factors that lead to high quality group tacit knowledge should be identified across organizational settings. In order to accomplish this, we believe in-depth field studies are greatly needed. Task performance may be used to evaluate whether or not individuals share tacit knowledge that mutually improves the quality of their work. Yet, high quality tacit knowledge might not only be reflected in the performance of a planned, executable, and measurable task but also in people’s ability to spontaneously design tasks, improve them, and discard old solutions and improvise new
approaches. In the theoretical literature, the notion of tacit knowledge quality has been linked to experiences. However, empirical work is needed to explore how various experiences play out in the organization, thereby enabling us to better capture the means of attaining quality in a work setting, especially when uncertainty is high.

References


ANALYZING FOR CLUSTERS IN THE BIOPHARMACEUTICAL INDUSTRY: A REVIEW AND METHOD

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Abstract

Clusters are groups of co-located and interconnected firms and institutions linked by commonalities and complementarities. There are several reasons for the geographical concentration in the biopharmaceutical industry. This paper unpacks some advantages and disadvantages of cluster participation, and proposes a simple new method for managers to identify clusters in the biopharmaceutical industry.

Introduction

Clusters are groups of co-located and interconnected firms and institutions linked by commonalities and complementarities [1]. What are the advantages and disadvantages of locating in a cluster of firms and institutions for biopharmaceutical firms? This is a critical question for managers in biopharmaceuticals, because cluster membership tends to be a salient feature of firms in this industry, and research has shown that cluster participation is linked to firm performance [2,3]. This paper unpacks some advantages and disadvantages of cluster participation, and proposes a simple new method for managers to identify clusters in the biopharmaceutical industry.
Since [4], the importance of agglomeration has been noted by many scholars in many disciplines and areas, including economic geography, management, and organization science (e.g. [3,5,6]). Marshall argued that agglomeration economies exist in many industries due to industry specialization, labor pooling, and the spillover of knowledge between firms and institutions [4]. Importantly, innovations tend to cluster in industries where R&D, skilled labor, and university research are important inputs [7]. The biopharmaceutical industry consists of firms that develop and/or manufacture drugs for human therapeutics and/or diagnostic purposes and that have at least one product that can only be produced by biotechnological methods. In this paper we show that this industry tends to be highly geographically concentrated, similarly to the high geographic concentration in the biotechnology industry [8,9].

There are several reasons for the geographical concentration in the biopharmaceutical industry. First, clusters play an important role in drug development due to the fragmented nature of knowledge in drug development and complementarities of competencies between firms. In the biopharmaceutical industry, innovation depends on tight relationships between suppliers, customers, and partners. With the introduction of biotechnology and increased complexity of the tools required, drug development has shifted from being an activity of a single large pharmaceutical firm to a collective and collaborative activity involving different actors, such as dedicated biotechnology firms, large pharmaceutical firms, contract research organizations (CROs), public research laboratories, universities, and regulatory institutions. Drug development consists of a less regulated phase of basic and pre-clinical research for new technology and compounds and a highly regulated chain of clinical trials for developing a therapeutic compound for a specific medical indication or need. This “basic” versus “applied” research distinction allows firms to focus and specialize in different parts of the value chain. Yet, specialization also increases the interdependency between actors where efficient and
effective drug development requires interaction within and between phases. In order to collaborate and develop new compounds, firms need to exploit complementary knowledge available in other specialized firms and universities, and public research laboratories [10].

Second, at a more fine-grained level, research has shown that clusters foster cooperation; knowledge flows between actors becomes less costly, more reliable, and easier [11]. Thus, not only vertical interactions between players in the industry, but also the knowledge spillover between competing firms impact on drug development. In clusters, knowledge can spill over between competing firms because of their membership of professional associations, informal social relationships between scientists, shared scientists and lab technicians, university collaborations, and market exchange of information [9]. In particular, the personal relationships between scientists may lead to the “spill over” or sharing of valuable tacit knowledge, not just more explicit types of knowledge such as scientific studies, engineering documents, and products of process specifications. Thus Michael Porter reasoned early on that by providing access to tacit knowledge, clusters offer firms the potential for differentiating from non-clustered competitors, and enhancing their competitive advantage [1].

Clearly, it is imperative for managers to understand the advantages and disadvantages associated with location within clusters. This is likely to be a long-term decision with strong implications for the firm’s financial performance. To understand these potential implications we should first identify the cluster boundaries in the biopharmaceutical industry, which in turn will give an indication of the types of “member” firms (competitors and potential partners) and other institutions. Today there is no common understanding of how cluster boundaries should be identified. Previous studies mainly used metropolitan statistical areas (MSA) to identify cluster boundaries [2,3,9,12]. This approach is conceptually problematic because clusters defined according to MSA do not necessarily provide accurate information
on the clusters in a specific industry. A cluster might consist of more than one MSA, or one MSA might be too large to capture knowledge spillovers due to clustering.

In the rest of this paper we outline advantages and disadvantages for firm membership of geographical clusters, introduce a new method for identifying cluster participation, and end with a brief discussion and conclusion.

**Advantages of geographical cluster membership**

Previous studies have outlined a number of advantages of cluster membership (e.g. [1,8,13,14]). Here, we categorize and explain the advantages of clusters according to their contribution to generic business-level strategies of cost leadership and differentiation [15,16]. The factors that enable a firm to reduce unit cost serve a cost leadership strategy, whereas factors that enable the firm to innovate and differentiate from others serve a differentiation strategy. These generic strategies are not mutually exclusive [17]. In dynamic industries like the biopharmaceutical industry, firms need simultaneously to pursue both strategies in order to achieve a sustained competitive advantage [18].

**Seeking Cost Advantages**

Clusters provide a number of cost advantages. First, firms can benefit from the investments made by governments, public institutions, and private firms to foster the development of a specific industry in a region. Public spending or private investments by companies in training programs, special infrastructure, quality centers, or laboratories may contribute to the firm's overall productivity [1,19]. For example, under the BioRegio Program, Baden-Württemberg’s biotechnology region, the “Rhine-Neckar-Triangle,” received public funding of around €25 million in 1997–2002 [18]. Until 2006 the firms funded had created approximately 1000 qualified jobs and had acquired private investments of more than €500 million [20].

Second, co-location of firms may incur lower coordination and transaction costs.
Transaction costs are reduced due to the proximity of buyers and sellers, lower search costs for finding buyer and seller, greater communication advantages, higher trust, more specialized labor, and increasing knowledge spillovers [1,14,19]. Moreover, clusters offer abundant specialized suppliers, lowering the cost of shipments and the need for in-house inventory, while improving support services, and learning through feedback between firms. In addition, there is a reduced risk that suppliers in the cluster will overprice their product because it is in the firm’s interest to retain an impeccable reputation among buyers in the cluster [1].

Third, clusters foster the development of a local labor market for specialized skills making it less costly for firms to search for talent and coordinate their hiring and other HR policies [1,4,5,14]. Because clusters may signal job opportunities and provide a well-connected network for rapid career development, they typically attract skilled labor [1,9,21]. For the biopharmaceutical industry, specialized labor with expertise in scientific disciplines such as microbiology, genetics, biochemical engineering, biochemistry, as well as entrepreneurial and management skills, is crucial, and here clusters may benefit the supply [8].

Fourth, clusters provide easier and less expensive access to specialized and complementary knowledge [4,5,14,19]. Since extensive technical, market, and complementary knowledge may accumulate among individuals, firms, and institutions in clusters, member firms may face lower search costs in obtaining access to such knowledge than non-member firms. In addition, R&D by firms and universities creates knowledge spillover for other firms to exploit [22,23], potentially leading to reduction of in-house R&D spending and higher innovation output. Thanks to this effect, in knowledge intensive industries like biopharmaceuticals in particular, small firms with limited R&D spending appear to be highly innovative [23,24]. The presence of universities in an area creates a sort of “intellectual commons” for the benefit of cluster members [23]—e.g. student placement
agreements between the university and firms foster the sharing of scientific knowledge [25]. Finally, high trust and co-location of firms decreases the costs of identifying, accessing, and transferring knowledge [26]. In particular, a local culture, a local work ethic, and local participants adhering to professional standards enable the sharing of tacit knowledge between firms [19].

Seeking Differentiation Advantages

According to [27], two main differentiation strategies are based on product innovation and/or intensive marketing and image management. Competition in the biopharmaceutical industry is mainly driven by firms’ ability continuously to learn and innovate new products, processes, and services [28]. Clusters are important for firms’ ability to create new knowledge and innovate [1], making cluster members potentially more innovative than non-members [29].

Scholars have argued that clusters contribute to firm innovation in three different ways. First, clusters allow firms to gain a wide variety of knowledge bases through knowledge spillovers [7,22,30]. Innovation depends upon the integration of different knowledge sets [31] and firms can build an advantage by locating close to the source of technology and knowledge [23]. Co-location helps firms identify and imitate superior solutions within the cluster, re-use, and combine these with various in-house ideas [19]. Key sources of knowledge for biopharmaceutical firms include university and industrial R&D, firms in related industries, and networks of business service firms (see also [23]). [3] identified clusters as a so-called “knowledge flow” channel and empirically found that a firm’s geographic area, due to various knowledge flows, positively impacts on firm performance in the biotechnology industry.

Second, clusters tend to speed up innovation among member firms compared to non-cluster firms [1]. Due to the trust, culture, and other effects discussed earlier, suppliers, customers, and competitors become more closely involved in the firm’s innovation process,
ensuring more efficient and effective knowledge creation geared to customer needs. For example, a biopharmaceutical firm conducting clinical trials can benefit from its proximity to a hospital. Here, it should also be noted that customers can be an important source of tacit knowledge [23] that enhances both the speed and likelihood of successful innovation. Tacit knowledge sharing, however, needs proximity [32], and thus non-cluster members cannot benefit from this “sticky” knowledge to the same degree.

Third, clusters enhance the reputation of member firms [1] allowing them to create a unique and superior image for their products and services. Investors like venture capitalists and business angels also gravitate toward active geographical clusters populated by innovative firms, universities, promising research projects, and unique expertise. For example, [33] found that venture capitalists invest most in co-located firms in order to increase collaboration, knowledge exchange, and eventual return on investment. Capital and management advice is critical for firms to pursue differentiation strategies through innovation and image building.

**Disadvantages of cluster membership**

Notwithstanding these advantages, managers should make prudent decisions on their firms’ cluster membership. Firms in a cluster may face several sources of agglomeration diseconomies due to unintended knowledge spillovers and other effects. Extensive spillover of valuable and rare knowledge to competitors may quickly erode the sources of a firm’s competitive advantage. Yet, given that intense knowledge spillover in a cluster is considered a source of advantage, an increasing number of firms may seek to join the cluster, leading to further knowledge spillover between firms. The total impact of these two opposing forces might be contingent on firm-specific features, means of knowledge protection (including trade secrets or patents), industry fragmentation, R&D investment levels, degree of innovation among member firms, similarities and differences in firms’ knowledge, and the
maturity of the industry. According to [34], firms that possess strategically relevant knowledge and other resources may choose not to co-locate with other firms, because of knowledge spillover. Firms with the weakest technologies and pools of talented employees, however, may choose to co-locate precisely for that reason. [34] found evidence that cluster members have survival disadvantages due to an adverse selection with respect to the types of firm that agglomerate (for a similar study, see [35]).

Some scholars also argue that very strong clusters might have a negative impact on the survival of new firms due to congestion and hyper-competition for resources and personnel [2,14]. This was typically the case among information technology firms in Silicon Valley during the late 1990s. Congestion and competition might increase firm costs for labor, land, services, and products [8], reducing the profit margins for cluster members. [2] investigated 806 US biotechnology firms founded between 1973 and 1998 and found that the advantages of cluster membership decrease as the number of firms in the cluster increases.

**Methods for identifying Clusters**

Although clusters are important to the strategies of biopharmaceutical firms, it is difficult to identity cluster boundaries [19]. The notion of spatial scale used in previous literature is arbitrary, extending from a street to whole nations. [19] argue that it is not possible to define a specific geographical scale once and for all and suggest using different scales according to the type of phenomenon under investigation. For example, if institutions or cultural and linguistic aspects are the focus, the nation state may be a good proxy for defining clusters; but if the focus is knowledge spillovers associated with social interactions and informal ties, then “small places,” such as cities, urban neighborhoods, and city blocks might offer a better proxy [19]. Such methodological diversity produces inconsistent results in prior research [14,36].

For example, several empirical studies investigate the impact of geographic agglomeration on knowledge spillovers, innovation, and growth (e.g. [7,22,23]). Scholars then defined the
cluster boundaries with different proxies, such as states, districts, provinces, MSAs, and specific regions in countries such as UK Central Statistical office regions [8,14,29,37]. [38], for example, used country to define the clusters. Yet, measuring the effect of agglomeration at country level could be misleading as countries are not homogeneous and strong agglomeration patterns exist in a nation [14].

Some authors have chosen “state boundaries” to define clusters (e.g. [7,34]). [23] used states and included a geographic concentration measure as a control variable to account for the degree to which manufacturing activity is concentrated within states. This allowed for controls of potential sources of aggregation bias. [8] also used the individual state although she discussed the problem that clusters may not be confined within state borders. However, states have their own tax regimes, utility pricing, and policies toward emerging industries, which provide some justification for their use as clusters. The state is a problematic unit of analysis for spatial phenomena, although [7] argue that it provides a superior number of data sources and the most relevant unit of policy making. Previous literature mostly used MSAs to identify cluster boundaries [2,3,9,12]. [30] used either the consolidated metropolitan statistical areas (CMSAs) or the MSAs. However, defined according to MSA, clusters do not necessarily provide accurate information on members and interactions in a specific industry. A cluster might consist of several MSAs, or one MSA might simply be too large to capture knowledge spillovers. To obtain a comparative view, [22] included three different geographic levels (country, state, and CMSA/SMA) in their analysis of patents and citations by firms in the same region.

Complementing such pre-defined cluster boundaries, some authors (e.g. [39]) have argued in favor of an algorithm to identify the geographic regions that constitute the clusters. [39] defined a region as a geographical area with a high degree of interactivity, appropriate to capture the interplay between labor supply and demand. Although their view of “region” does
Toward an alternative method

Although some empirical studies of clusters in the biotechnology industry are available, to our knowledge there is no study on clusters in the biopharmaceutical industry (a sub-field of the biotechnology industry). Taking into account the limitations of the previous methods discussed, we introduce a new method to identify the clusters in the biopharmaceutical industry. The method finds a configuration in which the distance between the firms in a cluster is minimized while the distance between the clusters is maximized. Our method has two advantages; first, it is flexible and can be used to determine clusters on different levels (e.g., state, country, or worldwide). In contrast, pre-defined boundaries, such as MSAs, cannot be used globally as there is no worldwide unit of area that can account for comparable clusters. Second, with longitudinal data, we can observe the evolution of clusters over time. It is not limited to static boundaries such as MSAs.

There are seven steps in the method:

1. Identify the industry.
2. List all the firms in the industry.
3. Collected unique data on the geo-locations (headquarter addresses) of the firms in the sample.
4. Based on headquarter addresses, use the Google Maps algorithm to generate the exact geocode (longitude and latitude) of firm location.
5. Calculate the point-to-point distance between companies using geocodes.
6. Conduct a cluster analysis using the point-to-point distance matrix of
companies as an input.

7 Approximate the area of each cluster as a rectangle, with the borders of the rectangle defined by the geocodes of the outermost firms in a cluster.

We applied the method to obtain precise information on existing worldwide clusters in the biopharmaceutical industry in 2003. First, we developed a list of all public and private biopharmaceutical companies worldwide, using the Bloomberg® database and the BioScan® database respectively. We recorded all companies belonging to the industry segment “pharmaceuticals, biotechnology & life sciences” (GICS: 3520) of the “health care” sector (GICS: 35). This resulted in a list of 2084 firms. Based on headquarter addresses, we used the Google Maps algorithm to generate the exact geocodes (longitude and latitude) of firm locations. Firms without a clear address, identifiable geocode, or identifiable founding year, were removed from the clustering sample, resulting in a list of 1777 firms. Based on the geocodes, we grouped all companies into five regions to account for the regional circumstances of cluster formation: Africa (two), the Americas (1024), Asia (282), Australia-New Zealand (75), and Europe-Middle East (394). Next, we ran a hierarchical clustering algorithm (Ward’s linkage method) using the point-to-point distance matrix of companies existing in 2003 as input. Based on the results of the clustering algorithm, the firms in each region were grouped into a defined number of clusters (Africa 2, Americas 45, Asia 31, Australia-New Zealand 7, Europe-Middle East 50). The area of each cluster was approximated as a rectangle, with the borders of the rectangle defined by the geocodes of the outermost firms in the respective cluster. Identifying the cluster boundaries in this manner is crucial in order to calculate different cluster features, such as cluster density. The resulting clusters for US and Europe can be seen in Figure 1 and Figure 2 respectively. Different colors (numbers) indicate different clusters.
Figure 1: The biopharmaceutical clusters in the US

Figure 2: The biopharmaceutical clusters in Europe

Conclusion
In this paper, we have reviewed the relevant literature on clusters, identified the advantages and disadvantages of clusters for biopharmaceutical and other firms, briefly reviewed the methods used in previous studies to identify cluster boundaries, and proposed a new method. Due to intense knowledge spillover, firms located in clusters are expected to realize higher rates of innovation. However, managers of biopharmaceutical firms should also consider the disadvantages and contingencies of cluster membership. Knowledge spillover from the firm to other cluster members may undermine the firm’s sources of competitive advantage.

Managers should keep in mind that the ability of the firm to benefit from knowledge spillovers might be contingent on certain factors, such as the technological proximity of firms in the cluster [40]; industry structure (e.g., bargaining power of suppliers, or monopolistic competition versus pure monopoly); the culture in the cluster; the diversity of firm strategy, etc. (see for example [24]). In addition, innovation is contingent on different interrelated factors, such as demand conditions, related and supporting industries, and firm structure and strategy [1]. Therefore, when choosing locations for their firms, managers should first investigate cluster boundaries, cluster characteristics, and afterwards find the most appropriate cluster for their goals, expectations, and capabilities. The method we proposed in this paper allowed us to identify clusters in the biopharmaceutical industry, using a sample of worldwide firms. One should be aware of the limitations of the method. Based on the clustering algorithm, the method only considers distance measures between firms to identify clusters. If the sample is worldwide, the resulting clusters might be located on the boundaries of different countries that make individual member firms subject to various tax, regulatory, and other policy-related regimes.

References


Knowledge externalities and the anchor hypothesis. *Ind. and Innov.* 10, 311-328


Appendix 4

FILLING THE TUB AT THE RIGHT PACE: 
HOW STOCKS AND FLOWS OF KNOWLEDGE IMPACT ON FIRM 
PERFORMANCE IN THE BIOPHARMACEUTICAL INDUSTRY

Publication under review, 
please do not circulate or quote without the explicit consent of the authors

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Abstract

The model of knowledge stocks and -flows (KSF) is a key advancement of the knowledge-based theory of the firm. The model hypothesizes a relative impact of stocks and flows of a firm's knowledge on the firm's performance (DeCarolis and Deeds, 1999, Dierickx and Cool, 1989). Until now, empirical examination of KSF has been strictly limited to a cross-sectional study of a small sample of biotechnology firms based in the United States, demonstrating linear relationships between some stocks and flow variables and firm performance. Thus, little is know about the non-linear and dynamic impact of knowledge stocks and flows on firm performance. Based on recent research on the knowledge-based view of the firm, we extend KSF towards a non-linear knowledge-based model. Using new
extensive panel data and new refined measures, we test this model on a global sample of biopharmaceutical firms (2003–2007). We demonstrate the relative impact of knowledge stocks and flows on firm performance over time. We find that firms’ performance does not depend solely on their existing knowledge but also on their search for new knowledge opportunities, through in-house creation or from the outside.

Introduction

According to the knowledge-based theory, how the firm creates, transfers, and uses knowledge impacts on its performance and its ability to compete within an industry (Dierickx and Cool, 1989). An important contribution to the knowledge-based view was the knowledge stocks and -flows model (KSF) (DeCarolis and Deeds, 1999, Dierickx and Cool, 1989). DeCarolis and Deeds (1999) used the metaphor of a “bathtub” to illustrate the difference between the stocks and flows of firm knowledge, likening the flow of knowledge to the amount of water that flows into or out of the tub, while the stock of knowledge is the amount of water stored in the bathtub at any point in time. Knowledge stocks—knowledge on record and in the minds of people—and their dynamics constitute the basis for knowledge creation and innovation. These accumulate through knowledge flows from individual and organizational learning. Knowledge flows may further be integrated and converted into knowledge stocks.

An important advantage of KSF is its synthetic quality, i.e. the ability to predict the relative impact of a large inventory of stocks and flows variables on firm performance. Rather than outlining the isolated impact of single knowledge variables, e.g. alliances (flow) or scientific publications (stock), KSF assesses the relative impact of several knowledge-related firm characteristics on performance in one industry. Thus, KSF has also significant value for management since it provides concrete insights regarding a profile of investment in knowledge stocks and flows to succeed in a particular industry (e.g. focus on basic contract research versus developing new pharmaceutical products).

To this date, the empirical examination of KSF has been limited. There are few studies that empirically tested the impact of KSF on firm performance (Bontis et al., 2002, DeCarolis and Deeds,
1999, Kyriakopoulos and de Ruyter, 2004, Zucker et al., 2007). Bontis et al. (2002) conceptualized organizational learning systems as stocks and flows of learning across individual, group, and organizational levels within an organization. Using a survey they tested their model with fund companies and found that business performance is positively associated with different stocks whereas negatively associated with the misalignment of stocks and flows. Kyriakopoulos and de Ruyter (2004) suggested that firms rely on two distinct types of knowledge stocks namely procedural and declarative memory and using a questionnaire they tested their impact on new product development outcomes in the food possessing industry. They found an inverted U-shaped relationship between procedural memory and new product development outcomes, a positive relationship between declarative memory and financial performance, and found that procedural memory reduces the value of internal or external information flows for product creativity. A seminal contribution to the knowledge-based view of the firm was DeCarolis and Deeds (1999), which conceptualized firm knowledge as stock and flows and tested their relationship to firm performance in the biotechnology industry. Their findings demonstrated that a biotechnology firm’s performance is predicted by location, products in the pipeline, and research performed by the firms’ research team. Previous research used a cross-sectional research design to test the impact of KSF on firm performance. Since stocks and flows of firm knowledge are dynamic and will change across firms and time, the cross-sectional research design found in prior work is limited in terms of making statistically valid inferences (Bierly and Chakrabarti, 1996, Bowen and Wiersema, 1999, Hill and Hansen, 1991).

Thus, little is known about the longitudinal impact of knowledge stocks and flows on firm performance. Based on recent research on the knowledge-based view of the firm, we extend KSF towards a dynamic knowledge-based model portraying non-linear mechanisms. We draw upon work on knowledge stocks and flows by (Dierickx and Cool, 1989) and DeCarolis and Deeds (1999) to develop a dynamic model of interactive stocks and flows mechanisms. Using new extensive panel data and new refined measures, we test this dynamic model on a global sample of biopharmaceutical firms (2003-2007). More specifically, we contribute to the work on KSF in three ways: 1) we advance the measurement of how stocks and flows of firm knowledge impact on firm performance by introducing
new variables, 2) we introduce a new interaction mechanism between the firm performance and stocks and flows of firm knowledge and 3) we provide a dynamic model of knowledge stocks and flows using panel data statistics.

First, to measure the impact of stocks and flows of firm knowledge on performance, we advance the variables suggested by the previous research (DeCarolis and Deeds, 1999) and add new, accurate stock and flow variables. To measure knowledge flows stemming from a firm’s geographical location previous research used a single score composed of different measures such as the number of high technology employees, and the number of medical schools per MSA (DeCarolis and Deeds, 1999). However, this approach neglects the individual impact of each measure of the compound variable, leading to a coarse-grained view of the mechanism between knowledge flows and firm performance. We develop new measures that capture the density of participants in a cluster as well as the specialization of clusters around a certain industry group (biopharmaceuticals). This allows for a nuanced view of knowledge flows stemming from a firm’s geographical location. We also refine the measure of “citations to publications” used to assess the quality of knowledge stocks (DeCarolis and Deeds, 1999), bearing in mind that citations accumulate over time. Furthermore, we introduce “clinical trials” as a new knowledge stock and “personnel growth” as a new knowledge flow variable.

Second, in terms of the interaction mechanism, previous research assumed a positive linear relationship between flows of knowledge and firm performance (DeCarolis and Deeds, 1999). Although redundancy of knowledge is often thought to benefit creativity (Nonaka, 1994), too much knowledge incurs excessive integration and coordination costs (Tiwana, 2008). Recent work specifically questions the assumed linear relationship between knowledge flow variables and firm performance (Folta et al., 2006, Rothaermel and Deeds, 2006). We attempt to resolve this issue by extending KSF by proposing a non-linear (inverted U-shaped) impact of flows of knowledge on firm performance.

Third, we analyze this mechanism by drawing on panel data econometrics to provide robust statistical support. Since stocks and flows of firm knowledge are dynamic and will change across firms and time, the cross-sectional research design found in prior work is limited in terms of making
statistically valid inferences (Bierly and Chakrabarti, 1996, Bowen and Wiersema, 1999, Hill and Hansen, 1991). The current study is the first to show the time-resolved impact of a comprehensive set of knowledge stock and flow variables on firm performance.

We use our comprehensive set of variables to analyze a set of public biopharmaceutical firms, because the biotechnology industry has diversified into new therapeutic areas and technologies since DeCarolis and Deeds’ (1999) original study. Firm knowledge is now dispersed between big pharmaceutical firms, smaller biotechnology firms, and academic organizations. The biopharmaceutical industry group, which is science-based, innovative, and rapidly evolving, is highly suited to the examination of knowledge stocks and flows. New products in this industry depend on firms’ capability to exploit knowledge flows and integrate them in their knowledge stocks (Zhang et al., 2007).

The objectives of this paper are to advance the knowledge-based view of the firm by introducing an extended KSF, and to advance the state of empirical knowledge through new data and a refined research design. In the next section, we review prior work on the stocks and flows of a firm’s knowledge. The third section develops our new model, and in the fourth section we present our research design. The fifth section presents the results, and finally, we discuss implications for theory and further research.

Towards a new model of knowledge stocks and flows and firm performance
Below we develop a new stocks and flows model of firm knowledge. The model is depicted in figure 1. With this model, we aim at assessing the relative impact of knowledge-related firm characteristics on performance and predicting the overall impact of firm knowledge on success in the biopharmaceutical industry.
Flows of firm knowledge

Unlike previous research which assumes a positive linear relationship between the flows of knowledge and firm performance (DeCarolis and Deeds, 1999) we propose an inverted-U shaped impact of knowledge flow variables on firm performance. In the following we separately discuss each flow variable and its relation to firm performance.

Cluster participation

Clusters are groups of interconnected firms and institutions concentrated in a geographical location (Porter, 1998). Building on research in economic geography (e.g., Malecki, 1985), DeCarolis and Deeds (1999) developed the variable “munificence of location” and identified clusters as a knowledge flow channel. A firm’s location in a geographical cluster enables it to benefit from knowledge spillover from other cluster participants (Jaffe et al., 1993). Knowledge spillover occurs through formal and informal interaction of employees, exchange of research results, a fluid labor market for experts, and so on. Investors are attracted to active geographical clusters populated by innovative firms, universities, promising research projects, and unique expertise. Environmental munificence characterizes geographical areas that can sustain growth through resources and knowledge (Starbuck, 1976). DeCarolis and Deeds (DeCarolis and Deeds, 1999) propose that the environmental munificence of a firm’s geographic area should have a positive relationship with firm performance, for which they
obtain evidence in their sample.

Yet, there is always a two-way knowledge spillover in a cluster. Whereas knowledge inflow to a firm positively impacts on firm performance, outflow from the firm to other cluster participants may reduce its competitive advantage. Firms cannot entirely avoid knowledge outflow even if intellectual property rights or secrecy are exercised to protect their knowledge (e.g., Dimaggio and Powell, 1983, von Hippel, 1987). Because of knowledge spillovers, firms in a cluster are likely to experience mimetic isomorphism and resemble other firms facing similar environmental conditions (Dimaggio and Powell, 1983, Ponder and StJohn, 1996). With time, as more competitors join the cluster, imitation of a firm’s knowledge may become widespread (Boisot and Griffiths, 1999). The net effect of inflow and outflow of knowledge brings decreasing marginal advantages to a firm’s performance, as cluster participation density increases. After a certain point, the net effect might even end in negative returns. Accordingly we propose:

**H1a: The density of participants within a cluster has an inverted U-shaped impact on firm performance.**

A recent study by Aharonson, Baum, and Feldman (2007) shows that spillover opportunities in a geographic region are impacted by several additional factors that might characterize environmental munificence. Most importantly, knowledge spillover is promoted by technological specialization among firms, due to positive information externalities. This factor is of particular relevance when an embryonic industry becomes more differentiated and specialized, and the value of knowledge flow is contingent on this specialization within a cluster. Prior research suggests that knowledge spillovers are greater among firms in a cluster specializing in the same technology area than across technology areas (Baptista and Swann, 1998, Wallsten, 2001). However, specialization comes at a cost. First, the benefits of specialization are balanced by the risk of over-specialization, narrowed knowledge bases, and stagnation, leading to lower variety (Maskell and Malmberg, 2007). Second, high specialization in a cluster increases competitive rivalry within the cluster, which in turn puts pressure on the firm’s financial performance. Like within-industry rivalry, intensified rivalry within a cluster might result in decreased profitability for the firm (Cool et al., 1999). Therefore, we
propose:

\[ H1b: \text{The specialization of firms within a cluster has an inverted U-shaped impact on firm performance.} \]

**Alliances**

DeCarolis and Deeds (1999) proposed the firm’s set of alliances as a knowledge flow variable. The literature on strategic alliances has argued that alliances provide a firm with access to its partners’ knowledge and help increase R&D productivity (Deeds and Hill, 1996). However, findings differ regarding the positive impact on firm performance of knowledge flows in alliances; support was found in Kelley and Nakosteen (2005), Gulati and Higgins (2003) and DeCarolis and Deeds (1999), while others rejected the hypothesis (Dyer et al., 2008, Jiang and Li, 2008). Recent research also casts doubt on the linear reasoning behind alliances and performance in the stock and flow model, and might explain why the variable did not turn out to be significant in the regression models of past studies. A reason for a non-linear relationship might be firms’ limited capacities in the processing of knowledge, management, and financial resources. After a certain point of learning from a partner, the gains from the alliance are offset by the costs of executing it, and a negative net effect on performance might ensue. Rothaermel and Deeds (2006) investigated a sample of 325 biotechnology firms and found an inverted U-shaped relationship between the number of alliances and new product development. Hence, we propose:

\[ H2: \text{The number of alliances a firm forms has an inverted U-shaped impact on firm performance.} \]

**R&D intensity**

The stocks and flows model identifies investment in R&D as one of the flow variables and suggests that it enhances knowledge stock through the flow of new scientific knowledge created within the firm (Dierickx and Cool, 1989). According to Cohen and Levinthal’s (1990) study of absorptive capacity, prior investment in R&D positively affects a firm’s ability to absorb new knowledge from the outside, including alliance partners, and its performance. However, research found equivocal support for this relationship (Coombs and Bierly, 2006, DeCarolis and Deeds, 1999, Droge et al., 2003). Often firms
cannot invest solely in R&D to explore new opportunities; they must dovetail their investments in manufacturing and marketing to exploit their knowledge stocks and commercialize their research. Thus, firms act “ambidextrously”; they seek to be efficient and aligned in their current business while investing enough in R&D to be able to adapt to changes in their environment (Gibson and Birkinshaw, 2004). Every investment has an opportunity cost, and an unbalanced investment in exploration and exploitation activities damages firm performance (Rothaermel and Alexandre, 2009). Successful firms find the optimal investment point that maximizes firm performance; increasing R&D expenditures enhances firm performance with diminishing returns until that balance is reached. R&D investments increased beyond the point of balance will result in lower performance. Hence, we propose that:

**H3: Investment in R&D has an inverted U-shaped impact on firm performance.**

**Personnel growth**

Prior work on stocks and flows of knowledge did not consider new personnel as a knowledge flow channel. To have a more complete model, we introduce personnel growth as a variable. Madsen, Mosakowski, and Zaheer (2003) showed that the firm’s knowledge can be augmented by the inflow of personnel into the firm. For example, hiring new people brings new expertise to research, production, management, services, and sales and has a positive impact on firm performance in a knowledge-intensive business. Yet, over time, a linear relationship between personnel growth and firm performance is questionable. A rapid inflow of new personnel might bring down labor productivity (Koch and McGrath, 1996) and in other ways create challenges of integrating expertise into a firm’s culture (Raisch and von Krogh, 2007). Thus, we propose:

**H4: The annual growth rate of personnel has an inverted U-shaped impact on firm performance.**

**Stocks of firm knowledge**

Knowledge stock is concerned with the content or outcome of knowledge creation, transfer, storage, and reuse. Products, patents, and research pipelines constitute important firm knowledge, which are used as stock variables in the literature (Coombs et al., 2006, DeCarolis and Deeds, 1999, Kelley and Nakosteen, 2005, Rothaermel, 2001). Measuring knowledge stocks inevitably raises the question of
what makes content valuable, to which the answers are industry specific. While flow variables may be
dynamic and generic, stock variables make predictions for a particular industry, although there may be
strong similarities across industrial spaces (Chang and Singh, 1999, Helfat, 1997). For example, the
role of patents in the semiconductor industry matches that in the biotechnology industry. In this study,
we account for the increasing differentiation of the biotechnology industry by focusing on the
biopharmaceutical industry group. The biopharmaceutical industry segment consists of firms that
develop and/or manufacture drugs for human therapeutics and/or diagnostic purposes and that have at
least one product (on the market or in the pipeline) that can only be produced by biotechnological
methods during the development and/or manufacturing processes. In the next section we discuss
separately each stock variable and its relation to firm performance.

**Clinical trials**

Prior research has suggested a firm’s pipeline strength is one of the indicators of its knowledge stocks
(DeCarolis and Deeds, 1999). The impact of the number of “products in pipeline” on firm
performance has been tested across several industries, including biotechnology (Coombs, et al., 2006,
DeCarolis and Deeds, 1999, Rothaermel, 2001), and the computer and telecommunication industries
(Kelley and Nakosteen, 2005). While some authors (DeCarolis and Deeds, 1999, Kelley and
Nakosteen, 2005, Rothaermel, 2001) found support for a positive impact, others (Coombs, et al., 2006)
found no significant impact. In the case of biotechnology, the contradicting results may stem from the
fact that a firm’s product pipeline consists of two parts: a highly regulated chain of clinical trials for
developing a therapeutic compound for a specific medical indication or medical need, and a less
regulated phase of basic and pre-clinical research for new technology and compounds within the
company (Chiaroni et al., 2008). Counting products in pipeline as a proxy for knowledge stocks can be
misleading, since having one compound under development for several medical indications during the
clinical trials would be treated in the same way as having several compounds targeting one medical
indication each. Especially in the pharmaceutical industry companies introduce several compounds
into their pipeline for clinical trials, which either target the same medical need or utilizes the same
development resources, in order to increase the probability of a successful therapeutic on the market
(Girotra et al., 2007). Clearly, knowledge created in clinical trials (development of therapeutics for
medical indications) and in basic/preclinical research (development of technologies and compounds) is different in these two cases. To have a more fine-grained knowledge stocks variable, we distinguish between stocks created in basic/preclinical research and stocks created during clinical trials. To capture the knowledge of a biopharmaceutical firm in terms of clinical trials, we introduce the number of completed trial phases as a knowledge stock variable. (We deal with the measure of knowledge stocks in basic/preclinical research in the section on patents below.) As shown in prior research, in the biopharmaceutical industry time-to-market for a new therapeutic is crucial for a firm to appropriate sufficient returns from R&D-related investments (Erden et al., 2009). Therefore, the more efficiently and effectively a firm conducts its clinical trials, the higher the returns from its investments. Nevertheless, this capability is not easy to build and requires years of experience with different compounds for various medical indications in each phase of the clinical trials. Hence, we propose:

*H5: The accumulated number of completed phases of clinical trials has a positive impact on firm performance.*

**Patents**

Another knowledge stock variable is patents held by a firm (DeCarolis and Deeds, 1999). Investment in scientific research may not increase firm performance unless the firm converts that research to an applied technology (Gittelman, 2007). Thus, “innovation,” when taken to mean the commercialization of patented knowledge, should positively impact on firm performance, especially in science-based industries such as biotechnology, where patents protect the new compounds that are developed for specified medical indications during preclinical research and clinical trials (Kang and Lee, 2008). Patents can also be seen as an indicator of a firm’s commitment to innovation (DeCarolis and Deeds, 1999). For example, Ernst (2001) investigated 50 German machine tool manufacturers between 1984 and 1992 and found that patent applications lead to sales increases with a time lag of two to three

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³ The process of bringing a new drug to the market consists of different stages like drug discovery, preclinical testing, and clinical trials. The clinical trials are conducted in four phases, known as Phase 1, 2, 3, and 4 clinical trials. In Phase 1, sponsors conduct studies on 20-80 healthy volunteers to evaluate drug safety, determine a safe dosage range, and identify side effect. In Phase 2, the drug effectiveness is tested on 100-300 volunteered patients. In Phase 3, the drug safety and effectiveness is tested on 1000-3000 volunteered patients. In Phase 4, post marketing studies are conducted to get additional information including the drug's risks, benefits, and optimal use (see ClinicalTrials.gov)
years. We expect a similar relationship to hold for the biopharmaceutical industry.

*H6: The accumulated number of a firm’s patents has a positive impact on firm performance.*

**Scientific publications**

In biotechnology, innovation depends strongly on basic scientific activities (Pisano, 1994). Biotechnology firms tend to publish the results of their basic and preclinical research activities in scientific journals, so that their stock of knowledge also consists of high quality research papers. Quality is reflected in frequent citations of these papers by other publications. DeCarolis and Deeds (1999) reasoned that the number of citations of a firm’s published research papers positively impacts on firm performance, and found evidence supporting this argument. They provided a detailed discussion of prior work on citation analysis and fields of applications (van der Eerden and Saelens, 1991), and proposed that the number of citations functions well as a proxy for a firm’s stock of knowledge. Recent investigations lend further support to the use of this proxy (see Han, 2007): Firms with more citations display a higher stock of scientific knowledge, and we expect this general result to hold for biopharmaceutical firms.

However, a refinement is called for in the new, time-resolved model. Citations can only be observed after some time and so is not always a good predictor of the future potential of the paper cited. Citations accumulate over time and at a given point measures may be biased toward older articles. To provide a more complete assessment of knowledge stock, it is useful to observe publications in “high impact” journals within a given scientific field or subfield. A journal’s impact factor is a measure of the frequency with which an average article in the journal has been cited over a certain period. A paper published in a journal with a higher impact factor has a greater likelihood of being cited by future publications, compared to papers published in lower impact journals. In that case, papers published in a high impact journal will potentially contribute more to the stock of firm knowledge than others. Thus, we propose:

*H7a: The number of publications of a firm, weighted with the impact factors of the respective journals, has a positive impact on firm performance.*
Another publication-related knowledge stock variable is the \( h \)-index, which quantifies the cumulative impact and relevance of the scientific output of a single researcher or research team (Hirsch, 2005). This information includes the number of papers published and the number of citations for each paper. It combines the effects of “quantity” (number of publications) and “quality” (number of citations) and takes into account the continuity of the firm’s publication track record (Braun et al., 2006). Therefore we suggest that:

\( H7b: \) The \( h \)-index of the publications of a firm’s research output has a positive impact on firm performance.

**Research design**

**Sample selection: public companies**

We tested our model with a sample of public biopharmaceutical firms, using the Bloomberg\textsuperscript{®} database to develop a list of all public biopharmaceutical companies worldwide. For this, Standard & Poor’s global industry classification standard (GICS) was used (effective Friday August 29, 2008). We recorded all companies belonging to the industry segment *Pharmaceuticals, Biotechnology & Life Sciences* (GICS: 3520) of the *Health Care* sector (GICS: 35). After we removed double entries and entries of stock derivatives, we had 1260 public companies of which 527 belonged to the *Biotechnology* industry classification (GICS: 352010), 572 to the *Pharmaceuticals* industry classification (GICS: 352020) and 161 to the *Life Science Tools & Services* classification (GICS: 352030). The resulting list of firms was coded according to the definition of a biopharmaceutical firm based on Rader (2008):\textsuperscript{4} Three independent coders with a background in the biological sciences (BSc or higher) were trained face-to-face in coding the sample according to the coding criteria, using publicly available information from annual reports, the firms’ websites, and financial information services such as Yahoo!\textsuperscript{®} Finance. Intercoder reliability (Cronbach’s alpha) directly after the coding was 0.712. Cases of disagreement among the three coders were discussed in a plenum and this led to

\textsuperscript{4} In order to classify as a biopharmaceutical firm, the firm under investigation had to fulfill the following two criteria: (1) the firm develops and/or manufactures drugs for human therapeutic and/or diagnostic purposes; (2) at least one of the drugs (on the market or in pipeline) can only be produced by biotechnological methods during the development and/or manufacturing processes.
increased intercoder reliability of 0.973. A firm was counted as a public biopharmaceutical firm if at least two of the three coders agreed, after discussion, that it met the coding criteria. This resulted in a list of 233 public biopharmaceutical firms. Next, the list was narrowed to firms going public before January 1, 2003, ensuring at least five years’ available, longitudinal data for the period 2003–7. Firms with no clear initial public offering (IPO) date, or firms that executed a reverse takeover transaction in that period, were dropped from the sample. The final sample included 167 firms, representing 13.3% of the initial population. By studying firms in a single industry group, differences in other environmental factors than those stated in the study are minimized and so are not examined in this research.

**Sample selection: private companies**

We used the BioScan® database to derive a list of all private biopharmaceutical firms worldwide. For this, all firms belonging to the BioScan categories “privately held,” “privately owned,” “privately-held, family owned,” and “filed for IPO (privately held)” were recorded effective Friday, June 12, 2009. From this list of 1109 firms, we removed those not belonging to the industry group Pharmaceuticals, Biotechnology & Life Sciences (GICS: 3520), resulting in 824 private firms. Each private firm was then coded by the same three independent coders using the definition of a biopharmaceutical firm. Intercoder reliability (Cronbach’s alpha) directly after the coding was 0.754. Disagreements between the three coders were discussed in plenum and led to an increase of intercoder reliability to 0.981. This resulted in a list of 123 private biopharmaceutical companies.

**Variables and data collection**

**Firm performance**

The performance of a firm can be operationalized using accounting-based, market-based, or combined indicators. The firm performance in the biopharmaceutical industry is often not reflected by traditional accounting-based indicators. For example, accounting-based measures such as sales growth, return on

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5 *BioScan* is published by the American Health Consultants Inc. and provides a comprehensive and publicly available directory covering the global biotechnology and pharmaceutical industry. It has been used in a number of prior studies on alliances (Lane and Lubatkin, 1998, Rothaermel and Deeds, 2004, Shan et al., 1994).
sales (ROS), return on investment (ROI), or return on assets (ROA) fail to reflect true performance, since few firms in this industry group have launched products that generate profit or revenue from sales (Joos and Zhdanov, 2008). Biopharmaceutical firms mostly generate revenue streams through royalties from out-licensing their intellectual property, through milestone payments in collaborative drug development processes, or through research grants from public agencies. At this stage of industry group development, they rarely realize profit, such as earnings before interest and taxes (EBIT).

As a second alternative, we evaluated performance indicators that combine accounting-based and market-based measures, namely total shareholder return (TSR), the price-to-earnings ratio of a stock (P/E-ratio), and Tobin’s Q. By definition, firms with no earnings have an undefined P/E-ratio, so a high number of firms would drop out of the sample and limit the statistical inference of our hypotheses. TSR accounts for the change of a firm’s stock price as well as the dividends the firm pays. Dividends are usually paid to stockholders as a portion of corporate profit. Although only few companies in the biopharmaceutical industry segment show profits, TSR remains defined for firms not paying dividends. However, applying TSR as the dependent variable in our model gave inconsistent and non-robust results because of missing data not reported in the Bloomberg® database or in the annual reports of the firm, causing a severe drop in available observations. Tobin’s Q has frequently been used as a performance measure in prior research (Bebchuk and Cohen, 2005, Brown and Taylor, 2006, Uotila et al., 2009) and is defined as the ratio of the market value of a company’s financial claims to the replacement value of its assets (Lee and Tompkins, 1999). The frequently used and generally accepted approximation of Tobin’s Q takes the book value of total assets as a proxy for the replacement value of a firm’s assets (Chung and Pruitt, 1994, Kaplan and Zingales, 1997). Although Tobin’s Q is a defined and proven measure of firm performance, it gave inconsistent results for our model and data on biopharmaceutical firms. This might be due to two reasons: First, missing data—when calculating Tobin’s Q, observations become lost, which has a negative impact on statistical
inference (Lewellen and Badrinath, 1997). Second, we use total assets in our models to control for firm size\(^6\), which results in nearly perfect multicollinearity.

Finally, we checked for purely market-based indicators of firm performance (Allen, 1993). DeCarolis and Deeds (1999) used the market value at the end of the first trading day to operationalize firm performance. However, investors’ optimism at the time of the offering might lead the IPOs to lose value in the long run, so that firm performance tends to be overestimated in a cross-sectional research design. In a longitudinal research design this problem is eliminated and market-based measures can be assumed to reflect long-term prospectus and short-term performance of a biopharmaceutical firm more accurately than any other accounting-based or combined indicator (Lubatkin and Shrieves, 1986). Consequently, we used market capitalization to operationalize the performance of the biopharmaceutical firms in our sample. We used the Bloomberg\(^8\) database to retrieve time-resolved data on market capitalization. The market capitalization of a firm was calculated by taking the share price of the last trading day of each year multiplied by the respective number of shares a company issued. Values of market capitalization in foreign currencies were converted into $US, based on the annual average exchange rate for each foreign currency in the respective years.

**Density of participants**

Cluster density is measured as the overall number of public and private pharmaceutical, biotechnology, and life science firms in a given cluster divided by the cluster area. Previous literature mostly used Metropolitan Statistical Areas\(^7\) (MSA) to identify cluster boundaries (DeCarolis and Deeds, 1999, Folta, et al., 2006). Clusters defined according to MSA do not necessarily provide accurate information on the clusters in a specific industry, so this approach is conceptually problematic; a cluster might consist of more than one MSA, or one MSA might be too large to capture

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\(^6\) The traditional proxy for size—number of employees—resulted in nearly perfect multicollinearity, as it was highly correlated with the independent variable personnel growth. Therefore we introduced the book value of total assets as a control variable for firm size.

\(^7\) According to the U.S. Office of Management and Budget bulletin (No. 10-02), “MSA have at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties.”
knowledge spillovers due to clustering (Wallsten, 2001). To obtain more precise information on existing clusters, we collected unique data on the geo-locations of the firms in our sample and subsequently conducted a cluster analysis. For this, we pooled the list of public companies belonging to the industry group Pharmaceuticals, Biotechnology & Life Sciences (see sample definition) with the list of private companies from the BioScan® database, resulting in a list of 2084 firms. Based on headquarters addresses, we used the Google Maps algorithm to generate the exact geocode (longitude and latitude) of firm location. Since the cluster density changes each year due to the emergence of new firms, we recorded the year of foundation for each firm, as stated on its website, in annual reports, or from financial information services, such as Yahoo! Finance. Firms without a clear address or identifiable geocode, as along with those without an identifiable year of foundation, were removed from the clustering sample, resulting in a list of 1777 firms. Based on the geocodes, we grouped all companies into five regions to account for the regional circumstances of cluster formation: Africa (two firms), Americas (1024), Asia (282), Australia-New Zealand (75), and Europe-Middle East (394). As a next step, we ran a hierarchical clustering algorithm (Ward’s linkage method) on the point-to-point distance matrix of companies existing in 2003. Based on the results of the clustering algorithm, the firms in each region were grouped into a defined number of clusters (Africa 2, Americas 45, Asia 31, Australia-New Zealand 7, Europe-Middle East 50). The area of each cluster was approximated as a rectangle, with the borders of the rectangle defined by the geocodes of the outermost firms in the respective cluster. To allow for the time evolution of cluster size, firms emerging in the years of 2004–7 were assigned to the clusters at least distance from the center of the respective cluster. The cluster borders—and therefore the area for each cluster—were adjusted accordingly for each year.

Unlike DeCarolis and Deeds (1999), we omitted the number of universities in a cluster when measuring cluster density. As all companies within a cluster are provided with the same level of university knowledge spillover, the number of universities in a cluster should have no impact on the

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8 The area in this model is dimensionless and based on the numerical differences between geocodes. Converting the area into SI units would not change or bias the results of our panel regression model. The density of clusters with fewer than three participants was set to zero.
inverted U-shaped relationship between cluster density and firm performance. Instead, it should have a moderating effect.

**Specialization of firms**

Firm specialization was calculated as the number of biopharmaceutical firms, identified from the coding results explained in the section on sample selection, divided by the total number of public and private firms belonging to the industry segment *Pharmaceuticals, Biotechnology & Life Sciences* in each cluster. Because new firms emerged between 2003 and 2007, firm specialization was evaluated individually for each cluster in each year.

**Alliances**

We obtained each firm’s alliance history from the BioScan® database that reports and classifies press releases by biotechnology and pharmaceutical firms. We recorded all detailed information on alliances, collaborations, and license agreements reported by the companies in our sample within the maximum time span of the historical data available in the BioScan® database (starting from 1999). We operationalized the knowledge flow resulting from alliances of a firm by the accumulated number of all alliances formed from 1999 until the respective years.

**R&D intensity**

In our model, R&D intensity is measured through R&D expenditures, as in prior studies (DeCarolis and Deeds, 1999). The data on R&D expenditures for the years 2003–7 were retrieved from the Bloomberg® database. Values of R&D expenditure in foreign currencies were converted into $US, based on the average annual currency exchange rate for each foreign currency in the respective years.

**Personnel growth**

Personnel growth is measured as the annual growth rate of numbers of employees. We used the Bloomberg® database to retrieve historical data on numbers of employees. Based on the values on December 31 of each year, the number of employees was recorded for the time span 2002–7 to calculate personnel growth for the years 2003–7.

**Patents**
We obtained each firm’s patent history as listed in the Derwent Biotechnology Abstracts\(^9\) database, which lists patents from 40 patent-issuing authorities worldwide. We first developed a list of search terms for each firm, taking into account possible misspellings of firm names (in the field “patent assignee”) as well as taking into account patent assignees that are full subsidiaries of a firm in our sample in the respective years. We then recorded detailed information of the patents issued by all firms in our sample as stated within the maximum time span of the Derwent Biotechnology Abstracts database. We operationalized the knowledge stored in patents with the accumulated number of patents a firm issued until the respective years.

**Clinical trials**

We obtained historical data of each firm’s clinical trials as listed on the database ClinicalTrials.gov\(^10\), which records clinical trials conducted in over 172 countries worldwide. We first developed a list of search terms for each firm, taking into account possible misspellings of the firm name (as in the field “sponsor”) as well as taking into account industrial sponsors of clinical trials that are full subsidiaries of a firm in our sample in the respective years. We then recorded detailed information of all entries for clinical trials by all firms in our sample. Although ClinicalTrials.gov started recording in 2002, the majority of publishing firms disclose their entire history of clinical trials. For each firm we evaluated the accumulated number of completed clinical trials for each year over the maximum time span of available data of each firm. We do not distinguish between different types of clinical trials (e.g., Phase I, Phase II, Phase III) treating them as equally important for the accumulation of firm knowledge and its impact on firm performance. From this data list, we entered the values for the years 2003–7 into our model.

**Scientific publications**

\(^9\) Derwent Biotechnology Abstracts is published by Ovid Technologies Inc. to serve the scientific and healthcare communities. It contains information from over 1200 scientific and technological journals, patents from 40 patent-issuing authorities, and international conferences and meetings. Derwent Biotechnology Abstracts contains important worldwide patent information and was used in several previous studies (Gittelman and Kogut, 2003; Gittelman, 2007; Zhang et al., 2007).

\(^10\) ClinicalTrials.gov offers up-to-date information on clinical trials sponsored by the U.S. National Institute of Health, other federal agencies, and private industry.
The quality and number of scientific publications of a firm in each year was measured as the sum over all scientific papers published by a firm, weighted with the five-year impact factor of the respective journal:

\[ \phi_y = \sum_i F_i \cdot N_{iy} \]

where \( N_{iy} \) is the number of published papers in a given journal \( i \) in a given year \( y \), and \( F_i \) is the five-year impact factor of the respective journal \( i \). We obtained each firm’s publication track record within the maximum time span of the Thomson Reuters Web of Knowledge database. For this, we used the firm name as a search item in the address field, taking into account possible misspellings. From the resulting list of publications we extracted the journals, and recorded their five-year impact factors using the journal citation reports for science and social science of the Thomson Reuters Web of Knowledge database. Journals with no retrievable five-year impact factor were cancelled out, including the corresponding scientific papers of each firm. For our model, we entered the values for the years 2003–7.

**h-index**

The quality and output of publications from a firm’s research team were calculated using the \( h \)-index (Hirsch, 2005). In this approach, a research team has index \( h \) if \( h \) of their \( N_p \) scientific publications have at least \( h \) citations each and the other \( (N_p - h) \) papers have < \( h \) citations each. Historical data on the citation pattern of all scientific papers published by the biopharmaceuticals firms were recorded (see the section on scientific publications, above, for how we retrieved a company’s publication track record) within the maximum time span of the Thomson Reuters Web of Knowledge database. We then calculated the \( h \)-index of each firm for the years 2003–7.

**Control variables**

IPO age: This controls for the age of the firm since firms accumulate knowledge over time, which impacts on their capacity to absorb knowledge flows. It is measured as the number of years since the firm disclosed its initial public offering.
The market value of the total assets of a firm: This controls for firm size since the traditional measure of firm size—number of employees—is highly correlated with one of the independent variables in our model (hypothesis 4: personnel growth).

We used the Bloomberg® database to record market values of total assets on December 31 of each year for the time span 2003–7. Market values of total assets in foreign currencies were converted into $US, based on the annual average currency exchange rate for each foreign currency in the respective years.

**Statistical analysis**

We tested the stock and flow model using a longitudinal panel research design with $N = 167$ companies over $T = 5$ time periods from the years 2003–7. The models used in panel data analysis need to be estimated by methods that handle possible infringements of the Gauss-Markov assumptions. As long as there are no groupwise or other heteroskedastic effects on the dependent variable (i.e. market capitalization), ordinary least square (OLS) regression for fixed or random model estimation can be used (Sayrs, 1989). Therefore, we first tested the characteristics of our data to determine which standard error estimator (i.e. fixed or random) to use. For that purpose, we applied a Hausman test, investigating the null hypothesis that the preferred model is the random effects model (Green, 2008). The results of this test suggested the use of a fixed effects model for our data set ($\text{Prob } > \chi^2 = 0.030$).

Next, we verified if there are any heteroskedasticity or autocorrelation effects to evaluate whether an OLS estimator would be suitable for our panel data. We applied a modified Wald test for groupwise heteroskedasticity (Laskar and King, 1997) as well as the Wooldridge test for first-order autocorrelation in panel data (Wooldridge, 2003). Both of these tests showed significant results (Wald-test: $\text{Prob } > \chi^2 = 0.000$; Wooldridge-test: $\text{Prob } > F = 0.000$). Thus, an OLS estimator in a fixed effect panel model would be biased and not suitable for our panel data.

We therefore focused on standard error estimators for $N > T$ that are consistent in any case of heteroskedasticity and first-order autocorrelation, namely the Rogers (Rogers, 1994) and Driscoll-Kraay standard error estimators (Driscoll and Kraay, 1998). The latter estimator also provides robust
results in case any cross-sectional dependence is present in the data set. In the case of no cross-sectional dependence, the Rogers and Driscoll-Kraay standard errors should only differ slightly (Hoechle, 2007). We compared the results of a fixed effects model based on the Rogers standard error estimator to the fixed effects model based on the Driscoll-Kraay standard error estimator (robustness against first-order autocorrelation of the moving-average type). To accomplish the first-order autocorrelation in our panel data, the lag of the moving-average type was set to one year. For some predictors, standard errors of the coefficients changed on a scale of more than one magnitude between the models, which contradicts the assumption of only slightly different results (Hoechle, 2007). The same picture appeared when using the Newey-West type GMM estimator (Newey and West, 1987), which led us to conclude that there is serious cross-sectional dependence in our panel data. Thus, we decided to test our hypotheses using the Driscoll-Kraay estimators for standard errors in a fixed effect panel regression model with a lag (of the moving-average type) of one year, as provided by the xtscc Stata module (Hoechle, 2007).

**Results**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market capitalization</td>
<td>809</td>
<td>10755.510</td>
<td>31962.540</td>
<td>0.034</td>
<td>2699532.600</td>
</tr>
<tr>
<td>Cluster density</td>
<td>835</td>
<td>98.925</td>
<td>280.292</td>
<td>0.000</td>
<td>2567.635</td>
</tr>
<tr>
<td>Specialization of firms</td>
<td>835</td>
<td>0.246</td>
<td>0.120</td>
<td>0.063</td>
<td>1.000</td>
</tr>
<tr>
<td>Total alliances formed</td>
<td>835</td>
<td>14.131</td>
<td>24.247</td>
<td>0.000</td>
<td>180.000</td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>724</td>
<td>497.472</td>
<td>1331.154</td>
<td>0.000</td>
<td>8089.000</td>
</tr>
<tr>
<td>Personnel growth</td>
<td>647</td>
<td>0.160</td>
<td>1.122</td>
<td>-0.998</td>
<td>17.000</td>
</tr>
<tr>
<td>Clinical trials</td>
<td>835</td>
<td>14.523</td>
<td>51.498</td>
<td>0.000</td>
<td>518.000</td>
</tr>
<tr>
<td>Issued patents</td>
<td>835</td>
<td>111.943</td>
<td>339.055</td>
<td>0.000</td>
<td>3343.000</td>
</tr>
<tr>
<td>Weighted publications</td>
<td>835</td>
<td>2381.514</td>
<td>7387.455</td>
<td>0.000</td>
<td>68914.280</td>
</tr>
<tr>
<td>h-index</td>
<td>835</td>
<td>25.534</td>
<td>47.112</td>
<td>0.000</td>
<td>294.000</td>
</tr>
<tr>
<td>IPO age</td>
<td>835</td>
<td>16.802</td>
<td>22.143</td>
<td>0.000</td>
<td>102.000</td>
</tr>
<tr>
<td>Total assets</td>
<td>772</td>
<td>5524.240</td>
<td>16736.190</td>
<td>0.001</td>
<td>123684.000</td>
</tr>
</tbody>
</table>

*Table 1 Descriptive statistics*
The descriptive statistics of the predictors in our model of stocks and flows of firm knowledge are shown in Table 1. In the time period 2003–7, an average firm in our sample had a market capitalization of $US10.755 billion with a book value of total assets of $US5.524 billion, had spent $US497 million on research and development, formed 14.1 alliances, received 111.9 patent grants, conducted 14.5 clinical trials, and had been publicly traded for 16.8 years. Furthermore, an average biopharmaceutical firm showed a personnel growth of 16% and was situated in a cluster with a density of 98.2 pharmaceutical, biotechnological, or life science companies per unit cluster area, from which on average 24.6% were as well specialized in biopharmaceuticals. The research output of an average biopharmaceutical firm was 25.5 (h-index) with a journal impact factor-weighted number of publications of 2381 each.

<table>
<thead>
<tr>
<th>Dependent variable: Market capitalization</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
<td>S.E.</td>
<td>Coeff.</td>
<td>S.E.</td>
</tr>
<tr>
<td><strong>Explanatory variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster density</td>
<td>-0.051</td>
<td>(0.015)**</td>
<td>-0.032</td>
<td>(0.008)**</td>
</tr>
<tr>
<td>(Cluster density)^1</td>
<td>0.029</td>
<td>(0.009)</td>
<td>0.031</td>
<td>(0.006)**</td>
</tr>
<tr>
<td>Specialization of firms</td>
<td>0.176</td>
<td>(0.235)</td>
<td>0.260</td>
<td>(0.175)</td>
</tr>
<tr>
<td>(Specialization of firms)^1</td>
<td>-0.083</td>
<td>(0.294)</td>
<td>-0.439</td>
<td>(0.258)-</td>
</tr>
<tr>
<td>Total alliances formed</td>
<td>-0.371</td>
<td>(0.068)**</td>
<td>-0.346</td>
<td>(0.059)**</td>
</tr>
<tr>
<td>(Total alliances formed)^2</td>
<td>0.142</td>
<td>(0.032)**</td>
<td>0.213</td>
<td>(0.034)**</td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>0.992</td>
<td>(0.152)**</td>
<td>0.887</td>
<td>(0.152)**</td>
</tr>
<tr>
<td>(R&amp;D intensity)^2</td>
<td>-0.401</td>
<td>(0.40)**</td>
<td>-0.171</td>
<td>(0.049)**</td>
</tr>
<tr>
<td>Personnel growth</td>
<td>0.014</td>
<td>(0.015)</td>
<td>0.006</td>
<td>(0.011)</td>
</tr>
<tr>
<td>(Personnel growth)^2</td>
<td>-0.012</td>
<td>(0.015)</td>
<td>-0.008</td>
<td>(0.012)</td>
</tr>
<tr>
<td>Clinical trials</td>
<td></td>
<td></td>
<td>-0.071</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Issued patents</td>
<td></td>
<td></td>
<td>0.450</td>
<td>(0.054)**</td>
</tr>
<tr>
<td>Weighted publications</td>
<td></td>
<td></td>
<td>-0.408</td>
<td>(0.176)*</td>
</tr>
<tr>
<td>h-index</td>
<td></td>
<td></td>
<td>0.391</td>
<td>(0.110)**</td>
</tr>
<tr>
<td><strong>Control variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPO age</td>
<td>0.113</td>
<td>(0.055)*</td>
<td>0.407</td>
<td>(0.050)**</td>
</tr>
<tr>
<td>Total assets</td>
<td>0.411</td>
<td>(0.016)**</td>
<td>0.210</td>
<td>(0.052)**</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.012</td>
<td>(0.005)**</td>
<td>0.033</td>
<td>(0.013)*</td>
</tr>
<tr>
<td>Observations</td>
<td>768</td>
<td>616</td>
<td>768</td>
<td>616</td>
</tr>
<tr>
<td>within R^2</td>
<td>0.255</td>
<td>0.360</td>
<td>0.347</td>
<td>0.512</td>
</tr>
</tbody>
</table>

Note: Standardized regression coefficients with two-tailed tests. Distributions of standard errors in parentheses. + = p<0.1 level; * = p<0.05 level; ** = p<0.01 level; *** = p<0.001 level.

Table 2 Panel regression results
We set up a regression model with stepwise introduction of regressors to test how stocks and flows of firm knowledge impact market capitalization. The results of the fixed effects panel data regression with Driscoll-Kraay standard errors (lag of one year: first order autocorrelation of the moving-average type) are shown in Table 2. In Model 1 we entered firm performance and the control variables. The results are highly significant for both IPO-age and total assets on the 5% and 0.1% significance level respectively (within-$R^2 = 0.255$). In Model 2 we entered the first group of predictors: the knowledge flow variables. This model led to a higher explanation of the variance in our data (within-$R^2 = 0.360$). Only three out of five flow variables (linear as well as squared terms) were highly significant either at the 5% or 0.1% significance level. In the third model we regressed firm performance on the second group of predictors: the knowledge stock variables. Compared to Model 2, the amount of explained variance is at a similar level (within-$R^2 = 0.347$). Three out of four variables proved to be highly significant on the 5% or 0.1% significance level. Model 4 runs the regression of market capitalization on the full set of our predictors. Here, the value for the explained variance increased steeply (within-$R^2 = 0.512$) compared to the other three models. Except for the coefficients of the predictor personnel growth (insignificant) and the coefficients of the predictor specialization of firms (linear term insignificant, squared term significant at 10% level), all predictors of our model were highly significant. Comparing all four models from our stepwise introduction of regressors, there is clear robustness of the magnitude and signs of all regression coefficients in all four models.11 Interestingly, when entering predictors into the regression model (variables of knowledge stocks or flows) the intercept is not significantly different from zero.

To confirm a hypothesis, specific conditions have to be fulfilled. For the flow variables, the coefficients have to be significantly different from zero (5% significance level), with a positive sign/value for the linear term and a negative sign/value for the squared term. These two conditions ensure an inverted U-shaped relationship between the regressors and the dependent variable, with the

11 While comparing the four models, one can also observe a significant drop in the number of observations that stem from missing values in the panel data. All of the missing observations are due to missing values such as R&D expenditure, total assets, market capitalization, or employee numbers, which were not reported in the annual reports or on Bloomberg. Nevertheless, the drop in observations was lower compared to when employing TSR or Tobin’s Q as dependent variable (see the section on firm performance).
inflection point within our data range (positive-positive quadrant). With stock variables, the coefficients have to be significantly different from zero, with a positive sign/value for the linear term. If one of the specific conditions, either for a stock or a flow variable, is unfulfilled, the respective hypothesis cannot be confirmed.

Hypothesis H1a was not confirmed. The regression coefficients were significantly different from zero both in Model 2 and Model 4 (1% and 0.1% level). Nevertheless, the sign/values of the coefficients for both the linear and the squared term were the opposite of what was proposed. Contrary to our hypothesis, this indicates a parabolic relationship of cluster density and firm performance with the inflection point within our data range (positive-positive quadrant). Hypothesis H1b was also not confirmed. The regression coefficients were not significantly different from zero in all models (5% level). Contrary to our hypothesis, this indicates that the specialization of firms in a cluster has no significant impact on firm performance in our model. The third hypothesis on knowledge flow variables, H2, was not confirmed. As with hypothesis H1a, the regression coefficients were significantly different in Model 2 and Model 4 (0.1% level), but the signs/values of the coefficients were the opposite of what we proposed. This also indicates a parabolic relationship between the total number of alliances and firm performance and the inflection point within our data range (positive-positive quadrant). Hypothesis 3 was fully confirmed. The regression coefficients in both models (2 and 4) were significantly different from zero (1% and 0.1% level) and showed the proposed signs/values for the linear and the squared term. This result demonstrates an inverted U-shaped relationship of investment in R&D and firm performance with the inflection point within our data range (positive-positive quadrant). The last hypothesis on knowledge flow variables, H4, was not confirmed. In either model, the regression coefficients were not significantly different from zero, demonstrating that there is no significant impact of personnel growth on firm performance in our model. The first hypothesis on knowledge stock variables, H5, was not confirmed. Whereas the regression coefficient was significantly different from zero in Model 4 (1% level), it was not distinguishable from zero in Model 3. Contrary to our hypothesis, the sign of the regression coefficient was negative in Model 4, indicating a negative, linear relationship between the number of completed
clinical trials and firm performance. Hypothesis H6 was fully confirmed. The regression coefficients in Models 3 and 4 were significantly different from zero (0.1% level) and showed the proposed positive sign for the linear term. This result demonstrates a positive, linear relationship between the number of patents a firm issued and firm performance. Hypothesis H7a was not confirmed. The regression coefficient was significantly different from zero, in both Model 3 and Model 4 (5% level). Nevertheless, the sign/value of the coefficient was negative. Contrary to our hypothesis, this indicates a negative, linear relationship between the number of scientific publications, weighted by the impact factor of the respective journal, and firm performance. The last hypothesis on knowledge stock variables, H7b, was fully confirmed. The regression coefficient was significantly different from zero, in both Model 3 and Model 4 (0.1% level) and showed the proposed positive sign. This result demonstrates a positive, linear relationship of the h-index with firm performance in our new stocks and flows model of firm knowledge.

**Discussion and implications**

The knowledge-based view of the firm proposes that knowledge is a source of sustainable competitive advantage (Dierickx and Cool, 1989, Grant, 1996, Nonaka, 1994, Spender, 1996). The performance of firms over time depends on the stocks and flows of firm knowledge, as these constitute the basis for knowledge creation and innovation. Incorporating recent research on the knowledge-based view of the firm, this paper presents a new model of the impact of firm knowledge stocks and flows on firm performance, which we examine empirically in the biopharmaceutical industry through a longitudinal research design. By focusing on the biopharmaceutical industry segment, we sought to obtain a pure sample of comparable firms in terms of firm knowledge.

We conceptualized knowledge flows as knowledge with the potential to be integrated in the knowledge stock of a firm from four sources—participation in a geographical cluster, alliances, personnel growth, and R&D expenditure. Overall the model predicted knowledge flows having an inverted U-shaped impact on firm performance. First, for the geographical clusters, we tested the impact on firm performance of the density of cluster participants and the specialization of firms within
a cluster. According to the results, cluster density has a parabolic, U-shaped impact on firm performance, disproving the original hypothesis. One explanation could be that if there is a very small number of cluster participants, there will be fewer companies competing with similar knowledge stocks, which in turn ensures enough market share and revenue generation. Yet, if the number of cluster participants increases, the inflow of knowledge fails to compensate for the outflow until the density reaches a certain level. The diversity of knowledge flows will be low (and very similar for each firm), which leads to very similar knowledge stocks, and hence competitive parity. If the number of companies in a cluster reaches a certain level the variety might become high enough for firms to differentiate from each other because of the increased opportunity to combine knowledge from different flows (see also Fleming, 2001). In this case, increasing the variety may impact positively on firm performance. Moreover, the business model of the participants, which we have not introduced in our model, might have an impact on the relationship between cluster density and firm performance. Not all biopharmaceutical and pharmaceutical firms are direct competitors; they might constitute different parts of the same value chain by offering complementary products and services (Porter, 1998). Increasing the number of participants in a cluster might have different impacts depending on participants’ business models. It might increase firm performance if the participants are potential customers or suppliers, or it might reduce it if participants are potential direct competitors.

Second, we tested the impact of specialization within a cluster on firm performance. Specialization had only a slightly significant impact on firm performance. This accords with the findings of Feldman and Audretsch (1999), who focused on particular industries at specific locations, and found evidence that specialization of economic activity does not promote innovative output. One explanation Feldman and Audretsch suggest is that diversity across complementary economic activities sharing a common science base is more important for innovation than specialization. Another reason might be that biopharmaceutical firms are not significantly differentiated from other pharmaceutical, biotechnology, or life science firms, in terms of their knowledge stocks. If this is the case, the value of knowledge spillover might not be contingent on specialization within a cluster.
Moreover, specialization combined with cluster density might have a significant impact on performance, something we do not check in our model.

The third flow variable, number of alliances, turned out to have a parabolic, U-shaped impact on firm performance, rejecting the initial hypothesis. The results contradict previous research findings by Rothaermel and Deeds (2006) and might be explained by the superposition of two effects of the way alliances (knowledge flow) impact on firm performance. On the one hand, firms have limited capabilities in information processing and managing and learning from alliances (Schreiner et al., 2009). Each new alliance offers the opportunity to learn, resulting in time compression diseconomies for the firm that is building up its knowledge stock with knowledge flows from alliances (Dierickx and Cool, 1989). In a longitudinal analysis, firm performance should theoretically decrease with an increasing number of alliances. On the other hand, benefits accrue for the firm over time. Extensive learning may take place in alliances, extending the firm’s capability to sustain and learn from them, integrating knowledge flows into knowledge stocks. With each new alliance, firms not only potentially learn from it but also learn how to learn from alliances over time (Argyris, 1991, Hamel, 1991). If this effect was predominant in a longitudinal analysis, firm performance should theoretically increase with an increasing number of alliances. The superposition of the two mentioned, diametrically opposing effects may result in the U-shaped, parabolic impact of alliances (knowledge flow) on firm performance, as seen in our time-resolved data on biopharmaceutical firms.

The fourth flow variable, R&D expenditure, turned out to have an inverted U-shaped impact on performance, as expected. Our finding resolves the inconsistent results in the literature that assumed a linear relationship (Coombs and Bierly, 2006, DeCarolis and Deeds, 1999, Droge, et al., 2003). Successful firms operate with ambidexterity; they keep the balance between exploration of new knowledge and exploitation of existing knowledge in their current business.

Our results show that the last flow variable, personnel growth, does not have a significant effect on firm performance. There may be two reasons for this. First, in our model the growth rate assumes that each employee brings the same level of knowledge, which underestimates individual
differences (such as star scientists being hired to work on a specific technical or scientific problem). Second, our measure does not take into account the actual turnover rate of personnel, since employees can also leave the company, although the overall growth rate of personnel is positive. The length of tenure of employees who leave the company, taking their experience with them, will have an impact on firm performance, and the intensity of the impact will change, depending on an individual’s duties (manager, scientist, marketing specialist), previous experience, or level of skills (i.e., star scientist or unskilled worker).

We also tested for the impact of knowledge stocks on firm performance. The hypothesized relationship between the accumulated number of completed phases of clinical trials and firm performance was not supported. Surprisingly, the results show a significant negative effect on firm performance. There are three possible reasons for this result. First, many biopharmaceutical firms collaborate with large pharmaceutical firms to exploit their experience in clinical trials and to mitigate the costs of the activity. Therefore, a firm’s business model might have an effect on the relationship between the completed clinical trials and firm performance. Second, measuring the number of completed phases does not distinguish between the different stages/phases of clinical trials. Specialization in specific clinical trial phases might have a positive impact on firm performance. A firm that has conducted the same specific phase eight times might outperform another firm, which has completed each of the four phases (I–IV) twice, although the total number of clinical trials stays the same for both firms. Third, the financial return on the clinical trials is realized after the product reaches commercialization. The investments made to complete the clinical phases have a negative impact on firm performance if the compound under development fails to reach market (Sharma and Lacey, 2004). This negative effect is especially more severe if a biopharmaceutical company does not have enough follow up components (for the same medical need or that use the same development resources) to compensate for the investment in clinical trials (Girotra, et al., 2007). Last, assuming that all firms have the same strategic intent to research, develop, and market a therapeutic, specialization in certain areas and increasing efficiency might have a moderating effect between the number of completed clinical trials and firm performance. For example, a firm that is more efficient in bringing
one specific therapeutic through phases (and has a lower overall number of clinical trials) might have 
a higher performance level than a firm that focuses on several therapeutics and conducts many parallel 
clinical trials, some of which will not make it to market, resulting in increased sunk costs.

Our results provide strong support for the positive impact of number of patents on firm performance. This finding contradicts DeCarolis and Deeds (1999), who found a negative impact on the 0.1 significance level, and is probably due to the differences between the two research designs. DeCarolis and Deeds used a cross-sectional research design, while we use panel data analysis in our study. Panel data analysis is better at predicting causal relationships than cross-sectional design and provides more reliable results (Bowen and Wiersema, 1999, Hill and Hansen, 1991).

Contrary to our hypothesis, we found a significant negative impact of weighted number of 
publications on firm performance. There are two possible explanations for this. First, basic research is 
an uncertain, long-term investment. There is no guarantee that expenditure will generate a future cash 
flow (Rosenberg, 1990). Second, there is a trade off between basic research and applied research. 
Gittelman and Kogut’s study (2003) shows that “science” and “innovation” may follow competing 
logics. Gittelman and Kogut analyzed the production of scientific papers and patenting activities 
involving scientists in 116 biotechnology firms in the period 1988–95, and found that important 
scientific papers are negatively associated with high-impact innovations. If a firm puts too much 
weight on basic research, applied research—as well as the subsequent development of new 
therapeutics—might be overlooked due to resource constraints, which in the end negatively impact 
firm performance.

In contrast to these results and Gittelman’s findings (2007), the hypothesized positive impact 
of a firm’s $h$-index on its performance was supported. When we compare the two measures, the $h$-
index puts more weight on publication quality than quantity. To have an increased $h$-index, the 
number of citations an article receives (i.e. the quality) should exceed the current $h$-index. However, to 
have a larger weighted number of publications, it is sufficient to have a new article published in a 
lower impact journal. This result suggests that having a large quantity of publications does not
necessarily have a positive impact on firm performance—high quality publications matter far more. Firms need to invest time and resources in publishing articles, and to obtain returns from their investment, the outcome should outweigh the effort and investment made. In other words, each low quality publication might become a sunk cost, whereas each high quality publication might contribute to performance. Consequently, the quantity and quality of publications, the continuity of the firm’s publication track record (Braun, et al., 2006), and the output of the firm’s research team, are crucial to firm competitiveness. Moreover, the difference between the impact of $h$-index and weighed publications might also stem from the fact that the $h$-index reflects the realized value of publications as it takes citations into account, whereas weighted number of articles reflects the potential value of publication. Publishing in a high impact factor journal is costly and does not automatically guarantee that the content of the paper will be widely cited in the future.

In conclusion, the results of our full model show that of all the flow variables, only R&D intensity has an inverted U-shaped impact on firm performance. However, all other flow variables except cluster specialization and personnel growth show a significant impact. In addition, all stock variables show a significant impact on firm performance. Previous research suggested that knowledge stocks have greater impact on firm performance (DeCarolis and Deeds, 1999). However, when we compare Model 2, which shows only flow variables, to Model 3, which shows stock variables, we observe similar values for the variance explained in our data, which suggests that knowledge flows are as important as knowledge stocks for firm performance. Over time, firms’ performance does not depend solely on their existing knowledge but also on their search for new knowledge opportunities, through by in-house creation or from the outside.

The study makes two main contributions to the literature on the stocks and flows model of firm knowledge. First, previous research assumed a positive linear relationship (mechanism) between the knowledge flow and firm performance (DeCarolis and Deeds, 1999). Building on recent contributions, we developed and tested a new model that predicts that flow variables have an inverted U-shaped impact on firm performance. Drawing on panel data econometrics, we also provide robust statistical support for hypotheses in the new stocks and flows model. Second, we advance the work on
knowledge stocks and flows and their impact on firm performance, by introducing new and more accurate measurement variables and by testing their impact on firm performance. Prior work used data from the biotechnology industry to test the stocks and flows model, which dates back to the mid-1990s (Burrill and Lee, 1993, DeCarolis and Deeds, 1999). Our data account for recent developments in the biotechnology industry, by distinguishing and focusing on a pure sample of biopharmaceutical firms.

Although our results will help scholars and managers to understand the role of stocks and flows of firm knowledge in the biopharmaceutical industry segment, and how to exploit them optimally for superior firm performance, they should be interpreted in light of their limitations. First, while operationalizing the stock and flow variables, we made some assumptions. With knowledge contribution, for example, we did not distinguish between different cluster participants, alliances, personnel, and clinical trials. We assumed that one type of variable always has equal impact on firm performance, despite the variations within the same variable: for example, clinical trials might differ from each other according to their phase (e.g. Phase 1, Phase 2, and Phase 3). Recently, the knowledge-based view of the firm has been criticized for paying limited attention to individual-level knowledge variables (Felin and Hesterly, 2007). Our study did not investigate the quality of personnel growth among biopharmaceutical firms. Future research would benefit from additional examination of individual-level variables, such as the hiring of star scientists or their publishing or patenting activities over time. Second, in longitudinal research it is challenging to make clear distinctions between stocks and flows of firm knowledge. For personnel, for example, we assumed that new people hired into a firm represent knowledge flow, according to the assumptions of the knowledge-based view of the firm. Yet, when people are working and integrated into a firm’s culture, it makes sense to consider them as knowledge stock. To understand when new personnel become fully integrated, one needs to observe the sociological and psychological factors behind the integration process. Third, the model only takes into account the time lags of one period for the impact of knowledge flows on firm performance (first order autocorrelation of the moving-average type). Yet, one should keep in mind that a firm might be quicker to integrate knowledge from close cluster participants, than to create knowledge within its R&D facilities. Fourth, the study does not consider the depreciation of
knowledge stocks. For example, with the introduction of a new technology, firm knowledge of older technologies might become obsolete, which would lower the value of its knowledge stocks. Last, in the biopharmaceutical industry, firms that follow different business models might show different results regarding knowledge stocks and flows; these are not covered in our study. For instance, firms that generate revenues through royalties from out-licensing their intellectual property might benefit from different knowledge flows than those that generate revenues from milestone payments in collaborative drug development projects, or fully integrated drug development.

In addition, recent work draws attention to possible interaction effects between stocks and flows of organizational knowledge, as well as within stock and flow variables. For example, Gittelman and Kogut (2003) show that important scientific papers are negatively associated with high impact innovations. Future research should investigate such interaction effects to gain a more comprehensive understanding of their impact on firm performance. Last but not least, future research should test the model in different knowledge- and science-based industries to assess its overall validity in different contexts.

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EGOS conference. Amsterdam, 2008. Knowledge Sharing in inter-Organizational Communities: The Role of “Community Building”, “Knowledge Activist” and “Leadership”

PhD Seminar: Publishing in Management, Technology, and Innovation. EPFL, Lausanne, 2008: Saving lives through community munificence
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