The Emergence of Intra-Organizational Communities of Operations: Evidence from the Software Industry

Completed Research Paper

Arne Beckhaus
University of Freiburg
Platz der Alten Synagoge
79085 Freiburg, Germany
arine.beckhaus@is.uni-freiburg.de

Dirk Neumann
University of Freiburg
Platz der Alten Synagoge
79085 Freiburg, Germany
dirk.neumann@is.uni-freiburg.de

Lars M. Karg
SAP Research
Bleichstr. 8
64283 Darmstadt, Germany
lars.karg@sap.com

Abstract

We contemplate the concept of intra-organizational communities of operation to account for the organizational design that has recently emerged. Intra-organizational communities of operation address operative tasks of information workers within the boundaries of a firm. By relying on community principles such as self-coordination and intrinsic motivation, this design is believed to be highly scalable and efficient. In order to understand the mechanisms of how these communities function, we develop a research framework aiming to explain performance by means of constructs adapted from conventional group research. We evaluate our model in an empirical study at a large software vendor in its bug tracking process. We find that community centrality, informal roles, and heterogeneity are associated with performance while sub-network centralization and size are not. Our findings will motivate managers to benefit from intra-organizational communities' flexibility and scalability and assist them in the design process by unveiling the mechanisms that influence performance.

Keywords: Communities, Group behavior, Issue Tracking, Efficiency, Social Network Analysis, Software Industry.
Introduction

Organizational scholars have long argued that today's highly dynamic business environment demands flexible organization of work (Ahuja and Carley 1999). In the shift from a materials-based towards an information-based economy, companies face the challenge of “unfettering many organizational aspects from physical constraints” (Child and McGrath 2001, p. 1135). Hence, hierarchical organization forms have long been superseded by more flexible designs, such as virtual teams (Martins et al. 2004). The teams’ importance for the organization of work is well documented (Sproull and Kiesler 1991). Virtual teams, defined as “temporary, geographically dispersed, and electronically communicating work groups” (Kanawattanachai and Yoo 2007, p. 784), are prevalent in today’s corporate world (Martins et al. 2004).

The core idea behind the creation of organizational design, such as virtual teams, is to organize a firm's operations. However, several organizational concepts have been discussed that abstract from this idea. An important example is the discussion of organizing in community form. One of the first works in this area was that of Rheingold (1993) analyzing internet-based ‘virtual communities’, such as internet relay chat. Subsequent works conceptualized ‘cybersocieties’ and ‘open online interaction spaces’ (Jones et al. 2004). These theories are the first to identify the opportunities of large-scale virtual collaboration in technology-mediated online spaces.

In an organizational context, theories of community have gained importance in the field of knowledge management. They are predominantly discussed under the term of ‘electronic networks of practice’ (McLure-Wasko and Faraj 2005). This theory is an advancement of Wenger’s (1998) work on ‘communities-of-practice’, which originally conceptualized offline cooperation and knowledge exchange. The basic idea behind ‘communities-of-practice’ and ‘electronic networks of practice’ is that experts in a specific domain exchange knowledge and experience on an informal basis. Membership in one of these communities does not coincide with formal procedures or hierarchies of a firm. They are rather unrestricted in access (often even open to the public) and collaboration occurs on a voluntary and informal basis. The predominant method of coordination in these communities is typically self-organization, as opposed to task assignment. Another important characteristic is that contributing individuals are primarily motivated by a common goal as opposed to expectation of reciprocal exchange or monetary returns.

The benefits of knowledge exchange in the form of ‘electronic networks of practice’ are manifold. Installing communities enables managers to foster knowledge exchange without the need to actively lead employees. Of course, an initial investment by management is required in order to achieve a self-sustaining level of interaction in the community. Another benefit is scalability. Electronic networks of practice can become large and, unlike virtual teams, nearly unlimited in size. They are also seen to be efficient due to the fact that they rely on self-coordination and require little explicit management effort (Wenger et al. 2002, McLure-Wasko and Faraj 2005, Ardichvili et al. 2006).

‘Communities-of-practice’ and ‘electronic networks of practice’ have important differences in contrast to traditional organizational designs due to their focus on knowledge management (Lave and Wenger 1991, Wenger 1998). The idea that these theories are built on is to informally transfer knowledge and to foster organizational learning (Brown and Duguid 1991). (Virtual) communities of practice have been reported to be a knowledge management tool that is widespread in today’s corporate world (Wenger et al. 2002, Ardichvili et al. 2006). One may thus see this research as a complementary extension of the traditional research stream of knowledge management systems (e.g., Alavi and Leidner 2001).

In contrast to these knowledge management centric theories of communities, we address operative information work. ‘Operative’ in this context refers to simple and potentially repetitive information processing tasks instead of complex and knowledge-intense tasks, such as new product development. Few works address this facet of information work in the context of electronic networks of practice (e.g. Dubé et al. 2006). Today, many business processes are completely digitized and do not require physical but information action, and so we argue that our perspective on operative information work rather explains by which organizational design business functions are executed than achievable by a strictly knowledge-based perspective. Correspondingly, our work is limited to organizations that rely on information systems for operating their business processes. The use of information technology must even go beyond automating highly specialized transactions but needs to offer electronic means of general purpose collaboration.
Transferring community principles to operations within the boundaries of firms is in line with a prevailing view among organizational scholars that organizational structure should be more closely aligned with information flow and actions (Kellogg et al. 2006, Bechky 2006). Both sociology and organization science also stress that informal networks consisting of horizontal, lateral connections are better representation of how work gets done than formal hierarchies (Hartman and Johnson 1990, Krackhardt and Hanson 1993, Ahuja and Carley 1999). Community forms of organizing directly address this finding by abstaining from superior control and leadership. We define an ‘intra-organizational community of operations’ as a large group of a firm’s employees who share a common interest in an operative business function from which they derive work ethics and shared norms in order to self-coordinate their technology-mediated, voluntary individual contributions. Intra-organizational communities of operations can coexist with electronic networks of practice in the same way as knowledge transfer must be explicitly taken care of when organizing work by means of virtual teams.

Our novel organizational design of intra-organizational community of operations has some distinguishable features. At first, it relies on information systems for collaboration and would hence not be applicable to offline setups that were the origin of traditional organizational designs. It distinguishes to hierarchical forms in that there is no disciplinary leadership involved. Our proposed organizational design includes many more employees than team research suggests and additionally, there is also no informal leadership as in project management. Previous theories of community share the cornerstones of large decentralized groups, self-coordination, and shared norms. However, we distinguish from these in the domain. While communities of practice are primarily limited to knowledge exchange, we address more common, operative tasks of information workers.

The concept of intra-organizational communities developed in this article addresses the emergence of this new organization design and is especially valuable to the business process of operative problem solving. It is important to distinguish between operative problem solving, which is an information-processing task, and knowledge-based problem solving of a trial-and-error-based engineering process. Focusing organizational studies on a specific business process is a common practice in the field (e.g., Hargadon and Bechky 2006, Chang and Harrington 2007) and allows for more detailed elaboration on the characteristics of intra-organizational communities of operation.

Theoretical Framework and Hypotheses

Intra-organizational communities of operations are applicable to many different business areas relying on information flow. We postulate that one such area is problem solving. It has been frequently studied in organizational research (e.g., Hargadon and Bechky 2006, Olivera et al. 2008) and is suitable for being conducted by communities due to the involvement of diverse experts in the firm and appealing to a collective understanding of the importance of quality for the firm.

Research on organizational structure, such as in problem solving studies, is usually carried out either on individual, dyadic, team, or organizational level (Brass et al. 2004). By definition, intra-organizational communities reside within firms. Studying their fundamental mechanisms by means of variance approaches requires the definition of a suitable research level. In order to develop an understanding of the internal structure and mechanisms of this novel organizational design’s functioning, we study an intra-organizational community at a functional group level of analysis. Thereby, we follow the generic group definition of Davis and Carley (2008, p. 201) as a “set of entities which experience the same membership relation”. On this functional group level of analysis, individuals are loosely associated to groups by functional criteria. Since contributors channel their activities according to topics and content, this level is most suitable in the study of virtual communities, which are characterized by self-coordination and intrinsic, interest-based motivation.

The research framework of our study integrates group constructs from diverse research streams in order to reflect the cross-disciplinary character of intra-organizational communities of operations. Thereby, we identify constructs that are central to intra-organizational communities of operations. In fact, we adopt a classical Input-Process-Outcomes (I-P-O) framework to organize the constructs that are relevant to intra-organizational communities of operations (Gist et al. 1987). The framework essentially embodies a heuristic model of group behavior and is thus a logical starting point. As intra-organizational communities of
operation are a quite young phenomenon, we cannot make the claim that our model (presented in Figure 1) is exhaustive.

Figure 1.  Heuristic Model of Intra-organizational communities’ interaction

The outcome of group interactions is group performance – we abstain from other outcomes devoted to group members such as quality of work of group members (e.g. Hackman and Walton 1985). Those aspects are also worthwhile to study, but the focus of this work addresses productivity issues. Inputs are the design factors of intra-organizational communities being the community structure that comprises of the geographic dispersion, size, external contribution, and the heterogeneity of the community members. The emergent group processes account for the potential intervening variables in the input-outcome relationship. Emergent processes denote “interdependent cognitive, verbal, and behavioral activities that convert inputs into outcomes” (Marks et al. 2001). In this work, we concentrate on task emergent processes, which refers to how activities are performed by members of the communities to structure, organize, control the work within the intra-organizational community. In the absence of formal coordination mechanisms, we approach the process construct by proxying the coordination mechanisms by the resulting network structure documenting the interaction patterns and by the informal roles, which constitute an alternative means of coordination. Typically, the task characteristics act as moderating factor between the process and the outcome relationship – in this study, however, we do not deepen the issue of task characteristics. In the following, we describe our constructs in reverse order starting from outcomes, processes and lastly inputs.

Performance

The most frequently studied concept of organizational designs’ consequences is that of performance (e.g., Espinosa et al. 2007, Wakefield et al. 2008). It has been used in a variety of contexts and at various levels of research. Performance at individual and team level is often defined in analogy to the employee’s or team’s goals. However, in an intra-organizational community, task and outcome are not explicitly linked to specific employees. They are rather defined by an overall business goal. We therefore conceptualize performance not from a people-centric but from a strictly functional perspective. In the case of problem solving, the typical representation of performance is the time that is required to resolve a problem.

Network Structure

Analysis of network structure has played a key role in both social science and organization science for more than two decades (Borgatti et al. 2009) and has covered various organizational phenomena (see Borgatti and Foster (2003) for a review). The analysis of organizational networks often refers to inter-organizational phenomena (e.g., Child and McGrath 2001). In contrast to this—often economically focused—research stream, scholars have stressed the importance of the behavioral and sociological paradigm to firm performance. For example, Hansen and Wernerfelt (1989) found that these organizational factors explain significantly more variance in firm profit than economic factors, such as competitive market position. Fundamental to the sociological perspective on organizational network structure have been the works of Granovetter (1973) on the strength of weak ties and Burt (1992) on structural holes. Network researchers have analyzed the consequences of these properties of network structure on different levels of research and across various application domains (e.g., Baldwin et al. 1997, Grewal et al. 2006, Reagans
Thereby, network centrality (Freeman 1979) is a frequently used factor of network structure. It is suitable for intra-organizational networks as specific forms of social networks since it captures the importance of the individual.

However, there are some peculiarities in analyzing intra-organizational communities by means of social network analysis. They mainly stem from the nature of the studied network. Collaborative communities are determined by interaction patterns. The edges of this network can be seen as collaborative ties and do not directly represent social constructs like friendship or trust, as is often the case in related network studies (Borgatti and Foster 2003). While centrality has often been found to be beneficial to individuals (e.g., Ahuja et al. 2003), centralized network structures have positive and negative effects on a collective’s performance. On the one hand, centralization reduces the number of edges that information needs to pass when flowing between nodes. This should reduce cycle times and be beneficial for performance. On the other hand, community forms of organizing operate in a very distributed manner and are prone to single points of failure. It is not clear whether the positive effects of centralized network structure overcome the negative ones in collaborative communities (Barbagallo et al. 2008).

We hypothesize that centralized network structures rather impede performance in intra-organizational collaborative communities. Central nodes in a collaborative community’s interaction network indicate the existence of bottlenecks, single points of failure, and uneven distributions of knowledge. These effects can hardly be offset by shortened paths of information flow. The collective mind principles of collaborative communities demand highly distributed and chaotic forms of self-coordination (Child and McGrath 2001). We therefore argue that de-centralized interaction instead suits the community idea of intra-organizational collaboration and is hence beneficial to performance.

HYPOTHESIS 1. An intra-organizational community’s network centralization is negatively associated with performance.

Informal Roles

The concept of roles has long been established in sociology due to its importance in providing continuity in organizations by means of socialization (Goffman 1961). Research on roles has been conducted on various levels (Ahuja et al. 2003) and has led to the development of an established role theory (Biddle and Thomas 1966). Because intra-organizational communities lack formal structures and traditional mechanisms of authority, roles are one alternative means of coordination. They have been reported to be suitable for self-coordination in new organizational designs: “In the absence of formal rules and permanent organizational structures, role structure and negotiation create the order needed for coordination” (Bechky 2006, p. 6). Role-based mechanisms have even been found to guide the actions of high reliability operations, such as aircraft carriers (Weick and Roberts 1993) and emergency response teams (Bigley and Roberts 2001).

Due to the absence of traditional concepts like authority or formal structure, we believe that roles are to a high degree informal in intra-organizational communities. This view is in line with Child and McGrath (2001) who found that in the new organizational forms, roles become larger but less well-defined. Ahuja et al. (2003) also state that functional roles are not necessarily formal but can also be defined in a bottom-up manner by individuals.

A second difference of roles in new and traditional organizational designs is that of role switches. They have been found to be rather typical in virtual organizations more than in classical ones (DeSanctis and Monge 1999). A frequent change in roles is grounded in the structural dynamic that is observed in modern organizational designs (Gibson and Gibbs 2006).

Roles have been argued to be associated with performance due to their suitability for division of labor (Ahuja et al. 2003). Though being an emerging research stream, there are some works that explicitly conceptualize role-based performance in team research (Mathieu et al. 2008). We argue that this evidence from team research and the close proximity to the principles of self-coordination in communities justify...
an association between informal roles and performance. When intra-organizational communities establish informal roles in a way that enables community members to distinguish their competencies, performance is believed to increase.

**HYPOTHESIS 2.** The implicit distinguishability of collaborators’ informal roles is positively associated with performance.

**Heterogeneity**

While in virtual team research, individual and group properties have been found to be associated with performance (Powell et al. 2004), properties of virtual communities have been scarcely studied (O’Mahony and Ferraro 2007). One such property, which we argue to be important to intra-organizational communities, is heterogeneity. This argumentation is based on public goods theory and the work of Marwell and Oliver (1993), who have identified key factors influencing collective action. One of these factors is group heterogeneity. It refers to the variation in individual properties of members of the community. Similar organizational phenomena are discussed under the term of diversity. Mathieu et al. (2008) identify the different research streams of diversity in demographics, function, personality, and attitude. Research on diversity and heterogeneity thus have in common that they refer to variation in individual properties of organizational actors.

Research on heterogeneity has been primarily conducted on interest and resource heterogeneity (Oliver et al. 1985). While the interest and motivational aspects of member participation are also relevant to intra-organizational communities, we follow the argumentation of Oliver et al. (1985) that the scarcity of resources is more limiting despite being less frequently studied. However, we abstract from the individual perspective of variation in resource availability—such as time, money, or expertise. We instead adapt the construct to our functional group level of research. In our view, the most important resource for achievement of output is collective action. The primary resource whose heterogeneity can cause variation in outcome is the ‘invisible hand’ (Dow 1988) of self-coordination.

Thus, we hypothesize that the execution of business functions by intra-organizational communities yields a higher performance when the system has reached a steady state of homogeneous self-coordination over several problem solving incidents. Though addressing a different level, we draw on previously found associations between heterogeneity and performance (e.g., Jehn et al. 1999).

**HYPOTHESIS 3.** Heterogeneous self-coordination of tasks is negatively associated with performance

**Geographic Dispersion**

Distributed work is today often associated with geographic dispersion. The opportunities provided by virtual collaboration are commonly believed to have a large impact on organizing knowledge work (e.g., O’Leary and Cummings 2007). Thereby, geographic dispersion refers to the spatial boundaries that physically separate people (Cummings et al. 2009). Community forms of organizing, such as communities of practice and intra-organizational communities of operations, build on geographic dispersion by definition. This is due to their large size, which automatically yields some degree of physical separation. This argument is supported by the typical definition of spatial boundaries to exist when individuals do not work on the same floor (Allen 1977, Cummings et al. 2009).

The construct of geographic dispersion has been well theorized in the information systems research domain. There, the focus is primarily on offshore software development (e.g., Stack and Downing 2005, Dibbern et al. 2008, Levina and Vaast 2008). However, the offshore software development research stream considers cost savings rather than the potential of collaborative work. An additional area of research analyzes intra-organizational issues of dispersed work, though typically stemming from the global virtual teams perspective (e.g., Maznevski and Chudoba 2000), which significantly differs from the prin-
policies of organizing in community form.

The fact that virtual work is geographically dispersed is of less interest to this study than potential variations in the degree of dispersion. In the literature, geographic dispersion has primarily been associated with lower work outcomes (Cummings et al. 2009). For example, Kraut et al. (1990) find that spatial boundaries reduce the amount of collaboration. This finding is in line with other works, which state that knowledge sharing among employees decreases in dispersed setups (Tsai 2002, Hansen and Lovás 2004). We therefore hypothesize that geographic dispersion is negatively associated with performance in intra-organizational communities of operations.

HYPOTHESIS 4. Geographic dispersion is negatively associated with performance.

**External Contribution**

A prevailing view among organizational scholars is that organizational designs are seldom pure but rather appear as combinations of different designs in firms (McKelvey and Aldrich 1983, DeSanctis and Monge 1999). Accordingly, employees active in intra-organizational communities of operations can still be part of a formal hierarchy. Despite primarily residing within the boundaries of a firm, these communities can also be selectively opened to external partners. The implications for performance can be assumed to be versatile. A positive impact might be an acceleration of problem solving due to the additional knowledge introduced to the community by external contributors. On an individual level, prior research finds ties with external partners to be positively associated with performance (Cross and Cummings 2004). A negative effect of opening communities can be seen in hindered coordination since the self-coordinative processes in the community are more difficult when externals participate. We even hypothesize that these negative effects are stronger than the positive ones. Internal contributors know little about their external peers' expertise and vice versa. The increased difficulty of self-coordination in this setup is believed to outweigh the positive effects of knowledge gain.

HYPOTHESIS 5. External contributions are negatively associated with performance.

**Size**

In the context of intra-organizational communities of operations, size effects play a crucial role. On the one hand, size can be seen as an enabler of community forms of organizing since virtuality and collaboration technology free teams of their limits in social relations that can be logistically maintained (Butler 2001, Leenders et al. 2003, Martins et al. 2004). This argumentation has, among others, led to the conceptualization of virtual communities.

On the other hand, intra-organizational communities of operations fulfill business tasks and can therefore be analyzed from an economic perspective. Production functions have been studied for various industries and business functions in order to determine the effects of size on outcome. The theory of economies of scale is to some degree related to the economic view on organizational design. The early economic views on the firm, such as neo-classical theory and transaction cost economics, have in common that they praise market mechanisms. Hence, the bundling of production volume and organization in hierarchies are not considered. However, both organization science and production economics research have later accepted the opposing view that markets are not the only accepted optimal design (Coase 1937, Williamson 1975, Thore 1996). Economies of scale, i.e. increasing average productivity with rising volume, have been found to exist in various industries while their existence has been questioned in others (Thore 1996).

Researchers have long discussed the existence of economies of scale in knowledge-based industries. Initial investments in research and development are rather high and variable costs are decreasing over time due to learning effects. This yields increasing returns to scale in setups where information is the primary production factor (Thore 1996).

A specific application that the domain of knowledge work has received most attention from researchers...
regarding to economies of scale is software engineering (e.g., Banker and Slaughter 1997, Kitchenham 2002, Pendharkar 2006). Over the last decades, several empirical studies have been published which lack a consensus as the existence of economies of scale in software engineering (Kitchenham 2002, Pendharkar 2006). Banker and Slaughter (1997) stress that software maintenance is fundamentally different from software engineering and thus has a different production function. Software maintenance is a typical knowledge worker process in the area of problem solving and is the scope of this article. Banker and Slaughter (1997) strongly advocate the existence of economies of scale in their case of problem solving. They criticize that performance is typically evaluated based on isolated incidents and on a short-term basis. However, scale effects can only be observed when problems are grouped and jointly solved. We argue that this effect can be studied at our functional group level of research due to its topic-based grouping of individual problem solving tasks. We believe that economies of scale are also present in intra-organizational communities of operations.

HYPOTHESIS 6. Group processing volume is positively associated with performance.

Method

Research Setting and Data Collection

As argued above, intra-organizational communities of operations have not yet been addressed to a high degree. Consequently, their identification in today’s corporate world can hardly be based on prior works in this field. Several characteristics of this new organizational construct have, however, been named in adjacent research streams. An example is the analysis of the bug tracking process by the Information Systems Research community. While the term “bug” refers to a software problem (Koru and Tian 2004), “bug tracking” is the collaborative process of reporting problems with software systems, routing these bug reports to other members of the community, and finally solving the problems (Crowston 1997); a “bug tracking system” is a technological implementation that supports employees in the execution of the bug tracking process (Serrano and Ciordia 2005). Bug tracking has been formalized by, e.g., Crowston (1997) and—for the purposes of this study—can be simplified to represent the reporting of a bug in the system, the routing of this bug report to experts in the corresponding field, and the resolution of the problem. This process’ suitability for a community perspective is supported by three characteristics described by Crowston and Howison (2006): first, bug tracking is a highly collaborative task, which requires a high degree of coordination. Second, it involves different persons in different roles. Finally, it involves the entire software project community instead of only a small group of people, such as a team.

Details about the conceptualization of the bug tracking process used in this study are illustrated in Figure 2. On the left hand side, functional groups are illustrated as detailed in the theoretical framework above. These groups represent a functional subdivision of a bug tracking community by content. Our empirical study is conducted at the functional group level of research with n = 97 data items. However, the dataset contains many more data items on the more fine-grained levels below groups. Over 7,500 bugs are associated with these groups. These bugs themselves consist of over 40,000 contributions, i.e., atomic interactions with the bug tracking systems. These activities are initiated by a total of about 3,500 different collaborators.

In the last decade, various studies of organizational aspects of the bug tracking process have been published. These works have made heavy use of publically available data from Open Source Software (OSS) communities (e.g., Mockus et al. 2002, Das 2003, Au et al. 2009). Despite fulfilling the criteria for virtual communities, we believe that OSS initiatives differ from intra-organizational communities of operations in several ways. Most importantly, these communities are public in both the contribution and availability of outcomes. A second difference is the organization in projects and teams. Frequently studied OSS platforms like Sourceforge.net are organized in software projects with associated teams, which contradicts the true nature of communities. In this study, our primary objective is to empirically evaluate our research framework in an intra-organizational community of operations.
We conducted our corporate study at a leading software vendor in the enterprise resource planning (ERP) market. The data source of our analysis is the bug tracking system. It is in company-wide use and is accessible to every employee. Quality assurance is hence a collective interest that regards all employees. Bug reports and problem solving expertise can therefore originate from many parts of the company, not only those responsible for product development and testing. The functional, topic-based grouping into suitable units for analysis is conducted according to the software components that bugs are assigned to.

The two predominantly used data acquisition strategies used in related work are sociometric surveys (e.g., Faraj and Sproull 2000, Borgatti and Cross 2003, Sykes et al. 2009) and archival data (e.g., Grewal et al. 2006, Liaquat et al. 2006, Leskovec and Horvitz 2008). Surveys have the advantage that very diverse items can be collected while archival data benefit from unobtrusive, unbiased, and large-scale data acquisition (Flap et al. 1998, Zwijs-Koning and de Jong 2005, Cattani and Ferriani 2008). In network analysis, the large size of networks inherent in archival data is able to reveal genuine patterns that are literally invisible in small networks. Despite the limitations in constructs measurable with these data, we follow the argument of Agarwal et al. (2008, p. 245) that “research in digital and social networks naturally lends itself to the use of archival and secondary data as scholars use the wealth of information generated and captured in online settings [...].”

The data excerpt of the software vendor’s bug tracking system used in this study comprises all recorded bugs that were created between January 1st, 2006, and January 1st, 2008. Each bug is recorded with a timestamp for its date of creation, a priority, i.e., an indication of its urgency, and a status, i.e., an indication of which part of the bug tracking process it is in. We only used bugs that have fully passed the bug tracking process and that are marked as urgent. Additionally, each bug has a list of associated contributions. Thereby, a contribution is an atomic action regarding the bug, such as creation, commenting, or resolution.

From this data basis, some filtering was necessary in order to restrict the analysis to meaningful problem reports and to exclude invalid entries for, e.g., documentation purposes. In accordance with related work, we require a minimum of 30 bugs per topic, completely resolvable associations of persons to contributions, a minimum of three distinct contributors to a bug, and a minimum of ten contributors to a topic (e.g., Crowston and Howison 2006).

The collaboration networks derived from this data basis are people-centric with ties being set when two corresponding employees have collaborated on at least two bugs. In order to focus on the bug resolution process, we exclude the reporter of a bug if he or she did not contribute to the bug in any other way than merely reporting it.
Variables and Measures

Resolution Time. The typical dependent variable depicting outcome in organizational studies is a context specific measure of performance. In bug tracking, a bug's resolution time is the most frequently used measure of performance (e.g., Au et al. 2009). It is highly influenced by hardly measurable factors, such as the technical complexity of a bug. Bug resolution time is, however, favored over alternative measures due to the nature of the software industry. The software business is coined by rapid technological change and short product life cycles. In order to cope with this ever changing environment, software development processes must be executed quickly and must be as free of waste as possible. In quality assurance as a subprocess of software development, timely process execution is even more crucial. The longer unfixed bugs remain in the software artifact, the more problems are experienced by different stakeholders of the project. In a setup where known problems take longer to be resolved, the product quality suffers, other groups might be hindered in their work, and the (internal) customer satisfaction decreases. Additionally, resolution times in the magnitude of days or even weeks are an indicator of waiting (i.e. phases where no one is actively working on the bug report). Not only in terms of lean thinking, this is wasteful and an undesired process inefficiency. We therefore use the bug resolution time as the dependent variable in our empirical studies.

Since the distribution of bug resolution times is typically skewed, we apply a logarithmic conversion that yields a normal distribution in the performance variable. Our dependent variable is named Resolution Time and depicts the arithmetic mean of the log-transformed resolution times of all bugs of a software component. The resolution time of a single bug is defined as the difference between the date when the bug has been solved and the date of its initial reporting.

Centrality. Our analysis of the network structure of interaction patterns builds on the frequently used centrality measure (Freeman 1979). While different variants have been proposed, we rely on the commonly used measure of betweenness centrality that represents the average frequency with which a node lays on the shortest path between two arbitrary other nodes of the network. It is a good measure of the ability to absorb information flowing through a network and important for the cohesion of a network (Freeman et al. 1980). Centrality is an ego-centric measure and therefore requires some form of aggregation when used on a research level other than individual. Since we are analyzing intra-organizational communities of operations, we calculate centrality scores for each member of the community. In order to use this measure on our functional group level of research, we introduce the CommunityCentrality variable which is the arithmetic mean of the betweenness centrality scores of all persons that have collaborated on bugs of the same software component. Due to the theorized importance of network centrality to intra-organizational communities of operations, we introduce a second network measure, called Centralization. While centrality is a property of an individual, the centralization index relates a network to the least and most centralized ones of the same size (Freeman 1979). For this variable, we do not analyze the entire community, but the interaction graph of all bugs of the same software component only. It is therefore a local measure of the interaction network structure within the functional unit of analysis. This separation of small and large scale network structures is in line with existing group research (e.g., Mehra et al. 2006).

Role Distinguishability. Informal roles are an important construct for an understanding of the self-coordination mechanisms present in intra-organizational communities of operations. To the best of our knowledge, few measures have evolved in literature that quantify this phenomenon. In a preliminary study of this work, (Beckhaus et al. 2010) have developed approaches to quantify informal roles. In order to develop an understanding of how important informal roles are to performance in intra-organizational communities of operations, a measure of the distinguishability of informal roles is best suited to our context. The variable RoleDistinguishability denotes whether the collaborators of the bugs of a software component are predominantly taking a specific role. The values of this variable will be low when contributors switch between roles reporting new issues, routing other ones, and solving even other ones frequently, whereas they will be high if one primary role can be determined for each person.

The RoleDistinguishability measure of a topic t is based on aggregations from people and bug levels. Let B represent the set of all bugs and C the set of all contributors that have ever been active in the bug tracking process. Further, for each contributor c in C let
• \( \text{BugsAsT}_c \) be the number of bugs in \( B \) that \( c \) takes the tester role in, i.e., reports the bug,

• \( \text{BugsAsQ}_c \) be the number of bugs in \( B \) that \( c \) takes the quality specialist role in, i.e., helps in the resolution in other ways than reporting and solving the bug, and

• \( \text{BugsAsD}_c \) be the number of bugs in \( B \) that \( c \) takes the developer role in, i.e., solves the problem.

Then \( RDC_c = \frac{3}{2} \max(\text{BugsAsT}_c, \text{BugsAsQ}_c, \text{BugsAsD}_c) / (\text{BugsAsT}_c + \text{BugsAsQ}_c + \text{BugsAsD}_c) - \frac{1}{2} \) represents the total role distinguishability of contributor \( c \) in \( C \). The multiplication by \( \frac{3}{2} \) and subtraction of \( \frac{1}{2} \) is necessary in order to linearly scale the role distinguishability measure to the \([0, 1]\) interval.

A first step of aggregation determines the role distinguishability \( RDB_b \) of a bug \( b \). Let \( C_b \) be the set of people that have contributed at least once to bug \( b \). Then \( RDB_b \) is calculated as the arithmetic average of these contributors’ personal role distinguishability values: \( RDB_b = \frac{\sum_{c \in C_b} RDC_c / |C_b|}{|C_b|} \).

A second step of aggregation is necessary in order to define the role distinguishability measure on topic, i.e., software component, level.

**RoleDistinguishability.** The \( \text{RoleDistinguishability}_t \) of a topic \( t \) is the arithmetic average of the distinguishability values of all bugs \( B_t \) belonging to \( t \): \( \text{RoleDistinguishability}_t = \frac{\sum_{b \in B_t} RDB_b / |B_t|}{|B_t|} \).

This two step aggregation is necessary in order to preserve valuable information that would have been lost when aggregating to topic level in one step due to the high number of infrequent contributors in our dataset.

**Heterogeneity.** In our study of intra-organizational communities of operations we are taking a resource based view on heterogeneity. While related work primarily puts this construct in the context of individual properties, we are taking a group level perspective. Heterogeneity in our context refers to the interaction patterns used to solve bugs. As a basis for the heterogeneity measure, we look at the quotient of the number of disjoint contributors to a bug and the number of contributions to that bug. The interaction pattern heterogeneity measure of a software component is defined as the standard deviation of this quotient over all bugs of that component. It expresses the variance in resource allocation of the self-coordination process.

Let \( C_b \) be the (distinct) set of contributors to a bug \( b \) and \( A_b \) the set of \( b \)’s contributions. Let also \( B_t \) be the set of bugs associated to a topic \( t \) and \( C_b \subseteq C \) be the set of contributors to a bug \( b \). Then, the heterogeneity measure is defined as

\[
\text{Heterogeneity}_t = \left( \frac{1}{|B_t|} \sum_{b \in B_t} \left( |C_b| / |A_b| - \mu_t \right)^2 \right)^{1/2}, \quad \text{with} \quad \mu_t = \left( \frac{1}{|B_t|} \sum_{b \in B_t} |C_b| / |A_b| \right).
\]

**GeographicDispersion.** The variable definition of geographic dispersion is highly determined by data availability issues. While some researchers, such as Bird et al. (2009), operationalize the construct on a very detailed level (e.g., ‘same building’ or ‘same cafeteria’), this amount of information is not available in our application context. The only attribute of location identifiable in the given data is an indication of whether an employee is located in the country of the software vendor’s headquarters or in some other country.

Correspondingly, the variable definition is as follows. Let \( C \) be the set of all contributors and \( lc: C \rightarrow \{0, 1\} \) be a function that maps all local contributors (i.e., those employees being employed in the country of the software vendor’s headquarters) to 1 and all international contributors (i.e., those employees being employed in any other country than that of the software vendor’s headquarters) to 0. Further, let \( B_t \) be the set of bugs associated to a topic \( t \) and \( C_b \subseteq C \) be the set of contributors to a bug \( b \). Then, the geographic dispersion measure is defined as

\[
\text{GeographicDispersion}_t = \left( \frac{1}{|B_t|} \sum_{b \in B_t} 1 - \prod_{c \in C_b} lc(c) \right).
\]
**External Contribution.** As theorized above, intra-organizational communities of operations can be selectively opened to external contributors. In the given application context, access to the software vendor’s bug tracking system is granted to partners for software testing purposes. The corresponding variable is aggregated from bug level and reflects the fraction of bugs in which external contributors are involved.

Let $C$ be the set of all contributors and $ic : C \rightarrow \{0, 1\}$ be a function that maps all internal contributors (i.e., those residing within the boundaries of the organization) to 1 and all external contributors (i.e., those residing outside the boundaries of the organization) to 0. Further let $B_t$ be the set of bugs associated to a topic $t$ and $C_b \subseteq C$ be the set of contributors to a bug $b$. Then, the external contribution measure is defined as $\text{ExternalContribution}_t = \left| B_t \right|^{-1} \sum_{b \in B_t} (1 - \prod_{c \in C_b} ic(c))$.

**Size.** The measure of size is straightforward to define. It is operationalized as the number of bugs that have been solved in the respective software component. Due to the skewed distribution of this variable, we apply a common approach from production theory to logarithmize the size variable.

**Time.** As a control variable, we include the average date of the bugs reported in a software component. Since our data comprises of two years, we need to control that time is not associated with performance. Time is measured in years since the earliest date recorded in the dataset.

**Analysis and Results**

**Regression Analysis**

In order to make our measures more comparable, we linearly scale the variables *Community Centrality* and *Centralization* to map to a $[0, 1]$ interval. This scale transformation does not influence our results in any way. Table 1 shows the correlation matrix of the variables used in our study. We provide the coefficient of variations (CV) because all variables have different measurement units and varying means; not using the CV metric would make it difficult to interpret the deviations of the variables. The metric is defined as the ratio of the sample standard deviation and the sample arithmetic mean.

<table>
<thead>
<tr>
<th>Variable</th>
<th>VC 1</th>
<th>VC 2</th>
<th>VC 3</th>
<th>VC 4</th>
<th>VC 5</th>
<th>VC 6</th>
<th>VC 7</th>
<th>VC 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ResolutionTime</td>
<td>0.276</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. CommunityCentrality</td>
<td>0.989</td>
<td>0.371***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Centralization</td>
<td>0.964</td>
<td>0.041</td>
<td>-0.102</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. RoleDistinguishing</td>
<td>0.125</td>
<td>0.278**</td>
<td>-0.011</td>
<td>-0.306**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Heterogeneity</td>
<td>0.119</td>
<td>0.267**</td>
<td>-0.035</td>
<td>-0.014</td>
<td>0.207*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. GeographicDispersion</td>
<td>0.463</td>
<td>-0.018</td>
<td>0.155</td>
<td>0.030</td>
<td>-0.115</td>
<td>0.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. ExternalContribution</td>
<td>1.285</td>
<td>0.304***</td>
<td>0.000</td>
<td>0.051</td>
<td>0.237*</td>
<td>0.195</td>
<td>-0.263**</td>
<td></td>
</tr>
<tr>
<td>8. Size</td>
<td>0.137</td>
<td>-0.075</td>
<td>-0.215*</td>
<td>-0.121</td>
<td>-0.093</td>
<td>0.005</td>
<td>0.088</td>
<td>0.122</td>
</tr>
<tr>
<td>9. Time</td>
<td>0.283</td>
<td>-0.034</td>
<td>0.123</td>
<td>0.098</td>
<td>-0.094</td>
<td>-0.060</td>
<td>-0.136</td>
<td>-0.014</td>
</tr>
</tbody>
</table>

Table 1. Descriptive Statistics and Pearson Correlation Coefficients

The correlation table does not indicate problematic correlations of independent variables. In order to study the associations between the independent variables and our dependent performance variable, we apply a regression approach and use the ordinary least squares (OLS) estimator. Its results are shown in Table 2.
Before applying the regression approach, we linearly scale both centrality variables, CommunityCentrality and Centralization, to the interval [0, 1]. The scaling does not remove any meaningful information, but ensures that both measures of network structure are comparable with each other. The scaling is necessary because both variables have different measurement units and varying means. We test the specification adequacy of our models by using Ramsey’s RESET test (Greene 2007), which is suitable to detect three common specification errors: omitted variables, incorrect functional form, and correlation between the independent variables and the residuals. At the p<0.05 level, we could not detect a misspecification.

Next, to ensure that the assumptions of the OLS approach are met, we use several checks (c.f. Table 3). Both the visual examination of the residual plots and the DFFIT measure indicate no influential observations. The values of the variation inflation factors (VIF) range from 1.074 to 1.257. Since potential problems due to multicollinearity are indicated by VIF values above 5.3, we conclude that multicollinearity is not a serious issue. Further, at the p<0.05 level, the Shapiro-Wilk test cannot reject the normality assumption for the model’s residuals. The Breusch-Pagan test does not indicate any violation of the homoscedasticity assumption and the Durbin-Watson test does not suggest the presence of autocorrelation (Greene 2007).

The model is significant at the p<0.001 level. The adjusted R² value of 0.28 indicates that the model is able to explain sufficient amounts of variation in residuals when compared to typical organizational and sociological studies (Faraj and Sproull 2000, Cohen 1988).

Table 2. OLS Regression Results for ResolutionTime

<table>
<thead>
<tr>
<th></th>
<th>β</th>
<th>std. error</th>
<th>p-value</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>-0.629</td>
<td>0.838</td>
<td>0.455</td>
<td>–</td>
</tr>
<tr>
<td>CommunityCentrality</td>
<td>1.129***</td>
<td>0.244</td>
<td>0.000</td>
<td>1.118</td>
</tr>
<tr>
<td>Centralization</td>
<td>0.630</td>
<td>0.356</td>
<td>0.080</td>
<td>1.184</td>
</tr>
<tr>
<td>RoleDistinguishability</td>
<td>2.101*</td>
<td>0.826</td>
<td>0.013</td>
<td>1.257</td>
</tr>
<tr>
<td>Heterogeneity</td>
<td>5.609*</td>
<td>2.678</td>
<td>0.039</td>
<td>1.083</td>
</tr>
<tr>
<td>GeographicDispersion</td>
<td>-0.018</td>
<td>0.191</td>
<td>0.925</td>
<td>1.165</td>
</tr>
<tr>
<td>ExternalContribution</td>
<td>0.873*</td>
<td>0.402</td>
<td>0.032</td>
<td>1.202</td>
</tr>
<tr>
<td>Size</td>
<td>0.081</td>
<td>0.097</td>
<td>0.407</td>
<td>1.124</td>
</tr>
<tr>
<td>Time</td>
<td>-0.115</td>
<td>0.177</td>
<td>0.517</td>
<td>1.074</td>
</tr>
</tbody>
</table>

Table 3. Regression Diagnostics

<table>
<thead>
<tr>
<th></th>
<th>test-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramsey’s RESET test</td>
<td>0.118</td>
<td>0.889</td>
</tr>
<tr>
<td>Shapiro-Wilk test</td>
<td>0.985</td>
<td>0.316</td>
</tr>
<tr>
<td>studentized Breusch-Pagan</td>
<td>13.425</td>
<td>0.098</td>
</tr>
<tr>
<td>Durbin-Watson test</td>
<td>1.922</td>
<td>0.324</td>
</tr>
</tbody>
</table>
Robustness Tests

In additional robustness tests, we checked whether our results are stable in alternative model specifications. First, we used an alternate definition of our dependent variable. Instead of measuring performance by the entire resolution time from the initial report of a bug to its resolution, we excluded the initial response time to a bug. The initial response time is defined as the time between reporting of the bug and the time of the first contribution by a person other than the initial reporter. We argue that this measure might more reliably reflect collaborative problem solving than the original measure of resolution time which is commonly used in literature. However, the results are not different to the ones reported in this study in regards to the direction of effects, basically stable significances, and passed regression diagnostics.

Next, we use an alternate measure of centrality. Instead of measuring betweenness centrality, we use degree centrality, which is defined as the number of ties to other nodes that an individual holds in relation to the total number of other nodes (Freeman 1979). This alternative measurement for the CommunityCentrality and Centralization variables does not lead to results differing from those reported here. As a third robustness test, we compare our results to those of a different conceptualization of size. In the original model, our argumentation over production functions and economies of scale leads to a bug-centric concept of size. Here, we instead experiment with the people-centric concept of number of collaborators. However, our results are also robust against this alternative model specification.

Results

Our research objective is to derive an understanding of the mechanisms that determine performance in intra-organizational communities of operations. In this section, we discuss the results of our empirical study with focus on our six research hypotheses.

The most significant association between an independent variable and performance in our model is that of the average betweenness centrality of a group’s contributors in the community-wide collaboration network ($\beta = 1.129, \rho < 0.001$). The positive sign of the coefficient indicates that centrality is associated with long bug resolution times and hence impedes performance. This supports Hypothesis 1 which states that a community’s network centralization is negatively associated with performance. This result is important because the literature suggests mixed effects (Barbagallo et al. 2008). The positive effects of centralization, such as shortened information flow, seem to be offset by the negative effects of introducing single points of failure and bottlenecks. In the analyzed intra-organizational community, self-coordination supposedly worked best in a distributed, decentralized way.

Our second measure of network structure, the interaction network centralization of a software component as the functional unit of analysis, is not significantly associated with performance. We interpret this difference between community-wide centrality and functional centralization as an indicator of a functioning community. Effects of network structure are predominantly observable on community level. The functional division into units of analysis does not coincide with local teams that build their own interaction networks. A functioning community is de-centralized and collaborates over functional barriers.

Hypothesis 2 states that the distinguishability of collaborators’ informal roles is positively associated with performance. A significant association between informal role distinguishability and resolution time could be found in our data. However, against our expectations, the coefficient is positive ($\beta = 2.101, \rho = 0.013$). When collaborators concentrate on a specific role in the bug tracking process, performance decreases. A possible explanation is that specialization contradicts the distributed and self-coordinating nature of communities. A collective might need to trade personal productivity by means of specialization with collective productivity by means of an improved understanding of the other roles for the sake of improved self-coordination. This result has the potential to direct the future discussion of informal roles in the context of communities and collective minds to a more detailed understanding on how shared role conceptions arise. Prior work is inconsistent. While some authors stressed the frequency of role switches in virtual organizations (DeSanctis and Monge 1999), others assumed fix stereotypical role perceptions, for example in film projects (Bechky 2006), or on aircraft carriers (Weick and Roberts 1993). Our results suggest that a shared understanding of roles is rather achieved by frequent role switches.
Heterogeneity of self-coordination is a group-level property of collaboration that refers to ‘invisible hand’ (Dow 1988) modes of self-coordination. We argued in Hypothesis 3 that heterogeneous self-coordination of tasks is negatively associated with performance. We find support for this hypothesis in our model ($\beta = 5.609, \rho = 0.039$). Our results suggest that homogeneous interaction patterns speed up the average resolution times of the bug tracking process. This result is expected and in line with the resource based heterogeneity findings of group research.

Hypothesis 4 states that geographic dispersion is negatively associated with performance. We cannot find support for this hypothesis in our data. This is possibly due to missing levels of detail in the analyzed data, which allows only for a distinction between the country of the software vendor’s headquarters and any other country. Another explanation is that collaboration in intra-organizational communities of operations occurs virtually. Hence, the location of individual contributors is less important than in face-to-face work.

Contributions by external members of the community are negatively associated with performance in our model ($\beta = 0.872, \rho = 0.032$). This result supports Hypothesis 5. Apparently, the negative effects of hindered self-coordination outweigh the positive effects of the inclusion of additional knowledge resources.

Economies of scale effects could not be identified in the analyzed intra-organizational community. Size and performance are not significantly associated with each other. Hypothesis 6, which states that group processing volume is positively associated with performance is not supported. A possible explanation is that the functional separation of bugs in associated software components as units of analysis do not sufficiently reveal learning and batching effects, which would yield economies of scale (Banker and Slaughter 1997).

**Conclusion**

Our intention with this study is to extend the principles of organizing in community form to operative business functions. Previous theories, such as communities of practice or electronic networks of practice, focus on knowledge management. However, community forms of organization can be found in areas of information work beyond exchange of knowledge. The vast availability of information systems supporting collaboration within enterprise boundaries has extended the scope of community organization to operative tasks. We hence conceptualize intra-organizational communities of operations as a novel organizational design. It builds on self-coordination, omission of size restrictions, and building a collective mind. Despite the increased flexibility that virtual teams brought to organizational designs, community forms are believed to even better support the view that adaptability is more important than specialization in the face of dynamic business environments (Rindova and Kotha 2001, Kellogg et al. 2006). We argue which constructs of group research are likely to explain the fundamental mechanisms behind performance in intra-organizational communities of operations and develop a conceptual framework. We test our model in an empirical study with a large software vendor.

**Implications for Theory**

Our study presents an important and original contribution to organization research. We conclusively outline an organizational design that builds on many features of prior theories of community but focuses on operative tasks. In this regard, our study advances current theory that has primarily focused on knowledge management communities. We build a theoretical framework as a starting point for researchers assessing the mechanisms that influence performance in intra-organizational communities of operations. Scholars have pointed out that “relatively little is known about the process of organizing in communities” (O’Mahony and Ferraro 2007, p. 1079). The evaluation of our framework at a large software vendor demonstrates its suitability and sheds light on some mechanisms of successful collaboration within this community. On our functional group level of research, we cannot replicate findings from prior work that find centrality to be beneficial for individuals. Communitywide centrality rather seems to impede performance, possibly due to resource bottleneck reasons. Unlike in knowledge management communities where centrality means power over a scarce resource, communities of operation might be run more effi-
ciently with more equal distribution of workload. Centrality might be of no special benefit to the individual in our case as it does not represent power but more work. In line with this finding, also interaction network centralization on the functional level of analysis is not significantly associated with performance. This might be due to functioning community principles and the absence of self-emerging sub-groups of the community. Since key individuals would need to be the glue between these sub-groups but the individual does not necessarily benefit from the centrality that this position would imply, a decentralized and community-oriented structure appear to be more efficient for communities of operations.

In line with existing literature, we find that informal roles are an important and performance-relevant aspect of organizing in communities. However, we cannot confirm stereotypical role understanding among peers like in emergency teams or aircraft carrier operators. In the studied case of bug tracking, performance is rather increased when people switch their informal roles and do not specialize. Providing another piece of empirical analysis to the controversial debate of the existence of economies of scale in the field of software engineering (Kitchenham 2002), we cannot identify a significant association between size and performance. One possible explanation lies in the peculiarities of organizing in a community design. Intra-organizational communities of operations are potentially highly scalable due to distributing work among many peers in a self-coordinative way. This avoidance of bottlenecks and explicit coordination comes at the expense of achieving learning effects, which are believed to be a mediator for economies of scale.

The conceptualization of intra-organizational communities of operations and unveiling first important antecedents of performance advances current theory of organization. Most importantly, we extend the community idea from its previous focus on knowledge management to operative tasks of information work. Many organizations have information systems in place that enable knowledge workers to collaborate beyond hierarchical or team structures. Our empirical study demonstrates the existence of a community of operations and reveals some of the underlying effects determining performance. Their discussion provides important insights to differences compared to knowledge management communities. Particularly the findings on the constructs of centrality and informal roles also enhance the current knowledge.

**Implications for Practice**

Our findings have some important implications for managers. We demonstrate that communities do not only function in public contexts, but also within the boundaries of the organization. As opposed to communities of practice, our theory of intra-organizational communities also addresses operations instead of knowledge management. Particularly in the analyzed case of problem solving, organizations are able to refrain from opening their information networks to external partners. Deciders can trade-off between bringing in expertise by opening to external contributors on the one hand, and concealment of problems in order to protect market reputation and perceived product quality on the other hand. With intra-organizational communities of operations, managers can benefit from the adaptability, scalability, and efficiency of community forms of organizing for business processes that need to reside within organizational boundaries.

Besides conceptualizing this organizational form, our results also have implications for the managerial design of intra-organizational communities of operations. We find that the distribution of load to many contributors is better than centrality in the community’s interaction network, i.e. the existence of key contributors that participate in far above average numbers of problem resolutions. While contribution should be primarily voluntary in intra-organizational communities of operations, managers can refrain from explicitly installing full-time problem solvers and rather appeal to the establishment of a collective mind among all employees. Another managerial implication is the effect of informal roles. We find that performance is increased when collaborators switch between different informal roles as compared to a specialization of one role. By definition, informal roles are not within the immediate scope of managerial instruction. However, company policies can promote adaptability and versatility over specialization for knowledge workers in order to indirectly influence informal role engagement. Our finding that geographic dispersion is not significantly associated with performance empowers managers with the opportunity to benefit from global wage differences, optimal knowledge sourcing, and around-the-clock work. However, the design of intra-organizational communities of operations should refrain from too much access to external contributors as we find that they reduce performance.
Limitations and Future Research

This study analyzes only one intra-organizational community. Hence, its findings might reflect the specifics of this company. Further studies should validate our findings in other communities.

While our results are limited to the collaborative process of bug tracking, we believe that they may be transferable to other problem solving areas. We also think that the determined influences on performance might not be limited to intra-organizational communities. As long as external collaborators share the informal role understanding and the interaction pattern networks do not reflect the organizational boundaries to a high degree, communities might be as effective when selectively opened to the public.

Another limitation of our study of intra-organizational communities of operations is that this organization form—just as other organizational designs that build on virtuality—is not pure (DeSanctis and Monge 1999). Every member of the studied community is employed by the analyzed software vendor and hence part of a formal hierarchy. This mixture of organizational form is common and does not prevent the study of communities within hierarchical corporations (Crowston 1997). Future research could attempt to identify the degree of voluntariness of participation, non-intrinsic forms of motivation, and aspects of explicit task assignment within the community. Despite not denying the existence of these effects, we argue that our study provides the first evidence that intra-organizational communities of operations can function and that informal properties of collaboration have been shown to be associated with performance.

Future research should continue to conceptualize and evaluate intra-organizational communities of operations and transfer other constructs of virtual team research and public communities to this novel form of organizing operations within the boundaries of a firm. It could be particularly interesting to compare problem solving activities of Open Source Software initiatives with intra-organizational communities. Despite different means of motivation and governance, public and private forms of community organization potentially share some mechanisms of functioning.
References


Hackman, R., R. E. Walton, 1985. The leadership of groups in organizations. Yale University Press, New Haven, CT.
Kitchenham, B. A. 2002. The question of scale economies in software—why cannot researchers agree?