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Antecedents of Knowledge Sharing in Globally Distributed Software Development Teams

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ANTECEDENTS OF KNOWLEDGE SHARING IN GLOBALLY DISTRIBUTED SOFTWARE DEVELOPMENT TEAMS

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Abstract

Knowledge is seen as a source of competitive advantage in organizations. The need to cater to global market places, competitive pressures and to avail the best resource possible has given rise to distributed form of working, which is further enabled by technological advances. The prime advantage of distributed form of working is access to diverse sources of knowledge, and hence sharing of knowledge is a prerequisite for effective outcomes. This paper presents a conceptual framework and develops testable propositions by identifying team level antecedents of knowledge sharing in distributed work context. Analysis plan and directions for future research is also discussed in the paper. The key contribution of this study is to view the knowledge sharing process in teams with respect to different dimensions of distributedness, and relational attributes of the team.

Keywords: Knowledge sharing; Distributed Teams; Software Development

1 KNOWLEDGE IN ORGANIZATIONS

The knowledge-based perspective of the firm suggests that organizational knowledge facilitates sustained competitive advantage. Organizational knowledge is inimitable and complex in nature and is manifested in organization culture and identity, routines, policies, systems, and documents, as well as individual employees (Alavi & Liedner, 1999). The massive globalization of 21st century has forced organizations to function in complex environments spanning spatial and temporal boundaries. Advances in the field of information and communication technologies coupled with the pace at which organizations are operating from multiple locations have resulted in increase in globally distributed work. To create and sustain competitive advantage, it is important that firms should be able to integrate and apply specialized knowledge of organizational members (Grant, 1996b). For organizations that are globally distributed or operate via globally distributed structures (teams), this requirement becomes all the more important. Since organizational members are separated through distance and time, integration of individually held knowledge becomes a challenging task. Task specific knowledge is also embedded in the context apart from being individually held. For distributed or virtual groups it becomes imperative to share the task related knowledge for effective outcomes.

1.1 Distributed teams

People have collaborated across geographical distance for many years. With the advances in ICTs and the beginning of the era of Internet, technical capabilities have given rise to the possibility of coordinating work across time zones with efficiency and increased capability. The phenomenon of distributed teams is gaining importance in organizations due to rise in outsourcing, globalization, alliances and joint ventures. Geographically distributed teams rely more on technology for their coordination and control needs. The terms virtual, distributed, non-collocated, global-virtual, dispersed, etc are all used interchangeably in literature to denote the new form of working where members are distributed across distance and collaborate and communicate primarily through technology-enabled communication (Webster & Staples, 2006; Ahuja & Galvin, 2003). Pure virtual teams have all members separated and they communicate via technology-enabled devices. For other kinds of distributed work, face-to-face meeting between the members of the team occurs at regular intervals, depending on the task characteristics (Maznevski & Chudoba, 2000). Virtuality has three key manifestations namely- work performed by remote employees who telecommute; organizations that are virtual; and the use of virtual technologies. Distributed teams may be bound by one organization, by a set of organizations (alliance based software development teams), or no organization, also known as virtual organization (open source communities) (Fulk et al., 2005). There are several definitions of distributed teams in literature depending on the extent of virtualness exhibited by these teams. The most relevant definition of virtual teams applicable to this study is given by Powell et al (2004) as "*virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks*".

The advantage associated with distributed teamwork is that knowledge from diverse context can be aggregated and put to use, regardless of geographical separation between the team members. Distributed teams also provide flexibility (Mowshowitz, 1997), responsiveness, lower costs and improved resource utilization in global business environments that is characterized by dynamically changing task requirements (Jarvenpaa & Leidner, 1999). Organizations can draw the benefit of working round the clock by placing the members of distributed teams in team zones that span the globe (Griffith et al., 2003). As opposed to collocated teams where the team members draw upon similar social networks and sources of knowledge resulting in highly redundant task related information (Granovetter, 1973), distributed teams

have the advantage of having access to unique information and know-how resulting in innovation and creativity (Ariel, 2000).

Distributed work has several challenges associated with it. In distributed setting the issues related with coordination of task and team communication become very cumbersome to deal with, especially when the distributedness of the team is high. Still many distributed groups "adapt their interactions" to the availability of communication technologies (Kiesler & Cummings, 2002). Other challenges associated with distributed teams are that there is lack of trust in team members, and what ever exists is "swift", being temporary in nature (Jarvenpaa et al, 1999), and conflict between team members due to lack of shared social context (Hinds & Bailey, 2003). Some distributed groups have been seen to develop a strong group identity despite limitations of prevalent technologies (Kiesler et al, 2002). Other problems include heavy reliance on technology to address the problems of coordination and communication. Despite the challenges posed by distributed form of organizing, more and more organizations are turning towards it to keep pace with competition. It becomes necessary thus; to understand how organizations whose primary resource is knowledge apply and integrate distributed pockets of knowledge.

There exists little empirical research, which explores the dynamic nature of virtual teams (Davidson et al, 2003; Montoya-Weiss et al., 2001). The conceptual and empirical understanding of such teams in underdeveloped (Cramton & Webber, 2005; Martin et al., 2004;Bell & Kozlowski, 2002). Many studies have focused on models used to study collocated teams to understand the virtual team effectiveness. Several empirical studies have focused on student teams rather than organizational work teams, which do not provide adequate insights into the functioning of such teams (Cramton et al, 2005). The purpose of this paper is to develop a theoretical framework to identify team level antecedents of knowledge sharing in distributed teams, to improve understanding of the dynamics involved in knowledge sharing process and its subsequent impact on team performance.

1.2 Research Questions

The research questions guiding this study are:

- How is Knowledge shared in distributed teams?
  - What are the antecedents of Knowledge sharing in distributed work environment?
  - What are the enablers of Knowledge sharing in distributed work environment?
  - How effective is the Knowledge sharing mechanism in distributed teams?

In the following sections we would briefly review the literature on knowledge sharing in organization, emphasizing on software development distributed teams, and develop propositions for team level antecedents of knowledge sharing. Proposed methodology for data collection, data analysis plan, implication for practice and direction for future research is further discussed in the concluding section.

2 KNOWLEDGE SHARING

Drucker defined knowledge as a key resource for production in recent times. With the shift in the boundaries of marketplace, the organizations are not confined to one location. Organizations cater to multiple marketplaces, which generates a need for products and services that are innovative, have faster-time-to-market and are cost effective. In such a dynamic scenario knowledge held by an organization becomes critical in providing an edge over competitors. External and internal knowledge sharing and information exchange help organizational work groups (or teams) to achieve effective outcomes (Cummings, 2004). Literature has looked at multiple facets of knowledge sharing process in organizations from transferring tacit knowledge across organizational subunits (Zander & Kogut, 1995), the nature of relationship of the two parties involved in the exchange process (Tsai, 2002) and the search transfer

problem (Hansen, 1999; Hansen et al., 2005). The importance of knowledge sharing is reiterated in literature for effective team performance. (Faraj et al, 2000; Townsend et al., 1998). Inability to transfer knowledge in an intra organizational context hampers the sharing of best practices, thereby leading to ineffective utilization of cognitive resources available with the firm (Szulanski, 1996; Argotey, 1999). An advantage offered by distributed work is the access to diverse sources of knowledge but since communication and coordination pose as challenge to the functioning of distributed teams, it becomes interesting to analyze what are the factors that impact the process of knowledge sharing.

2.1 Context of the study

Distributed form of organizing is manifested in several organizational work group such as functionally distributed new product development teams, where members from different line function get together for conceptualization and development of a new product; and in global virtual organizations that cater to several local markets such as multinational organizations and accomplish their work through team members who are distributed across several countries, interacting primarily through technology mediated communication.. The recent spurt in outsourcing has also seen phenomenal growth in distributed form of organizing. Another interesting context is the software development work, where distributed form of working has become a viable option primarily to cut costs and to avail the opportunity of working round the clock (Griffith et al., 2003). Software development is pure knowledge work and highly socio technical in nature (Faraj et al., 2000; Sawyer, 2004; Robillard, 1999). It is also characterized by high task complexity through incomplete user requirement, changing environmental conditions and high levels of team interdependence (Sussman & Guinan, 1999; Curtis et al., 1988). Despite the coordination and communication challenges associated with software development, more and more organizations are using distributed teams for information systems development (Hersleb & Mockus, 2003; Ocker & Fjermestad, 2000; Sarkar & Sahay, 2004). It is critical for knowledge teams, such as software development teams to manage and coordinate their resources to achieve their targets on time. As the projects become more complex, sharing of knowledge from technical and functional domains becomes necessary for the execution of the project (Walz et al., 1993). In the following section we present several team level antecedents that affect the process of knowledge sharing in distributed teams. The primary assumption here is that team members are affiliated to a given organization and have similar cultural context, and are distributed only geographically.

2.2 Knowledge Sharing in Globally Distributed Software Development Teams

It is important to define knowledge sharing, in the context of distributed software development. Knowledge sharing has been defined in various ways in literature, which more or less define knowledge sharing to be a team process involving interaction and communication among the team members (Cohen et al., 1997). In the specific context of our study, we use the definition of knowledge sharing given by Hansen as “the provision or receipt of task information, know-how, and feedback regarding a product or procedure” (Hansen, 1999; Cummings, 2004). In software development projects intra team knowledge sharing may happen at two levels, from one project to the other, which is normally a function of the transactive memory system (Wegner, 1987) which determines how key learning and sharing of context specific knowledge is applied to the next project. The other level where knowledge sharing happens is within the lifecycle of the project. The team members being distributed across various sites have access to diverse sources of knowledge (Fulk et al., 2005), which is non redundant (Ariel, 2000) and thus they can effectively contribute to the knowledge sharing process within the team, during the project. The focus of this study is on the latter part, i.e. to identify the antecedents of knowledge sharing among team members for the given distributed software development project. Knowledge sharing within a team is function of mutual trust, task characteristics, and individual capabilities of team members (Zarraga et al, 2003). In the

case of distributed teams, the effectiveness of communication and degree of distributedness also determine the extent of knowledge sharing. In the next section we analyze the given factors.

2.3 Degree of distributedness

Allen's (1977) seminal work on geographical distance and dyadic communication has powerfully affected the manner in which separation between distributed team (both intra and inter teams context) is conceptualized (O'Leary & Cummings, 2004). The focus has been on measuring the spatial distance between the two teams. Most studies that look at geographic dispersion conceptualize distance in feet or meters between people's desk as a representation of how far or near people are located. Moreover this construct of distributedness is only dyadic in nature. Studies on distributed software development have focused on the adverse effect of geographical separation (Espinosa et al., 2003; Carmel, 1999; Hersleb et al., 2003), which lead to delays, increased coordination efforts, difficulty in the communication process, etc. While geographical separation indeed can lead to several problems of coordination and control, the combination of other factors, such as communication technologies, which can reduce the liabilities of distance (Cairncross, 1997), different time zones operating from different locations can have an important effect on the team effectiveness (Cramton, 2001). In the context of software development issues like working across different time zones, distribution of members at different sites, and number of sites the team is operating from may provide important insights into understanding of distributed software development work. O' Leary's work on team based dispersion has looked at three dimensions of dispersion in distributed teams: 1) Spatial, which is also the geographical distance. 2) Temporal dispersion is a measure of the extent to which team member's normal work hours overlap. 3) Configurational dispersion is the measure of how team members are arranged across the number of sites. Based on the above three dimensions four kinds of indexes developed by Cummings are used for this study: Time zone index, Site index, Isolation index, and Imbalance index.

Please refer to table 1 for more details:

Index	**Summary**	**Dimension**
Time Zone Index	Average number of time zones between members	Temporal
Site Index	Number of sites across which the project is distributed	Configurational
Isolation Index	Percentage of team members with no other team members at their site	Configurational
Imbalance Index	Relative balance of membership across sites	Configurational

Table 1. Distribution Indices (adapted from. O'Leary & Cummings, 2004)

Time Zone Index: This index is developed using the time zone difference between the two sites. Difference of time zones between given sites, would impact the frequency of media usage for communication between the dispersed members across these locations. Same time zones imply longer conference calls, as work hours would be same for two locations. Different time zones would mean extending the workday for either of members located in different locations. It is calculated using a matrix of all possible non-redundant member-to-member connections (time zones separating them) weighted by number of members at the sites. Higher is the time zone index; more is the temporal distribution of the team. Greater temporal distribution would negatively impact knowledge sharing as team members would have to extend their work hours considerable to coordinate and communicate effectively. Hence,

Proposition 1(a): Time zone index of a software development distributed team is negatively associated with the extent of knowledge shared between the team members

The number of sites a team operates from also determines dispersion of team members. In the context of software development teams, most of the teams are distributed across different offices in the same city, different cities, and sometimes between different buildings in the same location.

Site Index: This index simply measures the number of different sites a team operates from. Greater is the dispersion of team across different sites, greater would be the coordination costs associated with it, and hence greater problem with knowledge sharing between the team members. Hence,

Proposition 1(b): Site index of a software development distributed team is negatively associated with the extent of knowledge shared between the team members

Isolation Index: The distribution of team members across sites also is an important factor while considering the extent of knowledge sharing in dispersed teams. Some of the sites may have one or two members while the rest may have the remaining members. The argument is thus, teams with high levels of isolation (most of the team member are isolated) will face problem in knowledge sharing between the team members, as greater degree of coordination is required for collaborative work. Members who are isolated at sites may find it difficult to share and receive knowledge. This index is calculated as the percent of team members who are at sites with no other team members. It ranges from zero (no team member alone at their site) to one (all members alone at their sites). Hence,

Proposition 1(c): Isolation index of a software development distributed team is negatively associated with the extent of knowledge shared between the team members

Imbalance Index: This index measures the balance or proportion of team members across each site. Members who are split unevenly (minority at one site, and majority at the other) could trigger problem related to communication and coordination. Minority sites members may feel out of loop, and would hesitate to participate in knowledge sharing. This index is different from isolation index in the sense it takes into account the relative balance of team members across sites. This is calculated by standard deviation of members per site divided by size of the team with low levels of index denoting balance between the sites. Hence,

Proposition 1(d): Imbalance index of a software development distributed team is negatively associated with the extent of knowledge shared between the team members

2.4 Task Characteristics

The team task of software development is inherently complex and highly interdependent (Sussman et al., 1999) involving expertise, skills and insights of many individuals (Tiwana & Mclean, 2005). The move towards new domain areas and the requirement to build sophisticated systems cause software development to be more complicated than ever before. The problem solving capability of the team is dependent on the type of task involved. Since high levels of task interdependence and complexity characterize software development, we study the impact of these two task characteristics on the knowledge sharing process.

2.4.1 Task Interdependence

In collaborative software development environment, the nature of tasks performed by team members is highly interdependent. The definition is: "*Task Interdependence at the work unit of analysis is the extent to which unit personnel are dependent upon one another to perform their individual jobs*" (Van de Ven & Delbecq, 1976). The term task interdependence has several connotations. At the very basic level there is need to distinguish task interdependence from resource interdependence. In task interdependence "*members must takes action for other members to do any part of their work*", whereas in resource interdependence resources are shared among team members and individual team members are responsible for completing their allocated tasks; the task is not considered complete until every member has completed

their respective tasks (Wageman, 1995). Other types of task interdependence are pooled interdependence (subtasks are performed separately) and sequential interdependence (tasks are performed sequentially) (Van de Ven et al., 1976; Thompson, 1967). For lower levels of task interdependence the need to exchange information is quite low (Vijfeiken et al., 2002). In software development, a project is successful as long as there is no cost or time overrun. In case of difficult project, which requires expertise of many people, the level of task interdependence is quite high (Van der Vegt et al., 2001). In this context, high level of task interdependence would imply greater degree of knowledge exchanges, as team members would interact frequently to share task related knowledge. Hence,

Proposition 2: The level of Task Interdependence faced by a distributed software team is positively related to the extent of knowledge sharing between the team members.

2.4.2 Task Uncertainty

Software development projects are characterized by high uncertainty, as requirements undergo a lot of moderation over time. Even in the case where requirements are frozen before the design begins, there is a lot of uncertainty till the project is implemented due to technological and environmental changes (Nidumolu, 1995). Also since the composition of the team is more fluid in nature, depending on the project status and estimated schedule overrun, team members may be added or rolled off. Given the complex and socio technical nature of software development, high task uncertainty would mean greater knowledge sharing between the members of the distributed teams. The team members are distributed geographically and hence the possibility of meeting face to face to discuss and share information is minimal. For a task that is low on uncertainty, much of planning for the execution of activities can be done before hand, thus limiting the extent of knowledge sharing between team members. Hence,

Proposition 3: The level of task uncertainty faced by a distributed software team is positively related to the amount of knowledge sharing between the team members

2.5 Absorptive Capacity of Team Members

As defined by Cohen and Levinthal (1990) absorptive capacity is termed as "the ability to recognize the value of new, external information, assimilate it and apply it to commercial ends". The construct of absorptive capacity has been studied mostly at the firm level or at the individual level. At the level of the team, absorptive capacity would constitute of "mosaic" of individual capabilities. For a given team higher is the absorptive capacity of its team members, greater is their shared conceptualization of each other's expertise and skill sets (Tiwana et al., 2005). In distributed software development projects, higher levels of absorptive capacity would enable knowledge sharing among team members, who are dispersed across several sites. Hence,

Proposition 4: Absorptive Capacity of members of a distributed team is positively related to the amount of knowledge sharing between the team members

2.6 Relational Capital

Relational capital is defined as the "level of trust, reciprocity, and closeness of working relationships among the members of the team" (Tiwana et al, 2005; Kale et al., 2000). Higher level of mutual trust lowers the inhibition to share knowledge. (Szulanski, 1996; Hansen, 2002)

Knowledge sharing culture within teams is a function of intra team respect, mutual trust, and reciprocity (Zakaria et al., 2004), and thus higher levels of relational capital among team members would foster knowledge sharing within teams. Hence,

Proposition 5: Relational Capital of members of a distributed team is positively related to the amount of knowledge sharing between the team members

2.7 Communication media

Literature on traditional teams suggests that high performing co-located teams can communicate effectively and share crucial knowledge in a timely manner (Piccoli et al., 2004; Ancona et al., 1992). For distributed teams communication is a crucial factor since members are located spatially and temporally, the role of information and communication technologies becomes important in bridging the geographical divide. Though technology cannot replace the efficiency of collocated tasks (Kiesler et al., 2002), but still can be a very strong enabler of work that is distributed in nature (Davidson et al., 2003). Literature has looked at various aspect of communication such as choice of media, volume of communication, lateral communication, norms of technology use, etc (DeSantis et al., 1999) but most of the work is done on student teams and hence corresponding validity in organizational work teams is difficult to establish. In the case of software development, highly interdependent nature of the task and distributedness of teams further necessitate the use of communication media. For a given virtual team, there exists plethora of choices for communication media. The frequency of media usage is what determines knowledge sharing, as higher is the frequency of media usage to communicate and coordinate, more easily will be the process of knowledge sharing through tech-mediated communication, as team members adapt the medium to meet their relational needs (Chidambaram, 1996). Hence,

Proposition 6: Communication Frequency between members of a distributed team is positively associated with the extent of knowledge sharing among team members.

3 DISCUSSION

The theoretical framework outlining the antecedents of knowledge sharing in distributed teams is illustrated in Figure 1 below.

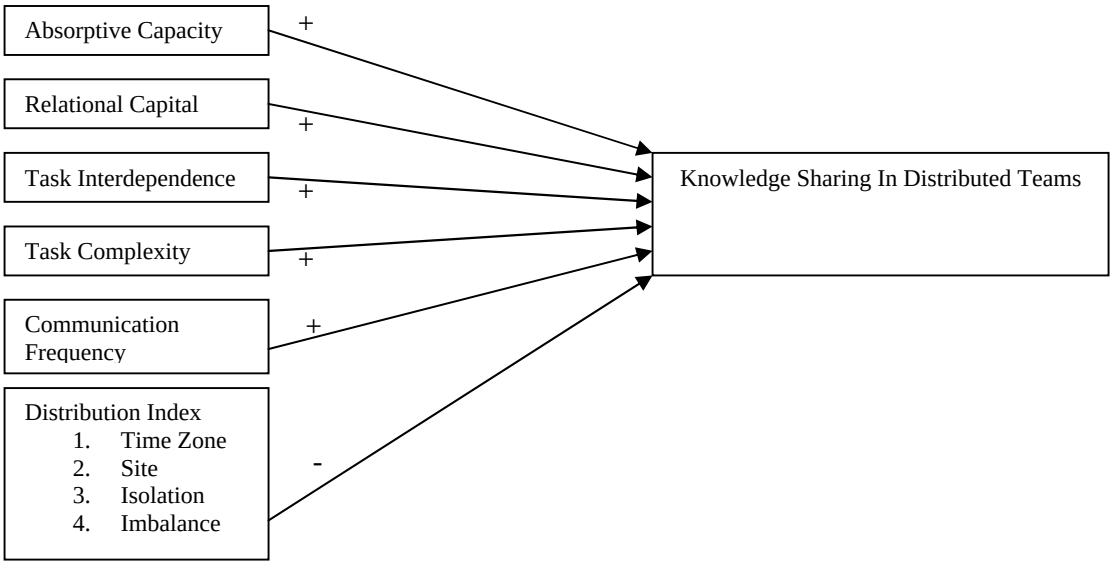

Figure 1. Team Level Antecedents of knowledge sharing in distributed teams

The second stage of the study will include operationalization of the constructs presented in figure 1. The main objective of this study was to highlight the team level antecedents of knowledge sharing in distributed work environment, and how it can be applied to software development context. Knowledge sharing is a complex social process and requires a great deal of communication and coordination efforts, moreover when the team members are dispersed across several locations (Tsai, 2002).

3.1 Proposed methodology, Data Collection and Analysis Plan

The proposed methodology for data collection is cross sectional questionnaire based survey method where team is the unit of analysis. Survey based method is the dominant form of data collection in the IS area and is a step towards validation of theory as results can be generalized for the given population. The literature on virtual and distributed teams is mostly conceptual and majority of the empirical work is limited to student teams. There is dearth of empirical studies involving organizational work teams, and there is need to validate the conceptual understanding of distributed team dynamics. This study proposes to address the same need. The sampling frame for this study is chosen to be the software development teams, which are distributed across sites. The data would be collected from software development teams following the offshore-onsite model, distributed between India, US, and Europe. The key respondent identified is the project/ team lead who has both operational and relational view of the team functioning. For operationalization of the constructs, nearly all scales are picked up from literature barring communication frequency. The scale for communication frequency is self developed and is perceptual. All other scales have been reported to have Cronbach's Alpha of values greater than 0.8, which is a reasonably good measure of validity. However we propose to have a pilot study to validate the measuring instrument in the specific context. A sample size of 30-35 respondent representing team leads/project leads of distributed teams across various software development organizations would be sufficient to validate the instrument. There are certain variables we would be controlling for, as they could have an important effect in determining the extent of knowledge sharing process. The variables to be controlled are; *team size, average experience of team members, and the type of software development work* (application development or product development). When the team size is large, it becomes difficult to coordinate across greater number of dispersed people, and hence intra team knowledge sharing become difficult. Similarly average experience of team members would also effect the process of knowledge sharing, as more is the average experience of team members, easier it is for them to share task related knowledge using a given communication medium. Lastly the type of software development work would also determine the extent of knowledge sharing in distributed teams. Product development teams are formed for longer duration, and the members work together on project, building close relationship, which positively affects the process of knowledge sharing. In the case of application development the teams are ad hoc in nature, and team members sometimes are not acquainted with each other, which deters the knowledge sharing between team members.

3.1.1 Data Analysis Plan

Structured Equations Modeling is suited for analysis of correlation between the hypothesized constructs. The measures of the constructs are perceptual in nature (metric variables) and hence SEM would be useful in controlling the measurement errors. Since the antecedents identified in the study might have interrelated dependence relationship with each other, SEM technique such as PLS (partial least square) would be better to analyze the proposed model. The research is exploratory in nature, as most of the factors identified in this study, have not been used before in literature. Hence PLS suits our requirement to explore the relationship between the team level factors affecting knowledge sharing in distributed teams.

3.2 Contribution to Theory and Implication for Practice

The study makes significant contribution to theory in terms of identifying team level antecedents of knowledge sharing in a distributed software development context. Another important contribution is the application of the concept of different dimensions of distributedness to software development teams as opposed to the dyadic treatment that has been primarily considered in literature.
Once the model is validated through organizational work teams, it will provide sufficient insights about how to efficiently allocate human resource across multiple sites for better coordination and knowledge sharing. Project managers and team leader can decide on the frequency of communication between team members for optimum knowledge sharing, based on task characteristics.

3.3 Limitations and Direction for Future Research

The theoretical model described above does not consider cultural factors impacting the knowledge sharing process, primarily because it is assumed that team members belong to one organization, and share similar cultural context. In a distributed software development, such kind of team distribution is prevalent. Also not all antecedents of knowledge sharing are discussed, the focus is primarily on identifying team level factors. Individual level factors will also have an impact on the knowledge sharing process, but literature is replete of similar studies, and hence we have focused primarily on team level facilitators of knowledge sharing in distributed setting. Another issue that needs mention here is that we have not used physical distance to capture the distributedness of the teams, primarily because communication using tech enabled 'richer media' such as video/audio conferencing is much more feasible and convenient than ever before. Hence temporal distribution of teams is used as proxy for understanding how people separated across distances coordinate their work efforts. An empirical test of the concepts described in the paper is necessary to validate the proposed model, as a future research work, and we propose to embark on the same once the measuring instrument is validate by pilot study. This study is part of the work in progress. Since much of the work is on student teams in distributed form of working (J. Webster & Staples, 2006), empirical work on organizational teams is highly desirable to better understand the dynamics of these teams.

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