Exploring the effects of trust, task interdependence and virtualness on knowledge sharing in teams

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Abstract. *The sharing of knowledge within teams is critical to team functioning. However, working with team members who are in different locations (i.e. in virtual teams) may introduce communication challenges and reduce opportunities for rich interactions, potentially affecting knowledge sharing and its outcomes. Therefore, using questionnaire-based data, this study examined the potential effects of different aspects of virtuality on a knowledge-sharing model. Social exchange theory was used to develop a model relating trust to knowledge sharing and knowledge sharing to team effectiveness. The moderating effects of virtuality and task interdependence on these relationships were examined. A strong positive relationship was found between trust and knowledge sharing for all types of teams (local, hybrid and distributed), but the relationship was stronger when task interdependence was low, supporting the position that trust is more critical in weak structural situations. Knowledge sharing was positively associated with team effectiveness outcomes; however, this relationship was moderated by team imbalance and hybrid structures, such that the relationship between sharing and effectiveness was weaker. Organizations should therefore avoid creating unbalanced or hybrid virtual teams.*

Keywords: distributed teams, hybrid teams, trust, team effectiveness, knowledge transfer, task interdependence

INTRODUCTION

Virtual teams, or groups of individuals who work together from different locations, perform interdependent tasks, share responsibility for outcomes, and rely on technology for much of their communications (Cohen & Gibson, 2003), are becoming commonplace in organizations (Bell, 2005; Morello, 2005). Although working in geographically distributed teams is becoming more widespread, processes for effective functioning are not fully understood. One such vital process is the sharing of knowledge among team members.

Knowledge represents a critical asset for organizations in today's economy. Successful orga-nizations need dynamic capabilities to create, acquire, integrate and use knowledge (Grant, 1996; Teece *et al.*, 1997; McEvily *et al.*, 2000; Sambamurthy & Subramani, 2005). Common to these capabilities is the movement of knowledge from one team member to another, typically called transfer, diffusion, distribution – or more commonly – knowledge sharing (e.g. Bergman *et al.*, 2004; van den Hooff & Ridde, 2004; Wasko & Faraj, 2005). However, practitioners have noted that sharing knowledge is personal (Caldwell, 2004) and that getting people to share knowledge effectively is difficult (e.g. Fisher & Fisher, 1998). As such, there is growing acknowledgement that employees may not always be motivated to share their knowledge with others (e.g. Kelloway & Barling, 2000; Husted & Michailova, 2002; Currie & Kerrin, 2003; Mac-Neil, 2003).

Research has found that knowledge sharing in traditional teams is critical for team effec-tiveness since team members rely on each other (Powell *et al.*, 2004). We suggest that sharing is also critical to virtual teams. Virtual teams are often created to allow people with different backgrounds, expertise and perspectives to work on a problem. This diversity has the potential to enhance team success and the quality of outcomes (Sole & Edmondson, 2002; Hinds & Bailey, 2003; Balthazard *et al.*, 2004). However, sharing expertise and knowledge within the team is critical to obtain the potential benefits of this diversity. Nevertheless, recent reviews of empirical research (Webster & Staples, 2006; Martins *et al.*, 2004; Powell *et al.*, 2004; Hertel *et al.*, 2005; Pinsonneault & Caya, 2005) have found very few studies of knowledge sharing in virtual teams. Notable exceptions include: Cummings's (2004) study of knowledge sharing with colleagues outside their immediate work teams, Majchrzak *et al.*'s (1995) case study of one high-tech team, Rafaeli & Ravid's (2003) study of students communicating via email during a simulation exercise, and Sole & Edmondson's (2002) study of situated knowledge. All of these studies support the importance of knowledge sharing in virtual teams.

Pinsonneault & Caya (2005) propose an agenda for future research on virtual teams: their first agenda item is a call for more research on knowledge sharing. This call is based on their conclusions that: (1) very few studies exist on knowledge sharing within virtual teams; (2) vir-tual teams exchange less unique information than traditional teams (e.g. Warkentin *et al.*, 1997); and (3) the premise that one of the most important benefits of virtual teams is access to wider knowledge and expertise. Further, Pinsonneault & Caya (2005), Hertel *et al.* (2005) and Martins *et al.* (2004) suggest that research is needed on knowledge exchange that exam-ines the effects of different aspects of virtualness. The current paper aims to meet these calls for additional research by examining knowledge sharing in virtual teams and investigating if knowledge-sharing relationships change for different types of teams (e.g. traditional vs. dis-tributed teams) and different aspects of virtualness.

We develop a parsimonious model of the effects of knowledge sharing on team effective-ness, in which sharing is affected by team trust and is moderated by task interdependence. Although past research on traditional teams would support this model (Gillam & Oppenheim, 2006), we extend it by exploring the moderating effects of team virtualness. To do so, we exam-ine knowledge sharing in teams with varying levels of virtuality. Team virtualness has often conceptualized in the past as either geographically distributed (i.e. virtual) or colocated (i.e.

face-to-face); however, very few teams operate at one extreme or another. In contrast, we examine the moderating effects of different dimensions of virtuality, such as time zone virtualness (O'Leary & Cummings, 2002) and structural forms (Fiol & O'Connor, 2005). For instance, we categorize teams into structures depending on where team members are located, at the same location (a traditional team), all members remote (a distributed team), or some members colocated and some remote (a hybrid team). Although these different team structures can influence team dynamics, cooperation and performance, little research has examined their influences (Pauleen, 2003; Fiol & O'Connor, 2005).

Our research model and associated hypotheses are described in the next section. The methodology used to test the model and the results found are then presented. Discussion of the results follow, in which we suggest implications for researchers and practitioners and highlight the key contributions of our study.

RESEARCH MODEL AND HYPOTHESES

The specific focus in this paper is the sharing of knowledge within teams. Knowledge sharing can be conceptualized as a flow activity (Nissen, 2006), an exchange where one party gives some knowledge that s/he has (explicit or tacit) to another party (a person, a group or a repository) (Hall, 2003). Our study examines the sharing of ideas within the team from the perspective of the team member. Based on Nissen & Jennex's (2005) knowledge dimensions, the study focuses on the tacit end of the explicitness dimension (the type of knowledge ranging from explicit to tacit), the group point on the reach dimension (the level of aggregation ranging from individual to inter-organizational), and sharing from the life cycle dimension (knowledge activities ranging from knowledge creation to forgetting).

The research model for this study is shown in Figure 1. We use Blau's (1964) perspective on social exchange as the theoretical basis for this model. Social exchange theory has developed
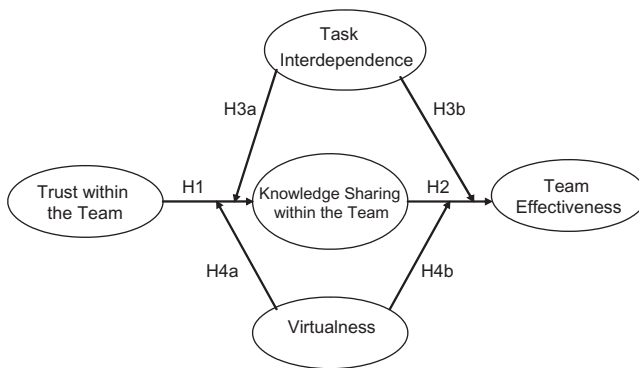

Figure 1. Knowledge-sharing research model.

over several decades to explain non-contractual interactions between people (Chadwick-Jones, 1976) and has been used to study a variety of social exchanges, including market relations, work relations, friendships and love (Blau, 1964), as well as knowledge sharing in teams (Cummings, 2004).

Our base model of knowledge sharing mediating trust and team effectiveness draws from traditional team research. It hypothesizes that interpersonal trust of others in the team will be positively associated with the amount of knowledge sharing within the team and that knowledge sharing will be positively associated with team effectiveness. We extend the base model by examining the moderating effects of task interdependence and virtualness. The logic and empirical support for each of our hypotheses are described next.

A key element of the model is interpersonal trust, or confident positive expectations regarding others' conduct (Lewicki *et al.*, 1998). Interpersonal trust is linked to a number of behaviours, including organizational citizenship behaviours (Pillai *et al.*, 1999), a desire for future interactions (Naquin & Paulson, 2003), team performance (Dirks, 1999) and information sharing (Butler, 1999). Trust is one of the underlying precepts of an effective social exchange (Blau, 1964), and as such, may also affect workers' knowledge-sharing behaviours. Social exchange refers to voluntary actions that are motivated by expected returns and actual returns. An exchange implies that one party supplies something to another party. An obligation is created in the receiving party. The receiving party must provide some sort of benefit to the first in order to discharge this obligation. The returns may be either direct or indirect. Exchanges that are driven by conformity to social pressures tend to be indirect. For example, charitable donations may be made to earn approval of philanthropic peers, not the gratitude of the recipients of the donation (Blau, 1964). Social exchange critically differs from economic exchange in that social exchange entails unspecified obligations. One person does something for another with the general expectation of some future return; however, its exact nature is not defined or stipulated in advance. Rewards that result in discharging obligations in social exchanges can vary greatly and may be intrinsic (e.g. attraction, acceptance), extrinsic (e.g. approval, services such as advice or assistance) or unilateral (e.g. respect, prestige, power or compliance) (Blau, 1964).

As described above, the sharing of knowledge can be conceptualized as an exchange where one party gives some knowledge that s/he has (explicit or tacit) to another party (a person or a repository). Although some suggest that knowledge can be a capability of groups or processes (Snowden, 2002), Grant (1996) proposes that most explicit and all tacit knowledge is stored within individuals. Sharing of this individually held knowledge is an exchange that the holder of the knowledge typically decides to participate in or not. In other words, the sharing of knowledge is largely a voluntary behaviour with uncertain rewards (Davenport *et al.*, 1998; Davenport & Prusak, 1998). The giving of knowledge is just one side of the exchange. What the giving party expects in return is what motivates the initial act of sharing. As reviewed by Hall (2003), social exchange theory has been applied to knowledge sharing to help understand why and when people share (e.g. Constant *et al.*, 1994; Tiwana & Bush, 2001; Bock & Kim, 2002).

According to social exchange theory, interpersonal trust will be positively associated with the amount of sharing. Social exchange depends heavily on trust because it involves unspecified obligations that cannot be enforced (i.e. there is no binding contract). In knowledge sharing,

interpersonal trust comes into play because requestors must allow themselves to be vulnerable to their colleagues, for instance, by acknowledging their lack of knowledge in a certain domain (Gray, 2001). The requestors may also need to trust that their colleagues will provide information that is accurate and helpful. Similarly, individuals who provide information must trust that the given knowledge will be used appropriately. Without trust, individuals will not be willing to engage in social exchanges and sharing will not take place.

The importance of trust for knowledge sharing is commonly mentioned in the knowledge management (KM) literature (Chowdhury, 2005); for example, 'Trust is, after all, the single most important precondition for knowledge exchange' (Rolland & Chauvel, 2000, p. 239). Additionally, empirical evidence supports the positive impacts of trust on knowledge sharing in a variety of situations, including teams (e.g. Butler, 1999; Connelly & Kelloway, 2003; Akgun *et al.*, 2005; Arthur & Kim, 2005; Chowdhury, 2005; Muthusamy & White, 2005). Thus, we hypothesize that:

Hypothesis 1: Team members' trust will be positively associated with knowledge sharing within the team.

The model next proposes that knowledge sharing will enhance team effectiveness. Sharing of knowledge is needed for good decision-making and the building of the team's base of knowledge. In traditional teams, we know that the sharing of expertise is an essential group process for team effectiveness (Cohen, 1994; Cohen & Bailey, 1997). Further, sharing of information and knowledge is a critical success factor for cross-functional teamwork (Holland *et al.*, 2000).

Knowledge sharing is also essential for virtual team effectiveness. Virtual teams are often created to bring together diversity of expertise and knowledge. With the increasing needs for technical knowledge bases and the requirements to integrate different technical and professional knowledge, individuals rarely can absorb and/or hold all the requisite knowledge domains needed for their teams' tasks (Sapsed *et al.*, 2002). Team members must rely on each other and share required knowledge with others. If sharing does not happen within the team, it is unlikely to meet its objectives.

Little synergy will be achieved without sharing and less innovation will result. It is through the harnessing and sharing of tacit knowledge that breakthrough innovations occur in project teams (Mascitelli, 2000). Further, empirical results from both virtual and traditional teams support a positive link between sharing of knowledge and team outcomes (e.g. Majchrzak *et al.*, 1995; Cummings, 2004; Hong *et al.*, 2004). Thus, we propose that:

Hypothesis 2: Knowledge sharing within the team will be positively associated with team effectiveness.

We now extend the base model by examining task interdependence and virtualness. Task interdependence, or the degree to which team members rely on one another and must interact in order for the group to accomplish its work (Guzzo & Shea, 1992; Jehn, 1995), is proposed to moderate hypotheses 1 and 2. To explain this, we draw on the recent theoretical work by Dirks & Ferrin (2001). They suggest that the role of trust varies depending on the strength of the situational structure. Structural strength relates to the level of uncertainty or ambiguity present in which an event occurs, or in our study, a team operates. Their work is based on the

assumption that trust reduces ambiguity and uncertainty in social perceptions, and therefore, cooperative or productive activity can take place. This is consistent with social exchange theory, in which trust enables the exchange because of the lack of other mechanisms that could ensure obligations are met. That is, in conditions with low structure, trust has important positive effects, because there are few other cues that guide individuals and their interpretations of others' behaviours (Dirks & Ferrin, 2001). In situations with stronger structures, there is other information available that helps individuals interpret behaviours and guide actions, such as training and procedures (Jarvenpaa *et al.*, 2004). In these situations, trust plays a weaker role.

We propose that task interdependence is a structural factor that can change the influence of trust. Under high task interdependence, individuals are performing tasks where they rely on each other, and may have discussed roles, expectations and deliverables (i.e. a relatively strong structural situation exists). Expectations of reciprocal actions are fairly strong. In situations like this, there are additional mechanisms driving expectations of fulfilling obligations. Therefore, knowledge sharing will be less dependent on trust. Consequently, we expect the relationship between trust and knowledge sharing to be weaker. However, under low task interdependence (i.e. weak structure), reliance on each other is low, and expectations of reciprocation are low (i.e. not driven by the task demands). This weak structure leads to trust playing a stronger role in determining knowledge sharing because future obligations are unspecified and the meeting of these obligations is uncertain. In these sorts of contexts, knowledge sharing approaches a pure social exchange, implying that trust is the critical enabler. Thus, we suggest that:

Hypothesis 3a: Task interdependence moderates the relationship between trust and knowledge sharing. Specifically, under low task interdependence, the relationship between trust and knowledge sharing will be stronger. Under higher task interdependence, the relationship between trust and knowledge sharing will be weaker.

The potential moderating role of task interdependence on the relationship between team processes and team outcomes has been suggested in several team effectiveness models (e.g. Goodman *et al.*, 1987; Guzzo & Shea, 1992). Task interdependence facilitates team processes such as knowledge sharing because team members will interact more if they rely on and need each other. Specifically, if the task is one where they need to learn from each other, share knowledge and interact (i.e. high interdependence), then the relationship between knowledge sharing and team performance should be strong. Similarly, if people are not sharing and sharing is needed in order to succeed, working in the team will be frustrating. This will lead to lower performance, with the resulting lack of desire to be part of the poorly functioning team. In contrast, if there is little benefit to knowledge sharing for the task, then the relationship between this process and task performance will be weaker (Gladstein, 1984).

Effectively, knowledge sharing has to fit task demands in order for sharing to positively impact team effectiveness. Under high interdependence, we expect the relationship between sharing and outcomes to be stronger. If there is little need for knowledge from others (i.e. low interdependence), these relationships will be weaker. Thus, we hypothesize that:

Hypothesis 3b: Task interdependence moderates the relationship between knowledge sharing and team effectiveness. Specifically, under high task interdependence, the relationship between knowledge sharing and team effectiveness will be stronger. Under low task interdependence, the relationship between knowledge sharing and team effectiveness will be weaker.

Hertel *et al*. (2005) suggest that research should examine the moderating effects of virtualness on team processes. To do this, we explore whether team virtualness moderates the model. Team virtualness can be described simply as either geographically distributed (i.e. virtual) or colocated (i.e. face-to-face). Although often conceptualized this way in the past (i.e. either virtual or traditional), very few teams operate at one extreme or another. There are different dimensions to a team's virtualness, resulting in varying degrees of dispersion (O'Leary & Cummings, 2002) and structural forms (Fiol & O'Connor, 2005).

The degree of dispersion represents the extent to which a team is virtual. For example, O'Leary & Cummings (2002) suggest that the number of members per site and the separation distance between sites capture different dimensions of degree of dispersion. The degree of dispersion can affect the sharing of knowledge. This is because colocation promotes contact and communication, both formal and informal. Teams with more informal communication (like accidental meetings by coffee machines) have greater cross-functional cooperation, which is more difficult in a distributed context (Sapsed *et al*., 2002). Sharing knowledge implies some loss of control over it, creating risks for the sharer. These risks are greater when sharing in a distributed environment, because the transparency of how the knowledge is understood and re-used can be low. Sharing with distributed people is associated with concerns about accountability of how the shared knowledge may be used in the future, monitoring and making decision processes too explicit (Malhotra & Majchrzak, 2004). Therefore, to achieve the same level of sharing, trust may have to be higher in distributed teams, implying a moderation effect.

Sharing in a virtual context becomes more difficult because of dependence on electronic communication. Although electronic communication tools can be effective for sharing explicit knowledge, tacit-to-tacit exchanges typically require close personal contacts (Mascitelli, 2000). Similarly, the sharing of emotions, experiences and insights are more difficult via leaner media. Virtualization can impair the sharing of sensitive and confidential knowledge between peers, potentially because of a lack of trust in the technology as an appropriate medium for sensitive knowledge sharing (Breu & Hemingway, 2004). Therefore, knowledge sharing in virtual teams may be substantially different than in colocated teams. A higher proportion of knowledge being shared may be of lower quality and less sensitive. A reduction in the quality of knowledge being shared could hurt the performance of the team and could reduce the team members' intention to remain on the team, because they could become frustrated with the knowledge sharing. This implies that the degree of dispersion may moderate the relationship between knowledge sharing and team effectiveness because, for the same amount of knowledge sharing, the higher quality sharing in colocated teams would have a stronger effect on performance.

Turning to structural forms, Fiol & O'Connor (2005) argue that teams should not be considered in terms of their degrees of dispersion but in terms of their team structures. They suggest

that there are non-linear differences between different team structures. Structures vary based on whether the team member resides at the same location as all of her team members (a traditional team), is the only team member at a particular location (a distributed team), or has some team members at her location and some at other locations (a hybrid team with some colocated members [Fiol & O'Connor, 2005]). Thus, we explore possible differences across the different structural forms of teams.

We suggest that different team structures can influence the relationships in the model. For example, we know that teams that evolve into subgroups exhibit interpersonal conflict, poor communication and low cohesion (Axtell *et al.*, 2004). Hybrid teams (where part of the team is local to the team member and part is remote, i.e. everyone is neither local nor remote) are potentially the worst performers because the structure provides the potential for the development of in-groups and out-groups. This in-group favouritism represents a robust finding across a variety of situations, ranging from artificial groups to existing organizational groups (Ashforth & Mael, 1989; Lewis & Sherman, 2003). Some empirical research supports this in-group/out-group distinction in hybrid teams, demonstrating an *us vs. them* mentality by local members (Armstrong & Cole, 2002), resentment of local members by remote members (Malhotra *et al.*, 2001), local members' making situational attributions for their own failures but dispositional attributions for remote members' failures (Cramton, 2002), and higher identity, communication and perceptions of local than remote team members (Webster & Wong, 2008). Thus, we expect to see weaker relationships in the model for hybrid teams.

In sum, we explore the moderating effects of virtualness (both structural forms and degrees of dispersion) in the knowledge-sharing model. Given the exploratory nature of this work and the paucity of past empirical research, this is structured as a non-directional hypothesis:

Hypothesis 4: Virtualness moderates the relationship (a) from trust to sharing, and (b) from sharing to team effectiveness.

The tests of these hypotheses are described next.

METHODOLOGY

A web-based questionnaire was developed to collect data from 985 individual members of teams (as part of a larger study). The questionnaire was piloted with five graduate students and three employees, and took about 25 min to complete.

Survey design and sampling

Participants from two sources were recruited through email messages and those who participated were entered into a lottery to receive gift certificates from an online organization. The first source ($n = 548$) was a very large global high-tech company with a great number of teams, many of which were geographically distributed. The second source ($n = 437$) was from an online panel (The StudyResponse Project (Stanton & Weiss, 2002)). Respondents in this panel

worked in different organizations on diverse types of teams, and team structure varied from traditional to virtual, with some teams being hybrid. A source control variable was included in the analyses to control for possible differences between the two sample sources. The response rate was approximately 4% from the high-tech company and 11% from StudyResponse (for an overall response rate of 7%). Standard non-response bias procedures (Armstrong & Overton, 1977) found no indications of differences between respondents and non-respondents on a variety of demographic variables and the construct scores.

Missing data reduced the sample size from 985 to 824. The sample had somewhat more men than women (56% vs. 44% respectively). The respondents had a wide range of ages (21% were less than 30 years; 36% were 30–39 years; 29% were 40–49 years; 14% were 50 years or older). The sample was well-educated (65% had a university bachelors degree or higher) and had considerable work experience (13% had less than 5 years of full-time work experience; 21% had 5–9 years; 35% had 10–19 years; 31% had 20 years or more). Job titles were varied, including positions such as software engineers, nurses, sales, administrative assistants, teachers and analysts; 32% were managers. Team purpose also varied, including developing and marketing software and hardware products, setting organizational strategy, customer service, product support and sales.

In the survey, we asked participants to 'think about a team (that includes yourself and at least two other team members) in which you currently spend the majority of your time'; this team could have been a traditional, hybrid or a distributed team. We then asked them to answer a series of questions concerning the structure and perceptions of this particular team, such as performance, sharing behaviours, trust and virtualness (i.e. to measure the constructs, described next).

Construct measurement

Where possible, we used validated measures for the constructs in the model (see Appendix A for all of the measures' items; unless otherwise indicated, all items were measured on 7-point scales).

Typical *team effectiveness* models (e.g. Cohen, 1994) usually include three main groups of outcome variables: (1) performance outcomes such as quality, productivity and controlling costs; (2) attitudinal outcomes such as satisfaction with the team, motivation and organizational commitment; and (3) behavioural outcomes such as turnover and absenteeism. We focused on the first and last categories, avoiding potential confounding problems caused by strong relationships between attitudinal outcomes and team trust (Cohen & Bailey, 1997). Perceived *team performance* was assessed with Van de Ven & Ferry's (1980) eight-item measure (reliability for the current study: $\alpha = 0.92$). *Intention to remain* was measured with three items adapted from Jehn (1995) ($\alpha = 0.76$).

Knowledge sharing was measured with Connelly & Kelloway's (2003) five-item scale ($\alpha = 0.86$). This measure focuses on more tacit types of knowledge, such as ideas and expertise. It examines knowledge from the perspective of the employee, that is, the respondent decides what knowledge means to him/her. *Trust* was measured with Schoorman *et al.*'s

(1996) six-item scale ($\alpha = 0.70$). *Task interdependence* was measured with six items from Bishop & Scott (2000) and Janssen *et al.* (1999) ($\alpha = 0.76$).

Multiple indicators of *team virtualness* were captured. To assess the *degree of dispersion*, we drew on O'Leary & Cummings's (2002) suggestions to create two measures: the number of members per site (isolation index) and the balance of people per site (imbalance index). We also built on Chudoba *et al.*'s (2005) to measure team time zone spread, change in team membership (team stability), the extent to which team members had not met face-to-face (lack of F2F knowledge), and the number of native languages represented within the team (language diversity).

To examine *structural forms*, we compared three conditions: traditional teams (all team members in the same location as the respondent, $n = 283$), hybrid teams (some team members at the member's location and some at other locations, $n = 357$) and distributed teams (no team members at the respondent's location, $n = 184$). Based on Cohen & Cohen (1983), we coded these three conditions into two dummy variables for the moderating analyses.

Analytical procedures

With a mediated research model, structural equation modelling (SEM) was warranted. Partial Least Squares (PLS) was chosen as the SEM tool for this analysis. PLS uses a combination of principal components analysis, path analysis and regression to simultaneously evaluate theory and data (Pedhazur, 1982; Wold, 1985). The path coefficients are standardized regression coefficients, while the loadings can be interpreted as factor loadings. Significance of the path coefficients is calculated using bootstrapping (generating *t*-statistics and significance levels). The objective of a PLS analysis is to explain variance in the endogenous constructs, rather than to replicate the observed covariance matrix, as is the case with covariance structure techniques (such as LISREL or AMOS). Because of this, PLS does not create overall fit statistics for its models (for more information on PLS, see Barclay *et al.*, 1995; Hulland, 1999; or Gefen *et al.*, 2000).

The interaction effects were modelled consistent with the approach described by Chin *et al.* (1996) and Aiken & West (1996). That is, we first centred the indicators for the direct and moderating constructs. Pair-wise product indicators were then created by multiplying each indicator from the direct construct (e.g. trust) with each indicator for the moderator construct (e.g. task interdependence or the virtuality indicators). We used these new product indicators to reflect the interaction construct and to test the research model.[1]

The existence of a significant interaction implies that the relationship between two constructs changes depending on the level of a third (i.e. in our case, task interdependence and/or an aspect of virtuality). For the interaction terms that were found to be significant in the SEM analysis, we used standard graphical analysis techniques to help understand the nature of the interaction (Aiken & West, 1996). We examined these interactions in charts that illustrate the moderating effects of each significant moderator on the relevant relationship. The units on

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[1]Direct effects were also included in the model, as per standard interaction modelling techniques, and these results are available from the authors.

the graphs are standard deviations and the values are all standardized. The range used for the *x*-axis is plus/minus two standard deviations. Two regression lines are plotted on each chart – one for a high value of the moderator variable (i.e. two standard deviations above the mean) and one for a low value of the moderator variable (i.e. two standard deviations below the mean).

RESULTS

Examining the results of SEM involves two steps: assessment of the measurement model and then assessment of the structural model.

Measurement model results

A base model (i.e. no moderating relationships included) was analysed first to assess whether the measurement model was reliable and valid. The initial analysis of the base model found one weakness: four items in trust and knowledge sharing overlapped and were therefore dropped to create acceptable discriminant validity.

The trimmed base model was then re-analysed. Table 1, based on the trimmed model, reports internal consistency values for the constructs using the Fornell & Larcker (1981) internal consistency formula. The internal consistency scores all exceed 0.7 indicating adequate reliability. Table 1 also reports the average variance extracted: the square root of this measure is used in the diagonal elements of the correlation matrix to assess discriminant validity. For discriminant validity, these diagonal elements should be larger than any of the intercorrelations between the latent variables (Barclay *et al*., 1995), which they are. We also examined the loadings of each individual item to ensure that adequate discriminant validity existed.[2] All the items

Table 1. Measurement model reliability and validity analysis

	Number of items	Mean	SD	Internal consistency*	Average variance extracted	1	2	3	4
Trust in team	3	4.910	1.355	0.782	0.549	**0.741**†			
Knowledge sharing	4	5.645	1.162	0.898	0.688	0.553	**0.830**		
Team performance	1	5.384	1.072	–	–	0.262	0.482	–	
Intention to remain on team	3	4.892	1.625	0.867	0.684	0.371	0.523	0.432	**0.827**

*Calculated using Fornell & Larcker's (1981) method.
†The bold diagonal elements are the square root of the variance shared between the constructs and their measures (no such measure exists for the single-item constructs). Off-diagonal elements are the correlations between latent constructs.
SD, standard deviation.

[2]A cross-loading matrix is available from the authors.

loaded highest on their target construct. Overall, the results suggest that the measurement model is adequate, allowing for the examination of the structural model.

Structural model results

The base model (before the inclusion of task interdependence and virtualness) showed strong positive relationships for hypotheses 1 and 2 (see Table 2). Specifically, the path coefficients were: 0.553 for trust to knowledge sharing, 0.482 for sharing to team performance, and 0.523 for sharing to intention to remain.

Analysis of the full model that includes task interdependence and virtualness found four interaction terms to be significant (the main paths remained strongly significant, consistent with the base model findings). Task interdependence significantly moderated (see Figure 2) the relationship between trust and knowledge sharing (path coefficient = −0.105) and the relationship between knowledge sharing and intention to remain on the team (path coefficient = 0.102), supporting H3a and partially supporting H3b. Virtualness did not moderate the relationship between trust and knowledge sharing (H4a was not supported). The relationship between knowledge sharing and team performance was moderated by two of the virtualness measures (see Table 3: imbalance path coefficient = −0.198 and virtual2 structure dummy variable path coefficient = −0.182), supporting H4b.

To help understand the moderating role that the three virtual structure conditions might play, further analysis was carried out by re-analysing the base model for subgroups of the sample. The variance explained in the endogenous constructs was examined for each of the three conditions (local, hybrid and distributed). A variance ratio test (Anderson & Sclove, 1978) was used to test for statistically significant differences (see Table 4). As implied by the statistically significant moderator described above, the variance explained in the endogenous variables by the model for the hybrid condition was considerably less than the variance explained in the other two conditions (providing further support for H4b).

Table 2. Results for hypotheses 1–3

Hypotheses and corresponding path(s)	Path coefficient	*t*-value†	Path statistically significantly different than zero?
H1: Trust to knowledge sharing (direct effect)	0.553	20.818***	YES
H2: Knowledge sharing to team outcomes			
• Team performance (direct effect)	0.482	15.692***	YES
• Intention to remain (direct effect)	0.523	18.339***	YES
H3a: Moderating effect of task interdependence on the relationship			
• Trust to knowledge sharing	−0.105	3.254**	YES
H3b: Moderating effect of task interdependence on the relationship			
• Knowledge sharing to team performance	0.083	1.368	NO
• Knowledge sharing to intention to remain	0.102	2.636**	YES

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$ (two-tailed test).

†*t*-statistics were calculated using bootstrapping with 500 samples.

Panel A: Task Interdependence Moderating the Relationship between Trust and Knowledge Sharing

Panel B: Task Interdependence Moderating the Relationship between Knowledge Sharing and Intention to Remain on Team

Panel C: Imbalance Moderating the Relationship between Knowledge Sharing and Team Performance

Panel D: Distributed Structure Moderating the Relationship between Knowledge Sharing and Team Performance
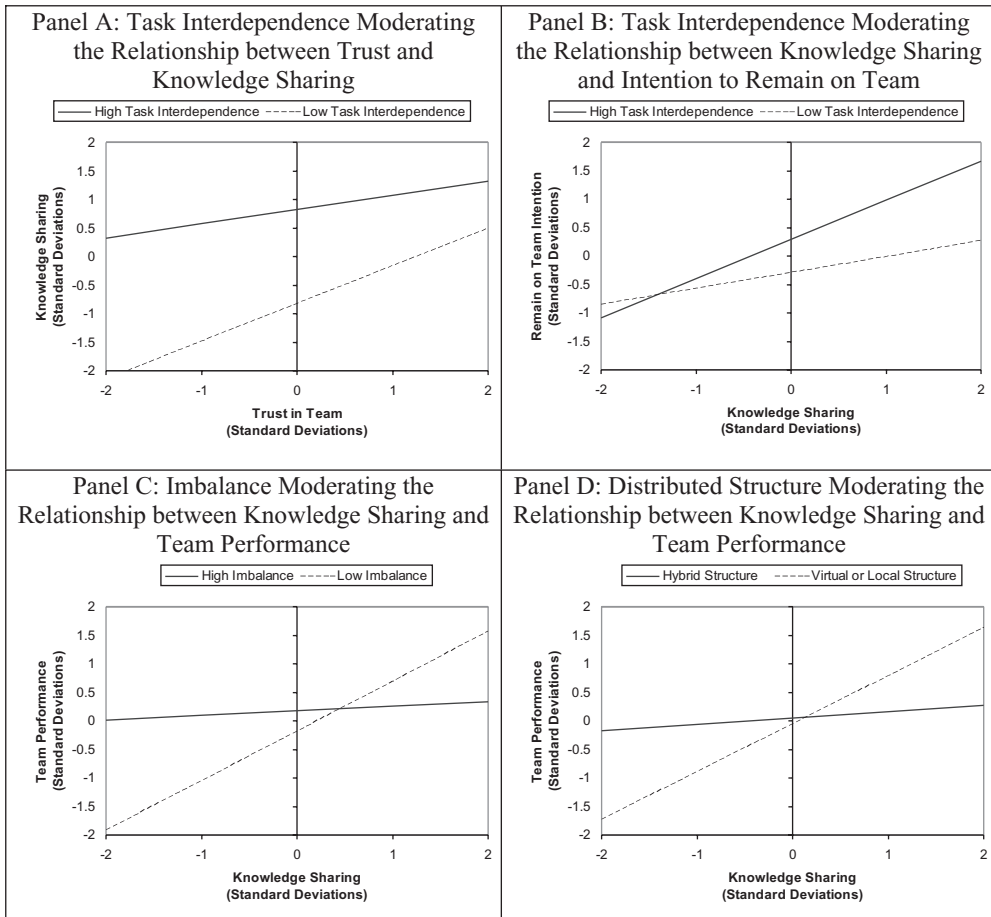
Figure 2. Significant interaction relationships.

DISCUSSION

The study of the management of knowledge is important and has grown rapidly as evidenced by special issues in leading journals, specialized KM journals and conferences. Various authors have proposed different phases or processes to be part of KM (e.g. Davenport & Prusak, 1998; Alavi & Leidner, 2001; Staples *et al.*, 2001; Nissen, 2002). Knowledge sharing is clearly a critical part of KM (Grant, 1996; Puccinelli, 1998) and the focus of this paper. Specifically, we extended past research by studying knowledge sharing in teams with varying levels of virtuality.

Table 3. Hypothesis 4: the moderating effects of virtuality†‡

Virtuality measures	Moderating the path from trust to knowledge sharing	Moderating the path from knowledge sharing to team performance	Moderating the path from knowledge sharing to intention to remain
Imbalance	−0.096	**−0.199**	−0.033
	($t = 1.61$)	(***t* = 2.08***)	($t = 0.50$)
Isolation	−0.03	−0.053	0.009
	($t = 0.87$)	($t = 0.89$)	($t = 0.18$)
Time zone spread	−0.056	−0.019	−0.019
	($t = 1.33$)	($t = 0.11$)	($t = 0.44$)
Team stability	−0.076	0.055	0.052
	($t = 1.94$)	($t = 0.94$)	($t = 1.24$)
Lack of F2F knowledge	0.005	−0.064	−0.065
	($t = 0.13$)	($t = 0.80$)	($t = 1.33$)
Language diversity	−0.036	0.067	0
	($t = 0.52$)	($t = 1.09$)	($t = 0$)
Virtual1 (distributed = 1)	0.011	−0.084	0.07
	($t = 0.18$)	($t = 1.01$)	($t = 0.39$)
Virtual2 (hybrid = 1)	−0.096	**−0.182**	0.003
	($t = 1.59$)	(***t* = 2.01***)	($t = 0.78$)

Significant results in bold.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$ (two-tailed test).
†Standardized path coefficient.
‡t-value, calculated using bootstrapping.

Table 4. Variance explained for endogenous constructs

Endogenous constructs	Full sample	Condition 1: Local teams R^2	Condition 2: Hybrid teams R^2	Condition 3: Distributed teams R^2	Variance ratio tests		
					Condition 1 vs. Condition 2	Condition 1 vs. Condition 3	Condition 2 vs. Condition 3
Knowledge sharing	30.6%	32.2%	25.5%	37.7%	1.26	1.17	1.48*
Team performance	23.3%	30.1%	18.3%	26.1%	1.64*	0.87	1.43*
Intention to remain	27.4%	34.5%	19.5%	31.3%	1.77*	0.91	1.61*

*$P \leq 0.05$ (two-tailed).

Implications for both traditional and virtual teams

Study results demonstrate a strong positive relationship between trust and knowledge sharing, consistent with social exchange theory (H1). However, the strength of this relationship changes depending on the nature of the task (H3a). As shown in Panel A of Figure 2, the slope of the relationship is steeper with less task interdependence: trust has a stronger effect on knowledge sharing in the absence of less structure. This is consistent with Dirks & Ferrin's (2001) suggestions that the effects of trust change under different structural conditions. Several impli-

cations and possible avenues for future research emerge from this. First, future research examining the relationship between trust and knowledge sharing should look at the structural strength in the situation because it could affect the findings (i.e. control for this effect). Second, managers of teams can use the results to consider the balance and trade-offs between trust and task interdependence. If task interdependence is low in the design of a team, then developing trust within the team is very important to facilitate the sharing of knowledge. The importance of doing so is also supported by the finding for H2: even under low task interdependence, the relationship between knowledge sharing and team performance remains strong.

If one is managing a team that has somewhat low trust or is having difficulty building trust, putting structure in place should facilitate the amount of knowledge sharing. In this case, sharing may be somewhat less voluntary and more of an expectation, perhaps becoming less of a prosocial behaviour and more of a job requirement. Consequently, future research should investigate different structural options that potentially affect sharing and compare the findings with the impact of trust on knowledge sharing. We assumed different levels of task interdependence created different structural conditions: explicitly varying structural conditions in future research would add to our understanding regarding the impact of trust on knowledge sharing. Additionally, identifying when the act of knowledge sharing moves from a social exchange to more of a contractual exchange, and the costs and benefits of this could be valuable avenues for future research and theory development.

Study results also demonstrate that knowledge sharing is strongly and positively associated with team effectiveness, measured as perceived team performance and intention to remain on the team (H2). Further, the relationship between sharing and intention to remain is moderated by task interdependence (H3b). Under high interdependence, higher sharing improves intention to remain (see Panel B of Figure 2). The relationship between sharing and intention to remain also remains positive under lower task interdependence, but to a lesser degree. These results suggest that team members may be more willing to be part of the team when sharing is needed to complete their tasks and is conducted. If sharing is not needed as much (i.e. under low task interdependence), sharing may still be perceived as beneficial, but it does not have as strong an influence on the behavioural intention. Interestingly, task interdependence does not moderate the sharing to task performance relationship. This implies that knowledge sharing is important for team performance, regardless of the level of task interdependence. These findings reinforce the importance of knowledge sharing in teams.

Comparing traditional with virtual teams

We explored whether multiple dimensions of virtuality moderated our model. None of the dimensions of virtuality moderated the strong relationship between trust and knowledge sharing (H4a). To examine this finding further, the path coefficients between trust and knowledge sharing for the three structural conditions were examined. The relationships for both the local and distributed teams were somewhat stronger than for the hybrid teams (path coefficients for local, distributed and hybrid are 0.567, 0.614 and 0.505 respectively). However, all the paths are positive and strong, implying that team trust is an important predictor for all types of teams.

It is relatively common to see suggestions that virtual teams rely heavily on trust (e.g. Handy, 1995; Gallivan, 2001). Our findings support the importance of trust with respect to knowledge sharing; however, the findings also suggest that trust is just as important in local team settings.

Two of the virtuality measures moderated the relationship between knowledge sharing and team effectiveness (H4b): the imbalance index and the hybrid structural variable. Negative relationships exist for both: that is, if the team was of a hybrid structure or had high imbalance, the relationship between knowledge sharing and team performance was very weak (see Panels C and D in Figure 2). A hybrid structure means that part of the team is local to the team member respondent and part is remote. Imbalance refers to how evenly a team is split between sites. Teams with equal numbers of people at each site will have a low imbalance index. Teams with the majority of the people at one site (majority site), and few at other sites (minority sites), will have high imbalance. Imbalance may result in minority sites feeling left out of the decision-making and communication loop (O'Leary & Cummings, 2002).

Recent work on the negative effects of surface-level diversity within traditional teams can be applied to the results to help understand why imbalanced and hybrid structures are so detrimental to teams. In the short term, surface-level team diversity has been found to create process losses that result in decreased performance and satisfaction (Hambrick *et al*., 1998; Lau & Murninghan, 1998; Williams & O'Reilly, 1998). These process losses include communication difficulties, misunderstandings, decreased cohesion and increased conflict. Social identity theory, social categorization theory and the similarity/attraction paradigm suggest that the negative effects associated with surface-level diversity are due to the creation of in-groups and out-groups (Salk & Brannen, 2000; Carte & Chidambaram, 2004). People implicitly categorize themselves into subgroups according to salient cues and identify more closely with people they perceive as being similar to themselves. They do this to achieve and maintain positive self-identity. As in-group and out-group characteristics become salient within subgroups, individuals become more biased towards their subgroup. Initial research in this area assumed a linear relationship (i.e. low diversity does not create the process losses, whereas high diversity does). However, recent work suggests that the relationship may be curvilinear, where diversity has its greatest effects on teams that have moderate diversity (Carte & Chidambaram, 2004). Teams with low diversity are similar, so subgroups do not develop. In highly diverse teams, few commonalities exist for the basis of creating in-groups, so again these subgroups do not develop. In moderately diverse teams, people do share some characteristics, but not with everyone, so subgroups develop. Teams with low and high surface-level diversity have been found to outperform moderately diverse teams (Earley & Mosakowski, 2000).

These findings concerning diversity for traditional teams can help to explain our study findings. Specifically, the relationship between knowledge sharing and team performance is strong for both local and distributed teams, but is weak for hybrid teams. Sharing is very weakly associated with team performance for hybrid and unbalanced teams. We suggest that this is due to the in-group/out-group phenomenon. Implications for practice are that organizations should design teams to minimize the formation of subgroups. A purely virtual team, where team members are all working apart from each other, reduces the chances that subgroups will form. If it is necessary to have some local groups and some dispersed, team leaders should make

strong efforts to make sure everyone is kept informed equally, and work to quickly build a team identity. The diversity literature has found that once a team forms an identity, subgroup problems tend to reduce (Carte & Chidambaram, 2004). Future studies could extend this research. For example, creating conditions that vary the level of in-group creation would be valuable to test if this is the theoretical mechanism that is behind our findings regarding unbalanced and hybrid teams.

The other virtuality dimensions (isolation, time zone spread, team stability, lack of F2F knowledge and language diversity) did not moderate the relationship between knowledge sharing and team outcomes. This suggests that effective knowledge sharing is very important for teams, regardless of their geographic distribution, frequency of face-to-face contact, stability of membership or language diversity. Often in past research, virtual teams have been defined by their degree of geographic dispersion. Our study suggests that KM researchers studying virtual teams should focus more on the balance and structure of the team, rather than on its distribution characteristics.

Directions for future research

This study extends knowledge-sharing research from traditional teams to hybrid and distributed virtual teams. To do so, we considered knowledge sharing as individuals sharing tacit knowledge with their team members. However, as described earlier, Nissen & Jennex (2005) outline multiple dimensions of knowledge flows. One dimension which we did not examine is their temporal dimension (e.g. the length of time required for knowledge to flow) and others have argued that knowledge is both a thing and a flow (e.g. Snowden, 2002). Further, others have proposed that Nissen and Jennex's life cycle dimension be extended to include not only knowledge sharing but various types of knowledge hiding (i.e. overt hiding, evasive hiding and playing dumb (Connelly *et al.*, 2006)). Therefore, future research should examine other types of knowledge transfer, taking into account the multiple and varied dimensions of knowledge.

Examining knowledge patterns and flows will suggest opportunities for developing new classes of IT (Nissen, 2006). Nevertheless, information system (IS) design needs to move beyond the IT artefact to include meta-design issues, that is, broader, non-technological considerations such as organizational structures, work processes and personnel systems (Nissen, 2006). In this study, we have considered such meta-design issues. However, this still begs the question: what IT artefacts (e.g. computers, networks) and information flows (e.g. email, teleconferencing) facilitate knowledge flows in teams? For example, Zhuge (2003) describes the use of IT agents on software development team members' knowledge and mechanisms for using this knowledge. Others conclude that virtual teams should rely on multiple media instead of a single tool (Pinsonneault & Caya, 2005). Using multiple communication media can lead to greater satisfaction with team processes, more effective team results, and more opportunities and flexibility for meeting different needs and exchanging different types of knowledge (Pinsonneault & Caya, 2005).

In contrast to suggesting the use of multiple media, Carte & Chidambaram (2004) provide theoretical advice on when and what media should be used in diverse teams. Because virtual

teams are often diverse, they suggest that communication technologies with reductive capabilities (e.g. visual anonymity, equality of participation and asynchronous communication) should be used early in the team's life. Reductive capabilities reduce the immediate saliency of surface-level diversity, potentially reducing the team member's categorization processes and the formation of perceived in-groups and out-groups. Less disintegration of the team into subgroups should improve team interaction processes by reducing interpersonal disagreements and conflict, resulting in higher cohesion, team performance and team satisfaction. Later in the life of a team, after a team has developed a shared identity, Carte & Chidambaram (2004) suggest that additive capabilities, such as coordination support, electronic trails, decision-making tools and rich messaging, can be added. More research on which information technology tools facilitate knowledge sharing and when they are most effectively used is needed.

As with any study, limitations of this research suggest other areas for future research. Although we had a wide variety of teams representing multiple organizations and types of tasks, supporting the external validity of our results, our survey response rates were low (but not atypical). Further, we measured employees' perceptions cross-sectionally at the individual, not the team, level of analysis. Future research using multi-level analysis, incorporating objective measures of team performance, examining specific types of tasks and utilizing other methods, such as case studies or grounded theory, would help to remove potential method biases and strengthen internal validity.

CONCLUSION

Overall, with the exception of the structure of the team (balance and hybrid issues), the results are encouraging for virtual teams and their members. Being virtual does not appear to hurt the relations between trust and knowledge sharing. However, task interdependence does affect the relation between trust and knowledge sharing, and team structure and balance both affect the relation between knowledge sharing and performance. These results suggest many opportunities for future research exploring virtual team designs and structures.

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Biographies

Sandy Staples received his PhD from The University of Western Ontario and is an Associate Professor in the School of Business at Queen's University, Kingston, Canada. He has served as an Associate Editor for *MIS Quarterly* and on the editorial boards of other journals. His research interests include virtual work (at both the

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Jane Webster received her PhD from New York University and is the E. Marie Shantz Professor of MIS in the School of Business at Queen's University in Canada. She has served as a Senior Editor for *MIS Quarterly* and Guest Associate Editor of *Information Systems Research*. She currently serves on the advisory board for *AIS-SIGCHI* and is the VP of Publications for *AIS*. She has published in a variety of journals including the *Academy of Management Journal*, *Communication Research*, *Journal of Organizational Behavior*, *MIS Quarterly*, and *Organization Science*. Her research investigates the impacts of technologies in the support of distributed work, organizational communication, employee recruitment and selection, employee monitoring, training and learning, and human–computer interaction issues.

APPENDIX A

Construct measurement details

Trust within the team
- Overall, I feel that I can trust my team members completely.*
- If possible I would not give the other team members any influence over issues that are important to our successful completion of team tasks (reverse coded).
- I feel comfortable depending on my team members for the completion of team tasks.*
- I am comfortable letting other team members take responsibility for tasks which are critical to the group even when I cannot monitor them.*
- I feel that I will not be able to count on my team members to help me (reverse coded).
- I wish I could oversee the work of the other team members (reverse coded).

Knowledge sharing
- People in this team keep their best ideas to themselves (reverse coded).
- People in this team are willing to share knowledge/ideas with others.
- People in this team share their ideas openly.
- People in this team with expert knowledge are willing to help others in this team.
- This team is good at using the knowledge/ideas of employees.*

Team performance
Instructions: Now, please think about your <u>team's performance</u>. In *relation* to other *comparable* teams in your organization, how did your team *rate* on each of the following factors during the past year?
- The quantity or amount of work produced
- The number of innovations or new ideas introduced by the team
- Reputation for work excellence
- Attainment of team production or service goals
- The quality or accuracy of work
- Efficiency of team operations
- Morale of team personnel
- Adherence to schedule and budget

Intention to remain
- If I have my own way, I will continue working on the team.
- I do not expect to stay on this team very much longer (reverse coded).
- I have thought seriously about leaving this team (reverse coded).

APPENDIX A Cont.

Task interdependence
- I frequently must coordinate my efforts with other team members.
- Goal attainment for one team member helps goal attainment for others.
- For the team to perform well, members must communicate well.
- To achieve high performance, it is important to rely on each other.
- Jobs performed by different team members are related to one another.
- Success for one team member implies success for others.

Virtuality measures

Degree of dispersion:
- Imbalance index – equal to the standard deviation of members per site divided by the size of the team. A low imbalance index indicates relatively balanced membership across sites.
- Isolation index – the percent of team members who are at sites with one or no other team members (low values of the index indicate low levels of isolation).
- Time zone spread – in your team, to what extent do you need to collaborate with team members in different time zones?
- Team stability – in your team, to what extent do you need to work with changing team members?
- Lack of F2F knowledge – in your team, to what extent do you need to collaborate with team members that have never met face-to-face (F2F)?
- Language diversity – in your team, to what extent do you need to collaborate with team members who speak different native languages or dialects than your own?

Structural forms:

Three team conditions (local, hybrid and distributed) were coded into two dummy variables for moderator analyses (Cohen & Cohen, 1983)
  - o Virtual1: a dummy variable, in which local and hybrid teams are coded as 0 and distributed teams are coded as 1
  - o Virtual2: a dummy variable, in which local and distributed teams are coded as 0 and hybrid teams are coded as 1

*Indicates that the item was not included in the final analyses (for the trimmed model).