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INVESTIGATING MULTILEVEL RELATIONSHIPS IN INFORMATION SYSTEMS RESEARCH: AN APPLICATION TO VIRTUAL TEAMS RESEARCH USING HIERARCHICAL LINEAR MODELING

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ABSTRACT

Information Systems researchers are often concerned with empirical questions spanning more than one level of analysis. For example, virtual teams research provides a good illustration because such teams are inherently hierarchical entities involving the situated nature of individuals within teams. Despite the importance of multilevel research questions to Information Systems research, the literature has yet to fully engage appropriate techniques for multilevel investigations. Using hierarchical linear modeling (HLM) as a statistical tool that can appropriately test cross-level relationships, we provide an illustration of the differences and advantages of using a multilevel technique over ordinary least squares (OLS) regression. Using data from a study of global virtual teams, we demonstrate that substantive research conclusions differ based on the use of HLM versus OLS regression. Using HLM, we find a significant relationship between individual level task liking and affective commitment; we also find a significant relationship between individual level task liking and satisfaction with the virtual team. When testing the moderating effects of team

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characteristics, we found a significant positive moderating effect of team work processes on the relationship between task liking and satisfaction. We conclude with recommendations for future research and provide a comparison of empirical techniques available for IS researchers testing relationships at single and multiple levels of analysis.

INTRODUCTION

Information Systems (IS) is the discipline concerned with all aspects of Information Technology (IT), from design and development to understanding technology use and the events that occur when technology interacts with social settings, i.e., people, management, organizations, business processes (Lee 1999). Phenomena of interest to IS researchers are often cross-level or multilevel in nature. For example, IS researchers study individuals' technology adoption and use, and the impact of contextual attitudes on this process (Carlson and Zmud 1999; Markus 1994); they also investigate technology mediated learning and the impact of different educational technologies on individual learners' performance (Alavi and Leidner 2001; Piccoli, Ahmad and Ives 2001).

Despite the many areas of IS research concerned with multilevel phenomena, appropriate research methods such as hierarchical linear modeling (HLM) have been slow to be adopted by many MIS researchers (See Ang, Slaughter and Ng 2002 for a recent exception). HLM is a multilevel statistical method employed in groups' research that appropriately tests for cross-level effects (Bryk and Raudenbush 1992; Hofmann 1997). A search of the top two outlets for IS research, *MIS Quarterly* and *Information Systems Research*, over the last 10 years revealed that no study used HLM to analyze group research data. This finding is troublesome because HLM can be a more appropriate multilevel technique to use than other more common techniques such as analysis of variance (ANOVA) or OLS regression (Hofmann 1997; Hox 2002; Raudenbush and Bryk 2002; Snijders and Bosker 1999). Using an inappropriate multilevel technique can create a variety of problems, from a violation of the statistical assumptions underlying techniques normally used, e.g., OLS regression, to increased chance of Type I error (Bryk and

CONTRIBUTION

This paper makes a contribution to IS research in three main ways. First, we provide a brief introduction to hierarchical linear modeling (HLM) and a description of how this statistical method relates to research involving groups. HLM is widely used in other academic areas, but MIS researchers have been slow to embrace this technique. Second, we apply HLM to a study involving global virtual teams, compare the results of HLM to OLS directly, and warn researchers of the increased possibility of detecting false positives (Type I error) when using OLS. Finally, we relate our results to substantive research questions of interest in virtual teams research.

The study offers evidence that HLM and OLS provide conflicting results that can lead to different empirical and substantive interpretations of research results. We show why HLM is a more appropriate technique to examine both individual- and team-level phenomena in a group context. We also find substantive results when examining variables in virtual teams that may affect the management of such teams. Specifically, we find that the relationship between task liking and satisfaction is moderated by team work processes.

This research is expected to be of interest to researchers focusing on multilevel analysis, particularly virtual teams. In addition, the application of a statistical technique not widely in use in the MIS field should be of interest to IS researchers in general. Finally, this study is one of very few in the IS literature to detect and explain substantive, statistical differences based on research techniques employed. We conclude with a brief comparison of techniques used to study virtual teams in IS research.

Raudenbush 1992). More importantly, substantive conceptual questions may be addressed inappropriately or not at all for want of a technique suited to adequately model multilevel data.

While HLM has been gaining momentum in other disciplines such as education (Cooperman 1999; Griffith 2001; Raudenbush and Bryk 2002; Wong, Young and Fraser 1997), management (Bloom 1999; Bloom and Milkovich 1998; Griffin 1997; Haberfeld, Semyonov and Addi 1998; Hofmann 1997; Kidwell, Mossholder and Bennett 1997; Naumann and Bennett 2000; Van der Sluis 2002; Wech 2002) and health sciences (Alexander, Lichtenstein, Jinnett and D'Aunno 1996; Rosenbeck, Stolar and Fontana 2000), information systems scholars have been slower in embracing this technique (see Ang, Slaughter and Ng 2002 and Hoegl, Parboteeah, and Munson 2003 for exceptions). This may be due to a lack of awareness, or a failure to recognize the benefits that the HLM methodology offers.

To improve our understanding of multilevel research techniques this study makes three distinct contributions to the literature. First, it raises awareness of the appropriate application of empirical techniques by presenting HLM as an analytical alternative when modeling data at multiple levels of analysis. Second, it demonstrates the value of multilevel techniques by highlighting the potential risks for incorrect conclusions associated with traditional approaches, i.e., OLS regression. Third, it demonstrates the use of HLM to test substantive research hypotheses in a typical cross-level domain that is receiving substantial attention in IS research, i.e., research in virtual teams.

This paper is organized as follows: The first section provides a brief introduction to multilevel IS research. We then introduce HLM and discuss how it differs from OLS regression when studying multilevel phenomena. Next, we describe the inherent multilevel nature of virtual teams and set up hypotheses that can be investigated using HLM. We then conduct empirical tests using HLM and OLS regression and discuss the results of our example. The paper concludes with some final comments, directions for future research, and a comparison of how different empirical approaches can be effectively used in virtual teams research.

A MESO APPROACH TO IS RESEARCH

Cross-level research examines "the effect of variables at one level [of analysis] on those at another" (Rousseau 1985 p. 2) and requires a "meso" approach to the investigation (House, Rousseau and Thomas-Hunt 1995). Meso-level research, in contrast to micro- or macro-level research, is defined as inquiry that "examines the relationship between organizational contexts and behavior of components (individuals, dyads, groups, organizations, and groups of organizations) and evaluates how those relationships shape outcomes" (House, Rousseau and Thomas-Hunt 1995 p. 85). Thus, a meso approach is one that theorizes a relationship among units that exist at different levels of analysis. As a consequence, meso analysis requires that our theories include constructs at multiple levels, e.g., individuals in teams, firms within industries, individual technology adopters in work groups, and the subsequent adoption of appropriate analytical techniques, i.e., multilevel analytical techniques.

Multilevel analysis has been defined as "a methodology for the analysis of data with complex patterns of variability, with a focus on nested sources of variability" (Snijders and Bosker 1999 p. 1). That is, when the distribution of variance between different levels of analysis is theoretically relevant, multilevel research is the best choice. Multilevel research methods are also appropriate when the research question calls for the study of relationships such as causality or moderation between constructs in units defined at different levels of analysis. In the following section we take a brief look at a number of areas of interest to IS researchers were the meso approach and multilevel methodologies are appropriate.

Technology adoption and use

Technology adoption and usage by individuals are informed by cultural norms and the habits of the work group in which they are embedded, i.e., nested (Carlson and Zmud

1999; Markus 1994). Work groups are, in turn, nested within very different organizations, e.g., innovative technology startups, traditional and technologically conservative firms, and these differing contexts are theorized to have an impact on the manner in which technology is adopted and appropriated (Orlikowski and Iacono 2001). For example, the technology acceptance model (Davis, Bagozzi and Warshaw 1989), and its later refinements, have been recently criticized for failure to account for the effect of contextual variables on individual responses to the introduction of new technology (Plouffe, Hulland and Vandenbosch 2001). Thus, this research could benefit from a meso approach that incorporates multiple levels of analysis.

Similarly, when the unit of analysis is the adoption decision made by firms rather than individuals, the adoption decision is partially influenced by the industry in which the firm is embedded, i.e., nested, the competitive set, or the propagating institutions such as vendors or consultants (Fitchman 2000). These 'environmental' characteristics may directly influence the diffusion of innovations and adoption decisions. More interestingly, they may mediate or moderate the relationship between firm characteristics and firm-level outcomes (and other variables of great theoretical interest), thus creating interesting cross-level patterns of causality.

Technology mediated learning

Technology mediated learning has received increasing attention with the recent prominence of the Internet (Alavi and Leidner 2001; Piccoli, Ahmad and Ives 2001). This research stream also presents a number of potential research questions that would require a meso approach. For example, the technology mediated learning literature has postulated that instructor characteristics, such as technical proficiency and attitude toward technology, have an impact on students' learning outcomes (Webster and Hackley 1997), as do course characteristics, such as the subject matter of instruction and the degree of learner control enabled by the course design (Piccoli, Ahmad and Ives 2001). In educational environments, students are members of (i.e., are nested in) classes taught by instructors and interesting cross-level patterns of causality are theorized.

Virtual teams

The literature on virtual teams is rapidly growing (Powell, Piccoli and Ives 2004), and recent surveys note that more than 60% of all professional employees work in virtual teams (Kanawattanachai and Yoo 2002). Virtual teams involve individual team members from different entities (departments, organizations, schools, etc.) placed within a group; as a consequence, virtual team research is inherently cross-level involving the individual, the team, and the organization. Important variables of interest to virtual team research, such as individual team members' satisfaction and commitment to the team, may be impacted by contextual variables, such as team coordination and cohesion (Powell, Piccoli and Ives 2004). A number of constructs typically used in virtual team research are contextual in nature. Examples include team cohesiveness (Chidambaram 1996; Warkentin, Sayeed and Hightower 1997), group processes (Chidambaram 1996; Warkentin, Sayeed and Hightower 1997), trust (Jarvenpaa, Knoll and Leidner 1998; Jarvenpaa and Leidner 1999; Jarvenpaa, Shaw and Staples 2004; Piccoli and Ives 2003), team coordination (Galegher and Kraut 1994), knowledge transfer (Kotlarsky and Oshri 2005; Sarker, Sarker, Nicholson and Joshi 2005), and frequency and type of team communication (Alavi, Marakas and Yoo 2002; Maznevski and Chudoba 2000). Satisfaction with the team experience, commitment to the team, social loafing, and perceptions of psychological contract breach are examples of critical individual-level variables that are likely impacted by the contextual constructs discussed above. Yet, previous research has been unable to explicitly model cross-level main effects and interaction effects with individual-level constructs.

Similarly, the IS discipline has a long tradition in the study of computer mediated groups and development teams. These are research areas where contextual (i.e., team-level) variables have important effects on individual-level outcomes and are suitable for multilevel research. Another team-level variable of particular interest to IS researchers is the portfolio of IT artifacts supporting the team as it performs its task (Orlikowski and Iacono 2001). Studying the emerging norms of technology use and interaction (Majchrzak, Rice, Malhotra, King and Ba 2000), how different teams appropriate the available technology, and the impact of these contextual constructs on the individual- and team-level outcomes represents an important avenue for future research, and possibly the primary contribution of IS scholars to the virtual team literature (Orlikowski and Iacono 2001).

In summary, IS research is ripe with topics suitable for cross-level research, and researchers should pay careful attention to three key features needed to appropriately design and conduct empirical tests when engaging in such multilevel research. First, researchers should be cognizant that many concepts and relationships in the IS field involve phenomena at multiple levels of analysis. Awareness of important group and/or industry contexts is critical to avoid misspecification and increase our understanding of important outcomes. Second, research should be careful to appropriately measure constructs and create variables that are appropriate to each level of analysis. Finally, researchers should be careful to utilize empirical techniques that are aligned with the unique assumptions inherent in research testing relationships at or across multiple levels of analysis.

TESTING CROSS-LEVEL RELATIONSHIPS

Traditional approaches to the investigation of cross-level relationships in the IS literature present a number of limitations. One approach consists of using OLS regression to carry out the analysis at either the individual (a) or team level (b) exclusively. In the former case, the following model is estimated:

a) $Y_{ij} = b_0 + b_1 X_{ij} + b_2 G_j + e_{ij}$

Where i represents a specific lower-level unit (e.g., individual team member) and j represents the higher-level unity (e.g., team) that i is nested within. Y_{ij} represents the lower-level dependent variable, e.g., individual-level variable, X_{ij} represents a lower-level independent variable and G_j represents a higher-level independent variable, e.g., team-level variable. With this approach, the same value for G_j is assigned to each lower-level unit (e.g., individual team members) i in the j groups, e.g., teams.

In the latter approach, the following model is estimated:

b) $Y_j = b_0 + b_1 X_j + b_2 G_j + e_j$

where j represents a specific higher-level unit (e.g., a virtual team) and both the dependent (Y) and independent (X) lower-level variables are aggregated.

OLS regression is based on the assumptions of normally distributed independent random errors with constant variance. When group scores are assigned to individuals (a), the assumption of independence of the error terms is violated because error terms now contain a systematic component due to the group-level effect, as well as a random component (Bryk and Raudenbush 1992). Moreover, if random group-level errors vary across groups, the assumption of homoschedasticity is violated (Bryk and Raudenbush 1992). Finally, when group scores are duplicated across individuals, the standard errors are underestimated and the chance of Type I error is inflated (Bryk and Raudenbush 1992).

When lower-level variables are aggregated to the team level, typically using the mean scores for each unit, it is difficult to investigate the cross-level nature of the relationships (Bryk and Raudenbush 1992). In the virtual team literature for example, Warkentin, Sayeed and Hightower (1997) recently used this approach to study the effect of individual perceptions of group interaction processes, satisfaction with virtual team interactions, and team cohesiveness on effective information exchange by virtual team members. While this approach is not necessarily incorrect, researchers are forced to aggregate individual satisfaction to the team level of analysis and lose the ability to model any variance that exists in individual team members' satisfaction.

A third approach consists of focusing the analysis at one level by developing theories that do not explicitly acknowledge and model contextual-level variables. Individual perceptions of contextual- and team-level variables are used instead, and the analysis is carried out at the individual level exclusively (as in equation (a)). While this approach is technically accurate, it severely limits the range of research questions that can be pursued, the theories that can be developed, and, ultimately, our understanding of virtual teams.

AN INTRODUCTION TO HIERARCHICAL LINEAR MODELING

HLM provides a tool to appropriately conceptualize and test cross-level relationships where the dependent variable is at the individual level of analysis. HLM models cross-level relationships by specifying distinct level-1 (i.e., lower-level observations such as individuals) and level-2 (i.e., higher-level units such as groups or industries) models. The first model, level-1, examines relationships among variables at the lowest level of analysis (often individuals) that generate intercept and slope parameters linking to the outcome measure for each group. This model is analogous to OLS regression, although the Bayes algorithm used to estimate the level-1 components is noted for its superior precision and reliability (Bryk and Raudenbush 1992). In the level-2 model, the intercept and slope parameters from the level-1 model are used as outcome variables and regressed on level-2 variables. By estimating multilevel models explicitly in this manner, HLM models do not violate the independence of errors assumption that is the basis for OLS regression (Hofmann 1997).

HLM proceeds with a system of model building at each level of analysis. Although there are numerous appropriate model-building strategies, we will provide an introduction with the primary research question of interest being the moderating effect of a level-2 variable on a level-1 relationship with a single dependent variable. The first model estimated with HLM is a "null" model estimated without predictor variables, and thus the level-2 model is essentially a one-way analysis of variance (Bryk and Raudenbush 1992). This specification partitions variance into individual-level (level-1) and group-level (level-2) components (Bryk and Raudenbush 1992). The following set of equations is estimated to conduct the variance partitioning:

Level-1: $Y_{ij} = \beta_{0j} + r_{ij}$
Level-2: $\beta_{0j} = \gamma_{00} + U_{0j}$

Where, in the example of virtual team research, Y_{ij} represents a dependent variable expressed by individual i in team j. β_{0j} is the mean for the dependent variable for team j, and γ_{00} is the grand mean of the dependent variable, i.e., the mean of group means. In this set of equations, the level-1 equation includes no predictors and, as a consequence, the regression equation only includes an intercept estimate. The level-2 model regresses mean dependent variable scores of each group onto a constant; that is, β_{0j} is regressed onto a unit vector resulting in a γ_{00} parameter equal to the grand mean of the dependent variable, i.e., the mean of group means, β_{0j}. The level-1 residual (i.e., r_{ij}) represents within-group variance in the dependent variable. The level-2 residual (i.e., U_{0j}) represents any group-level variance. By calculating a ratio of the between-group variance divided by the total variance, HLM is able to highlight what percentage of variability in the dependent variable is accounted for by individual-level (i.e., level-1) and team-level (i.e., level-2) effects (Raudenbush and Bryk 2002; Snijders and Bosker 1999).

The next step in the analysis consists of testing one or more independent variables at the individual level of analysis. The following set of equations is used to test the effects of X, a level-1 independent variable, on the dependent variable.

Level-1: $Y_{ij} = \beta_{0j} + \beta_{1j}\,X_{ij} + r_{ij}$
Level-2: $\beta_{0j} = \gamma_{00} + U_{0j}$
$\beta_{1j} = \gamma_{10} + U_{1j}$

To test cross-level relationships involving one level-2 (i.e., team-level) variable G, the following set of equations is estimated:

Level-1: $Y_{ij} = \beta_{0j} + \beta_{1j}\,Xij + r_{ij}$
Level-2: $\beta_{0j} = \gamma_{00} + \gamma_{01}\,Gj + U_{0j}$
$\beta_{1j} = \gamma_{10} + \gamma_{11}\,Gj + U_{1j}$

The prediction of β_{1j} by the level-2 variable results in an interaction term that estimates the cross-level interaction. A significant level-2 slope parameter (i.e., γ_{11}) indicates that the group variable moderates the relationship between the individual predictor and the outcome variable (cf. Hofmann and Gavin 1998). In sum, HLM builds off a regression foundation but follows a random coefficient modeling framework to more appropriately test relationships at multiple levels of analysis (Bliese and Ployhart 2002). More advanced applications and concepts can be found in Hox (2002), Pinheiro and Bates (2000), Raudenbush and Bryk (2002), and Snijders and Bosker (1999).

An additional key issue in the application of HLM involves the "centering" of level-1 predictor variables. When using HLM, variable "centering" affects substantive conclusions that can be drawn from empirical tests (Hofmann and Gavin 1998). In the previous set of equations, we have presented an "uncentered" model. However, if our primary research question was to assess the effect of group-level variables while controlling for level-1 variables, then individual-level variables should be "centered" around their grand means (Hofmann and Gavin 1998). In the present study, our concern is effectively testing the contextual or moderating effect of a group variable on individual-level relationships; consequently, we "group mean" center the independent variables in our study. Thus, the group mean of the independent variable is subtracted from each individual (Raudenbush and Bryk 2002; Hofmann and Gavin 1998). Centering decisions for level-1 variables are critical in hierarchical linear models, and "group mean" centering is the appropriate specification in the moderational paradigm where the substantive research question is understanding how a group-level variable moderates the relationship between two individual-level variables (Hofmann and Gavin 1998).

SATISFACTION AND COMMITMENT IN VIRTUAL TEAMS: A CROSS-LEVEL ANALYSIS USING HLM

The extraordinary development of Information Technologies (IT) in the last two decades has been critical in supporting the development of new organizational forms (Jarvenpaa and Ives 1994). As businesses strive to respond to competitive pressures and seek to improve their flexibility, they increasingly turn to the use of virtual teams (Townsend, DeMarie and Hendrickson 1998). Virtual teams are groups of geographically, temporally, and/or organizationally dispersed knowledge workers brought together across time and space via information and telecommunication technologies (DeSanctis and Poole 1997; Jarvenpaa and Leidner 1999). Recognizing the potential benefits and risks that the introduction of virtual teams engenders, IS researchers have recently begun their systematic study. Because IS researchers understand the technological context in which virtual teams exist, as well as internal team processes, they are well positioned to contribute substantially to this line of inquiry (Orlikowski and Iacono 2001). See Martins, Gilson, and Maryard (2004) and Powell and colleagues (2004) for recent reviews of the literature.

To provide a relevant context for exploring the use of multilevel techniques, we investigate the effect of task liking (an individual-level variable), and team cohesion and work processes (two team-level variables), on individual satisfaction and affective commitment in temporary virtual teams. While our work adds to substantive research in the extant virtual team literature, our primary objective is to provide an illustration of multilevel analysis and the research questions that can be investigated with HLM, and to compare this technique with OLS regression.

Research Hypotheses

Commitment to the team is defined broadly as a psychological bond that ties the individual to the team (Allen and Meyer 1990; Becker 1992). In this study, we concentrate on affective commitment to the team – that is, the emotional attachment, identification, and involvement with the team (Meyer and Allen 1991). Individual satisfaction is defined as the degree to which the individual feels that the team experience has been personally rewarding (Hackman 1989; Pinto, Pinto, and Prescott 1993).

The virtual team literature has recently begun to study both individuals' commitment to teams and individuals' satisfaction with the virtual team experience (Alavi, Marakas and Yoo, 2002; Edwards and Sridhar 2005; Furst, Blackburn and Rosen 1999; Huang, Wei, Watson and Tan 2003; Majchrzak, Malhotra, Stamps and Lipnack 2004; Warkentin, Sayeed and Hightower 1997). Previous research suggests that individual characteristics and perceptions are important determinants of individual commitment and satisfaction (Allen and Meyer 1990; Chidambaram 1996; Galegher and Kraut 1994; Zaccaro and Dobbins 1989), and that the social context developing within teams as they perform influences team members' attitudes and behaviors (Hackman 1989). Such social context is shaped by the characteristics of the individuals involved, the organizational environment in which the team is embedded, and the technology available to the team and how it is appropriated (Majchrzak, Rice, Malhotra, King and Ba 2000; Orlikowski and Iacono 2001). Because the social context is partly shaped by the team experience, a different social context will emerge in different teams. Thus, we propose two general research assumptions concerning the nature of individuals within teams:

Proposition 1: Significant variance in individual commitment to the team exists both within and between teams.

Proposition 2: Significant variance in individual satisfaction with the team experience exists both within and between teams.

Task liking is defined in virtual teams as the degree to which individuals enjoy the project, the specific tasks that they are responsible for, and the means of carrying out their tasks (i.e, how well they liked completing tasks using electronic means of communication). While task characteristics are critical for virtual team successes (Martins, Gilson and Maynard. 2004), the effect of task liking in virtual teams has received little research attention to date. Yet, given the novelty of virtual teams and their almost exclusive reliance on IT to support task accomplishment, it may be an important variable. How tasks are carried out in virtual teams is very different from how tasks are carried out in traditional collocated teams. In particular, virtual teams are more likely to use asynchronous communication while traditional collocated teams use synchronous communication (Montoya-Weiss, Massey and Song 2001). Research has shown that individuals react differently to the leaner form of communication that is used in virtual teams (Massey, Montoya-Weiss, Hung and Ramesh 2001). Perceptions of task-technology fit to complete a project will likely influence perceptions of task liking.

Research on project teams has shown the importance of "fit" between task and team (Keller, 1994; Olson, Walker and Reukert 1995). Task liking has been found to be important in traditional collocated teams, influencing commitment (Zaccaro and Dobbins 1989). In addition, "pleasant surprises" about the job and tasks for new hires leads to increased organizational commitment (Garavan and Morley 1997). The more the individual likes the tasks they are assigned, the more committed they are to them. Thus, we propose the following:

H1: Individual task liking is positively related to commitment to the virtual team.

Compositional characteristics and interpersonal processes of the virtual team can dramatically influence how teams operate and perform (Martins, Gilson and Maynard 2004). One characteristic, team cohesion, is defined as a "connectedness" or sense of "we-ness" between members (O'Reilly and Roberts 1977). Individual goals are put aside for the benefit of the team (Owen 1985). Team cohesion has been found to have positive impacts on commitment to the team and/or organization (Allen and Meyer 1990; Mathieu and Zajac 1990; Zaccaro and Dobbins 1989). In a cohesive team, members are satisfied with their team, like their teammates, and desire to remain with the team (Mudrack 1989). Several studies have shown that when team members communicate primarily through electronic means, the team is more task-oriented than traditional teams that primarily meet face-to-face (Chidambaram and Bostrom 1993; Walther 1995; Warkentin, Sayeed and Hightower 1997). Thus, impressions of cohesiveness in virtual teams may be more task-related than in traditional collocated teams because there is usually more emphasis on the task in virtual teams (Hart and McLeod 2003).

Team level cohesion is expected to positively moderate the influences of many individual characteristics on an individual's commitment to a virtual team. Group cohesion is associated with greater employee compliance and an increase in behaviors associated with group identity (Fiol and

O'Conner, 2005), suggesting that an increase in cohesion should enhance the existing relationship between employee's task affect and commitment to the team. The consequences of cohesion may be especially important in virtual teams, because physical contact among members is often reduced (Wiesenfeld, Raghuram, and Garud, 2001). Evidence of a moderating effect of cohesion is also supported by empirical research finding interactions between task liking, cohesion, and commitment (Vogel et al. 2001). Thus, this example serves to illustrate how a variable at the team level of analysis (i.e., team cohesion) moderates a relationship at the individual level of analysis, i.e., the relationship between task liking and commitment. Stated formally,

H2: Team cohesion positively moderates the relationship between task liking and commitment to the virtual team.

One of the most important prerequisites to job satisfaction is a personal interest in the work or tasks themselves (Locke 1976). In addition, more positive attitudes toward tasks assigned, such as task identity, significance, and variety, positively affects job satisfaction (Hackman and Oldham 1976, 1980). Research investigating the concept of "fit" between the individual and the tasks they are to do has shown that perceptions of the "fit" between the individual and the tasks is positively related to job satisfaction (Saks and Ashforth 1997). Research has shown that a well-defined task is perceived positively, liked more than a poorly-defined task, and leads to more satisfaction in the virtual team (Edwards and Sridhar 2005). However, both the individual and the situation are important in determining satisfaction (Robie, Ryan, Schneider, Parra and Smith 1998). Attitudes toward computers, including computer anxiety and computer liking, are negatively related to satisfaction (Harrison and Rainer 1996). Thus we propose:

H3: Task liking is positively related to individual satisfaction with the team.

Prior research has shown that effective team interaction is a key ingredient in improving team outcomes, such as satisfaction (Van de Ven and Delbecq 1974). Team work processes refers to how team members perceive each member is interacting with other members to accomplish the work required to achieve the team's goal. Team work processes can include aspects of managing conflict, communicating effectively, decision making, adaptability, helpfulness, procedural justice/fairness, providing substantive feedback, and balancing socio-emotional and task requirements (Allen and Meyer 1990; Alper, Tjosvold and Law 1998; Chidambaram and Bostrom 1997; Korsgaard, Schweiger and Sapienza 1995; Wheelan and Hochberger 1996; Zaccaro and Dobbins 1989).

Team work processes are likely to positively moderate the relationship between task liking and individual satisfaction with the virtual team. Positive perceptions of team work processes are important factors in creating a well-developed team, while negative perceptions of team work processes can lead to reduced motivation by team members and more dissatisfaction with the team (Steiner 1972). The finding that conflicts about work processes are detrimental to a virtual team (Hinds and Bailey 2003) also provides evidence that processes at the team level can have a moderating effect on individual level relationships. Previous studies have found a significant relationship between the nature of the task and group member satisfaction (Dennis and Wixom, 2002), and this relationship is likely to be strengthened in groups with strong, positive work processes. Team work processes have been shown to impact satisfaction in both face-to-face as well as virtual team environments (Hertel, Konradt, and Orlikowski, 2004), providing evidence for the robustness of this critical team level effect. Thus, we hypothesize a cross-level moderation effect of team work processes, a team-level variable, on the individual-level relationship between task liking and satisfaction with the team. Formally,

H4: Team work processes positively moderates the relationship between task liking and individual satisfaction with the team.

Figure 1 graphically depicts the research hypotheses of this study.

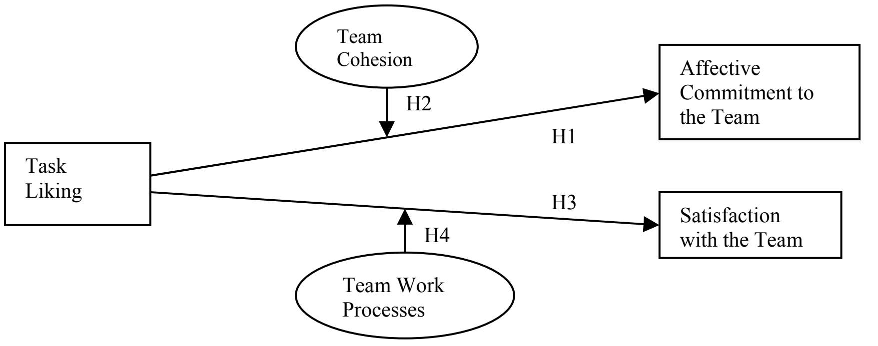

Figure 1: Research Hypotheses Model

METHODOLOGY

Participants

A total of 72 students from three business schools in three separate English-speaking countries on three continents participated in this research (usable data was available for 70 individuals). The average age of the subjects was 30, and subjects averaged four years of work experience. 66.7% were males, and 9.7% of them reported having been a member of a virtual team in the past. A total of 24 three-member teams were created drawing one randomly selected member from each participating university.

Procedures

The project entailed the development of a business plan for a new Internet-enabled venture (see Appendix 1), and was consistent with projects used in similar studies (Jarvenpaa and Leidner 1999; Piccoli and Ives 2003). This project is particularly well suited for virtual team research because it requires considerable interaction among teammates and has components of decision-making, idea development, and information exchange. The project also requires the extensive communication and coordination of work processes typical of virtual team efforts (Furst, Blackburn and Rosen 1999). The teams independently selected the product or new business they intended to pursue.

The project lasted four weeks, and the teams were provided with detailed instructions and a template for the business plan. A substantial portion of students' final course grade (20-25%) depended on their team's project performance. In addition, a financial incentive was also provided. The top team received $2,500, the second team received $1,500, and the third team received $1,000.

A communication hub was created for each team. Team members had access to an email distribution list, chat session facilities, discussion boards, shared server space, and the exercise schedule. Members were also allowed to phone each other. Although provided with numerous communication options, teams relied on email on a daily basis. Most of the other communication media were never used because of time zone differences, although 2/3 of the teams did report using the chat sessions on occasion. At the conclusion of the project, a survey was administered to collect data on task liking, team work processes, team cohesion, satisfaction with the team, and commitment to the team.

Variables and Measures

All scales in this study used a seven-point Likert scale (0 to 6, with 0 representing strong agreement and 6 representing strong disagreement). Satisfaction was measured using a subset of a validated instrument (Pinto, Pinto and Prescott 1993). The scale we used consisted of four-items (all items can be seen in Appendix 2). Commitment was measured using the affective commitment scale developed and validated by Meyer and Allen (1991), modified to reflect commitment to a team rather than to an organization. In addition, the scale was further modified after confirmatory factor analysis showed two items loading on both commitment and cohesion, leaving four items to measure commitment. Team work processes was measured through a six-item scale adapted from Taylor and Bowers' Measures of Group Processes (1972). Cohesion was measured using eight items from Dobbins and Zaccaro (1986), Stokes (1983), and Wech, Mossholder, Steel and Bennett (1998). Items were taken from all three scales based on applicability to a virtual, asynchronous team format. Finally, task liking was measured using a five-item scale that measured not only liking for the overall task itself, but also liking for specific tasks that an individual may have been assigned (Powell 2000). The scales displayed satisfactory reliability (satisfaction with team: $\alpha = .90$; commitment: $\alpha = .80$; work processes: $\alpha = .92$; task liking: $\alpha = .91$; cohesion: $\alpha = .96$). Factor analysis showed all items loaded as expected on their corresponding factors.

When conducting multilevel research the decision of what level of analysis a construct belongs to must be theory driven. For example, in our work both team cohesion and work processes belong at the team level of analysis, i.e., theoretically, cohesion and work processes can only be thought of as characteristics of a team, as opposed to characteristics of individuals within a team. Because these constructs cannot be easily observed or measured directly, however, it is often necessary to rely on team members' assessments when constructing team level variables. When this approach is taken, individual responses are aggregated into team-level measures by averaging individual respondents after ensuring the appropriateness of aggregation (James, Demaree and Wolf 1984; Rousseau 1985). When doing so, an aggregation index must be computed to ensure the reliability of the measure. Aggregation is warranted when the median $r_{wg(j)}$ index (James, Demaree and Wolf 1984) among all teams is greater than .70 (Janz, Colquitt and Noe 1997; George 1990). Aggregation at the team level is warranted in our study ($r_{wg(j)} = .98$ for cohesion and $r_{wg(j)} = .95$ for work processes). Because the variables of satisfaction with team, commitment to team, and task liking were not team-level variables, individual responses were not aggregated into a team-level score. Therefore, the $r_{wg(j)}$ index was not calculated for these 3 variables.

RESULTS

Confirmatory factor analysis was used to evaluate the psychometric characteristics of the instruments employed. The measurement model suggests adequate fit to the data ($\chi^2 = 105.51$, RMSEA = 0.073, GFI = 0.92, NNFI = 0.96, CFI = 0.97). Descriptive statistics are provided in Table 1.

HLM 5.05 for Windows statistical package was used to test hypotheses (Raudenbush, Bryk, Cheong and Congdon 2000). Although there are other multilevel modeling software packages (e.g., NMLE: Pinheiro and Bates 2000) and statistical packages (e.g., PROC MIXED in SAS) that can be used to conduct multilevel modeling, HLM is well known to management researchers, e.g., Hofmann 1997, and has recently begun to be used in IS research, e.g., Ang, Slaughter and Ng 2002. Additionally, the HLM package has the advantage of conveniently generating multilevel modeling results alongside results under the assumptions of OLS regression. To provide a statistical examination of proposition 1, we first conducted variance decomposition by examining a null model with no predictors

Table 1. Descriptive Statistics and Correlations

	N	Mean	Standard Deviations	Task Liking	Satisfaction	Commitment	Team Work Processes	Team Cohesion
1. Task Liking	70	2.011	1.445	1.0				
2. Satisfaction	70	2.061	1.353	.52	1.0			
3. Commitment	70	2.401	1.290	.40	.45	1.0		
4. Team Work Processes	24	1.714	.924	.38	.64	.33	1.0	
5. Team Cohesion	24	2.172	1.05	.46	.79	.53	.61	1.0

The results of this HLM analysis are presented in Table 2. The χ^2 test for the amount of variation in the changes in affective commitment between teams approached, but was not significant (χ^2 = 34.58; p=.06). HLM can also be used to compute the intraclass correlation, a measure of the degree of resemblance between micro-units (i.e., individuals) belonging to the same class, i.e., groups (Snijders and Bosker 1999). This analysis shows that 86.67% of the variance in affective commitment was within teams and 13.33% of the variance was between teams. The lack of significance at the team level of analysis would generally indicate that a multilevel model should not be pursued since the variance between teams is not statistically significant (which suggests that variables at the individual level of analysis should account for the majority of the outcome variable's variability). The use of HLM is critical to reach this conclusion, which would not be evident if a researcher relied solely on OLS regression. To illustrate problems that may arise when researchers rely solely on OLS regression, we will continue to use HLM and OLS with our hypotheses tests for affective commitment to illustrate important differences between the two techniques. Proposition 2 was tested in a similar manner with satisfaction as the dependent variable. The χ^2 test for the amount of variation in the changes in satisfaction between teams was significant (χ^2 = 38.64; p<.05), providing support for proposition 2. Calculation of the intraclass correlation reveals that 82.58% of the variance in satisfaction exists within teams and 17.42% exists between teams (Table 3). We should note that this preliminary step of variance decomposition is rarely conducted with OLS regression, and our results for propositions 1 and 2 demonstrate that important differences among dependent variables emerge when such an analysis is conducted. We should also note that there are several definitions and methods for calculating the intraclass correlation (Snijders and Bosker 1999). The simplest and most commonly used definition of the intraclass correlation contains no explanatory variables and simply indicates the proportion of variance at each level of analysis (Hox 2002).

Hypotheses 1 and 2 were tested by adding independent variables to the null models used to test propositions 1 and 2. According to hypothesis 1, individual task liking is positively related to commitment to the virtual team. HLM tests this hypothesis in two ways, which are presented in Table 4. First, like regression, HLM provides a "fixed effect" coefficient for each parameter tested. This coefficient was significant (p<.01). Second, HLM provides a deviance statistic for

Table 2. Results of Hierarchical Linear Modeling Variance Components Analysis for Affective Commitment (Proposition 1)

Fixed Effect			*Coefficient*	*se*	*p Value*
Average team mean, γ_{00}			2.39	.17	.00
Random Effect	*Variance Component*	*Percentage of Total*	*df*	χ^2	*p Value*
Team mean, u_{0j}	.22	13.33%	23	34.58	.06
Level-1 effect, r_{ij}	1.43	86.67%			

Table 3. Results of Hierarchical Linear Modeling Variance Components Analysis for Satisfaction with Virtual Team Experience (Proposition 2)

Fixed Effect			*Coefficient*	*se*	*p Value*
Average team mean, γ_{00}			2.05	.18	.00
Random Effect	*Variance Component*	*Percentage of Total*	*df*	χ^2	*p Value*
Team mean, u_{0j}	.31	17.42%	23	38.64	.02
Level-1 effect, r_{ij}	1.47	82.58%			

each model estimated. Comparison of the log-likelihood ratios (deviances) to the null model, and an indication of the improvement in explanatory power of the model, is accomplished via an χ^2 difference test (Bliese and Ployart 2002). As shown in Tables 4 and 6, this test was significant ($\Delta\chi^2_3$ = 24.32; p<.01), providing support for hypothesis 1. Similar results were found using OLS regression, which should not be surprising since HLM revealed that most of the variance was at the individual level of analysis.

According to hypothesis 2, cohesion, a team-level construct, moderates the individual-level relationship between task liking and commitment to the team. As shown in Table 6, the addition of cohesion to the model was significant as a team level variable ($\Delta\chi^2_1$ = 34.08; p<.01). However, when testing cohesion as a team level moderating variable our tests of fixed effects varied considerably based on model assumptions and the technique used. In Table 5 we provide our results of

Table 4. Results of Hierarchical Linear Modeling Test of Task Liking on Affective Commitment (Hypothesis 1)

Fixed Effect			*Coefficient*	*se*	*p Value*
Average team mean, γ_{00}			2.39	.17	.00
Task Liking slope, γ_{10}			.55	.11	.00
Random Effect	*Variance Component*	*Standard Deviation*	*df*	χ^2	*p Value*
Team mean, u_{0j}	.44	.66	22	59.84	.00
Task Liking slope, u_{1j}	.05	.22	22	31.14	.09
Level-1 effect, r_{ij}	.77	.88			
Model comparison test			3	24.32	.00

Table 5. OLS and HLM Results of Tests of Cohesion as a Moderator of the Effects of Task Liking on Affective Commitment (Hypothesis 2)

	Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	*df*	*p Value*
OLS	Average team mean, γ_{00}					
	Intercept	.71	.16	4.38	66	.00
	Cohesion	.76	.07	10.47	66	.00
	Task Liking slope, γ_{10}					
	Intercept	.12	.24	.51	66	.61
	Cohesion	.17	.08	2.15	66	.03
HLM	Average team mean, γ_{00}					
	Intercept	.71	.16	4.38	22	.00
	Cohesion	.76	.07	10.46	22	.00
	Task Liking slope, γ_{10}					
	Intercept	.21	.26	.81	22	.43
	Cohesion	.15	.09	1.61	22	.12
Final estimation of variance components						
Random Effect	*Variance Component*	*Standard Deviation*		*df*	χ^2	*p Value*
Team mean, u_{0j}	2.62^{10-3}	.05		21	15.77	>.50
Task Liking slope, u_{1j}	.05	.23		21	34.94	.03
Level-1 effect, r_{ij}	.63	.79				
Model comparison test				1	1.57	.21

fixed effects under OLS and HLM assumptions available from HLM software version 5.05. Examining OLS results, we find that the t-ratio of 2.15 is significant ($p<.05$). Using the standard HLM specification, however, the t-ratio of 1.61 was not significant ($p=.12$), nor was the deviance test for the effect of cohesion as a team level moderator (see Table 6). This result demonstrates that the two techniques yield conflicting results and lead to different substantive interpretations.

Hypothesis 3 posits that task liking will have a significant impact on individual satisfaction with the team. As shown in Table 7, hypothesis 3 was supported based on tests of fixed effects ($p<.01$), and the χ^2 test of the deviance statistic (see Table 9) shows a significant improvement in the model's explanatory power ($\Delta\chi^2_3 = 45.37$; $p<.01$).

Hypothesis 4 posits a positive moderating effect of teamwork processes (a team-level, or level-2, variable) on the effects of task liking on individual satisfaction with the team (an individual-level, or level-1, variable). As shown in Table 9, this test for the addition of work processes to the model was significant ($\Delta\chi^2_1= 4.09$; $p<.05$). Furthermore, Table 8 demonstrates that across the assumptions of OLS as well as HLM there is a significant effect for work processes as a moderator of the relationship between task liking and individual satisfaction with team. Thus, researchers can have confidence when using this test that study findings were not a result of model assumptions made or the statistical technique used in their research. We should note, however, that although our results in Table 8 revealed no substantive differences, they did reveal statistical differences between the two techniques. Specifically, the use of OLS revealed a significant intercept term not detected with HLM; this finding underscores the assertion of others who have argued that OLS is more likely produce Type I errors than hierarchically specified models (Aitkin, Anderson and Hinde 1981; Kidwell, Mossholder and Bennett 1997).

Table 6. Comparisons of Model Fit for Affective Commitment as Dependent Variable

Model	*Deviance*	*Number of estimated parameters*	*Chi-square statistic*[a]	*Number of degrees of freedom*
Null model	232.26	3	-	-
Model with task liking level-1 (hypothesis 3)	207.94	6	24.32*	3
Model with main effects of cohesion at level-2	173.86	7	34.08*	1
Model with main and moderating effects of cohesion at level-2 (hypothesis 4)	172.29	8	1.57	1

***p < .01**

Table 7. Results of Hierarchical Linear Modeling Test of Task Liking on Satisfaction with Virtual Team Experience (Hypothesis 3)

Fixed Effect			*Coefficient*	*se*	*p Value*
Average team mean, γ_{00}			2.06	.18	.00
Task Liking slope, γ_{10}			.57	.09	.00
Random Effect	*Variance Component*	*Standard Deviation*	*df*	χ^2	*p Value*
Team mean, u_{0j}	.64	.79	22	106.55	.00
Task Liking slope, u_{1j}	.07	.26	22	34.25	.05
Level-1 effect, r_{ij}	.52	.72			
Model comparison test			4	45.05	.00

Table 8. OLS and HLM Results of Tests of Work Processes as a Moderator of the Effects of Task Liking on Satisfaction with Virtual Team Experience (Hypothesis 4)

	Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	*df*	*p Value*
OLS	Average team mean, γ_{00}					
	Intercept	.59	.21	2.76	66	.01
	Work Processes	.86	.09	8.84	66	.00
	Task Liking slope, γ_{10}					
	Intercept	.29	.13	2.19	66	.03
	Work Processes	.19	.07	2.95	66	.00
HLM	Average team mean, γ_{00}					
	Intercept	.59	.21	2.76	22	.01
	Work Processes	.86	.09	8.95	22	.00
	Task Liking slope, γ_{10}					
	Intercept	.25	.14	1.81	22	.08
	Work Processes	.19	.07	2.73	22	.01
Final estimation of variance components						
Random Effect	*Variance Component*	*Standard Deviation*		*df*	χ^2	*p Value*
Team mean, u_{0j}	.06	.24		21	29.57	.10
Task Liking slope, u_{1j}	.05	.22		21	30.09	.09
Level-1 effect, r_{ij}	.47	.69				
Model comparison test				1	4.09	.04

Table 9. Comparisons of Model Fit for Satisfaction as Dependent Variable

Model	*Deviance*	*Number of estimated parameters*	*Chi-square statistic*[a]	*Number of degrees of freedom*
Null model	237.21	3	-	-
Model with task liking level-1	191.84	6	45.37**	3
Model with main effects of work processes at level-2	162.99	7	28.85**	1
Model with main and moderating effects of work processes at level-2	158.90	8	4.09*	1

$^{**}p < .01$, $^{*}p < .05$

Results of HLM variance components can be used to calculate a proportion of variance explained as somewhat analogous to a change in R^2 statistic in OLS regression (Raudenbush and Bryk 2002; Raudenbush, Bryk, Cheong and Congdon 2000). For satisfaction, the proportion of variation at level-1 explained by the final model was 68.02% ((1.47 - .47)/1.47). The proportion of variance explained at level-2 was 80.64% ((.31 - .06)/.31). For affective commitment, the proportion of variation at level-1 explained by the final model was 55.94% ((1.43-.63)/1.43). The proportion of variance explained at level-2 was approximately 100% ((.22 – 2.62^{10-3})/.22). We should note that while multilevel texts use this calculation as a simple and straightforward method to approximate an R^2 value, this approach should be used with caution as it does introduce a possibility of a decrease in R^2 or in some cases negative explained variance (Kreft and De Leuw 1998: 117-119).

DISCUSSION

This paper makes the case for the importance of using appropriate multilevel analytical techniques when studying Information Systems phenomena that require the modeling of data at multiple levels of analysis. We present our case using the data from virtual team research and examine the effects of task liking on individual commitment to the team. Additionally, we demonstrate that the substantive conclusions of cohesion as a team level moderator of this relationship vary significantly based on the assumptions of the analytic tool used to analyze this relationship. A number of important results emerge from our work.

We demonstrate how to partition the variance in the dependent variable between level-1 and level-2 effects. Specifically, we find support for our proposition 2 by showing that significant variability in individual satisfaction with the virtual team experience can be explained by individual-level variables as well as team-level variables. Conversely, we do not find support for proposition 1. We also show how to use HLM to test direct level-1 effects and assess cross-level moderation. We found both substantive and minor differences between OLS and HLM using our sample of global virtual teams.

A key contribution of this paper is demonstrating the differences and advantages of HLM versus traditional techniques such as OLS regression and the problems that failing to use the appropriate multilevel technique in cross-level research may engender. Specifically, we demonstrate that the use of OLS regression in multilevel research may lead to incorrect conclusions. In our study, proposition 1 was not supported. Thus, we cannot conclude that the variability in individual commitment to the team varies systematically across teams. In other words, it appears that only individual level (i.e., level-1) variables are responsible for the variability in individual commitment to the team. This is a critical insight because additional hypotheses build on this variance decomposition. Our test of hypothesis 2 provides one such example. Using HLM, hypothesis 2 was not supported and no conclusion regarding the effect of team cohesion as a cross-level moderator can be drawn because lack of support for proposition 1 suggests that there is no significant variance in commitment among teams. On the other hand, hypothesis 2 would have been supported using OLS regression, leading to the conclusion that team cohesion is a significant moderator of the relationship between task liking and affective commitment to the team. This disparity in results is due to the fact that OLS regression is an inappropriate technique in multilevel research due to the violation of independence of the error terms, which inflates the chance of Type I error leading to misleading results and inaccurate conclusions. While these results may be exacerbated by the small sample we had available in this study, they provide a powerful illustration for the need to use appropriate techniques when conducting research that tests multilevel theory (since team cohesion is a construct that can only be meaningfully defined at the team level of analysis).

Our findings also demonstrate how HLM can be utilized to address substantive questions of interest in IS research in general, and virtual teams research specifically. Hypothesis 4 was supported, demonstrating that the relationship between task liking and satisfaction is moderated by team work processes (a cross-level moderation effect). These results are important because they suggest that managers have the opportunity to influence individual satisfaction by being attentive to the context in which team members interact. This finding is particularly important for virtual teams research and supports the assertions of scholars who argue that the degree to which virtual team members meet face-to-face and interact influences important individual-level outcomes (Griffith, Sawyer and Neale 2003). Future research could build on our results and use our two-level HLM approach to test the determinants of team work processes. To accomplish such a test, independent variables at the team level of analysis would be used at level-1 and variables at the organizational level of analysis would be modeled at level-2.

Our findings on the moderating role of team work processes provide the impetus for important future research on virtual teams in two main ways. First, future research should test what other individual-level relationships are moderated by the team work processes construct. Any such relationships would represent a set of research questions that require the application of multilevel analytical techniques. Second, future work should focus on the determinants of effective team work processes in the virtual environment – determinants that are theorized to be different than those found in traditional teams (Furst, Blackburn and Rosen 1999). The ability to properly test and model moderating effects is critical to the IS discipline, yet researchers have often made poor choices when testing for interactions (Chin, Marcolin and Newsted 2003). HLM provides an analytical tool for IS researchers to model such interactions when substantive research questions relate to multilevel phenomena.

The merits of HLM can be applied to additional questions of interest to virtual teams researchers in two other ways not utilized in the present study. First, HLM is a useful analytic technique for modeling longitudinal data because multiple data points for a single individual over time represent another example of nested data at multiple levels of analysis (Bliese and Ployhart 2002; Deadrick, Bennett and Russell 1997). Future research should use this capability to model how individual attitudes within virtual teams change over time. Second, HLM allows for the simultaneous study of higher levels of analysis such as strategic groups and industries (Short, Palmer and Ketchen 2003). Virtual teams comprise individual members that are situated in organizational settings. The organizational context in which virtual teams are embedded plays an important role in shaping individual- and team-level outcomes (Furst, Blackburn and Rosen 1999; Martins, Gilson and Maynard 2004). Thus, HLM provides a useful tool for future research to investigate three level relationships, such as how organizational characteristics (e.g., culture, degree of innovativeness) and team dynamics affect individual-level outcomes.

While HLM offers a number of advantages to IS scholars, researchers should use caution when selecting from the vast number of empirical strategies available. Researchers should be vigilant to apply the technique that most matches with the conceptualization and measurement of concepts and constructs of interest to their particular research questions. OLS regression is a well-known and reliable technique for analyzing the influence of multiple independent variables on a single dependent variable at a single level of analysis. Analysis of variance (ANOVA) is often useful for detecting differences in groups, as is often the key concern in virtual teams research. Structural equations modeling (SEM) can be useful for detecting relationships among latent constructs (most often, but not always, at a single level of analysis). Partial least squares (PLS) is useful for detecting interaction terms at a single level of analysis, and HLM tests are useful when testing main effects and interactions of moderating variables at a different (i.e., higher) level of analysis. Table 10 provides a summary of the differences among these techniques and suggests research questions in the virtual teams literature that could be examined with each technique. To provide additional guidance for future research, we note published studies in the IS literature using each of the techniques.

Table 10. A Comparison of Empirical Techniques used in IS research

	Empirical Technique				
	HLM	***OLS***	***PLS***	***ANOVA***	***SEM***
Levels of Analysis Examined	*Multiple Levels of Analysis*	*Single Level of Analysis*	*Single Level of Analysis*	*Single Level of Analysis*	*Single or Multiple Levels of Analysis*
Key Advantages	*Ability to Test Main Effects and Moderation Influences From Variables at Higher Levels of Analysis*	*Familiar and Well Understood Method and Interpretation*	*Ability to Model Interaction Terms*	*Ability to Test Group Mean Differences*	*Ability to Test Mediation Effects and Understand Relationships Among Variables*
Substantive Research Question for Virtual Teams Research	*How do virtual team characteristics moderate the relationship between individual characteristics and outcomes?*	*What individual level differences influence outcomes for virtual team members?*	*How do individual characteristics moderate the relationships between other individual characteristics and outcomes for virtual team members?*	*How do virtual teams compare with face-to-face teams on various factors? Do individual or team characteristics vary across time frames?*	*How do relationships among latent constructs influence virtual team outcomes?*
Example Study in IS Research Using Each Technique	*Ang, Slaughter and Ng 2002; Hoegl, Parboteeah and Munnson 2003*	*Edwards and Sridhar, 2005; Kayworth and Leidner, 2001; Morris, Marshall and Ranier 2002*	*Chin, Marcolin and Newsted 2003*	*Edwards and Sridhar, 2005; Jarvenpaa Knoll and Leidner 1998; Tan, Wei, Huang and Ng 2000*	*Sarker, Valacich and Suprateek 2003*

We believe that HLM holds great potential as a tool to help IS researchers develop and test multilevel theories, and we hope that this paper provides a blueprint and a call to action that will encourage future research to engage in this promising line of work. While multilevel analysis involves greater complexity than traditional approaches, we believe that our illustration of substantive interpretation differences based the analytic method employed will convince many IS scholars that its use is warranted in light of the ensuing payoffs.

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APPENDIX 1

Description of Business Plan Project

Your project consists of the development of a viable business innovation and the creation of a business plan. You should discuss with your teammates your ideas and the team should reach a consensus on what innovation to pursue. The creativity, viability, and potential of your proposed innovation are the most important attributes for a successful business plan. To further stimulate your thinking and to help you select an innovative solution, we have compiled a list of resources that we strongly encourage you to read before starting to develop the business plan.

The project you select must be Internet enabled, i.e. its implementation must be made possible, or greatly facilitated, by Internet technologies. On the other hand, you cannot simply propose to develop an online storefront or a web hosting service. While these are legitimate Internet enabled products/services, we encourage you to go beyond accepted business models and look for innovation strategies. We suggest that you look actively for integration opportunities, for example, "pay per view" online recopies with one click ordering and delivery of the ingredients. Again, do not settle for deja vu. Be creative! Your innovation does not necessarily have to be targeted to end-consumers, but it could be a business-to-business or an intra-organization solution.

The final deliverable will consist of a business plan for a new company or a business proposal for a product/service to be offered by an existing company. A key component of your strategy will consist of leveraging the Internet and/or the World Wide Web to enable you to develop, produce, or deliver your product or service.

The business plan should be targeted to potential investors, banks where you are seeking financing, or the board of directors of an existing company where you are submitting your proposal. In developing the business plan, your team should pay particularly close attention to the critical success factors of your innovation, as well as market receptiveness and the competitive landscape (existing suppliers, barriers to entries, customers' lock-in to competing technologies or products, etc.). You will have to identify your target markets and engage in extensive research on the viability of the innovation and likely customer acceptance

The resource section contains a number of valuable links for business plan development. For consistency of each team's deliverable, grading, and to facilitate your task, please follow the available template.

APPENDIX 2

Complete Scale Items Used in Study

Task Liking

1. I have a strong interest in the project and what I’m learning from participating in it.
2. I liked working on this project.
3. I have a strong interest in the project and tasks prescribed to my team.
4. I have found the time spent working on this project enjoyable.
5. Working on this project has been fun.

Cohesion

1. There was a high spirit of teamwork among my teammates.
2. I would still stay with my current teammates given the chance to do a similar project.
3. Members of this team like each other.
4. Members of this team fit what I believe to be “ideal” team members.
5. The members of my team would readily defend each other from criticism by outsiders.
6. The members of my team got along well together.
7. Compared to other teams in the course, our team worked well together.
8. The team that I belonged to was a close one.

Affective Commitment

1. I really felt as if this team’s problems were my own.
2. I did not feel like “part of the family” with my team. (R)
3. I did not feel “emotionally attached” to this team. (R)
4. I felt a strong sense of belonging to my team.

Team Work Processes

1. Team members planned together and coordinated their efforts.
2. Everyone in the team understood what they were to do and how to do it.
3. As a team, we were dedicated to meeting our objectives successfully.
4. Team members worked hard to provide substantive and timely feedback on ideas and work presented.
5. For the most part, team members had confidence and trust in other team members.
6. The people on my team made my job easier by sharing their ideas and opinions with me.

Satisfaction with Team

1. I enjoyed working with the members of my team.
2. Each team member contributed his/her fair share.
3. I would enjoy working with my team members again.
4. I enjoyed working on the team project.

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