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Flexible Global Software Development (GSD):

Antecedents of Success in Requirements Analysis

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ABSTRACT

Globalization of software development has resulted in a rapid shift away from the traditional collocated, on-site development model, to the offshoring model. Emerging trends indicate an increasing interest in offshoring even in early phases like requirements analysis. Additionally, the flexibility offered by the agile development approach makes it attractive for adaptation in globally distributed software work. A question of significance then is what impacts the success of offshoring earlier phases, like requirements analysis, in a flexible and globally distributed environment? This article incorporates the stance of control theory to posit a research model that examines antecedent factors such as requirements change, facilitation by vendor and client site-coordinators, control, and computer-mediated communication. The impact of these factors on success of requirements analysis projects in a "flexible" global setting is tested using two quasi-experiments involving students from Management Development Institute, India and Marquette University, USA. Results indicate that formal modes of control significantly influence project success during requirements analysis. Further, facilitation by both client and vendor site coordinators positively impacts requirements analysis success.

Keywords: *agile development; Globally distributed software development; offshoring; requirements analysis*

INTRODUCTION

Globalization has resulted in software development being outsourced to emerging and developing nations (Edwards & Sridhar, 2005). An increasing range of services and processes are being delivered by global vendors as per quality, price, and requirements independent of geography, suggesting a growing capability and acceptance of global service delivery

(NASSCOM, 2007). Outsourcing is the largest and fastest growing category within worldwide IT services spending. In 2006, the total spending on IT outsourcing was estimated at over USD 170 billion (more than 36% of the total) with an above average growth at 7.3 % (NASSCOM, 2007). Accordingly, software development has moved away from the traditional colocated model, often called on-site development, to the offshoring model (Edwards & Sridhar, 2006) in which global virtual teams collaborate across national borders (Carmel, 1999).

Global software development (GSD) presents abundant business opportunities as well as challenges in terms of control, coordination, communication, culture, and technology. To address these challenges, many researchers propose that firms must have ambidextrous capabilities (Lee, Delone, & Espinosa, 2006) and combine the flexibility offered by the growing agile development approaches with the traditional plan-based approaches (Agerfalk & Fitzgerald, 2006; Lee, Banerjee, Lim, Hillegersberg, & Wei, 2006; Ramesh, Cao, Mohan, & Xu, 2006). As organizations become more virtual, distributed development will become increasingly apparent throughout the entire software development life-cycle, particularly so in early stages such as requirements analysis (Evaristo, Watson-Manheim, & Audy, 2005). Despite the abundance of literature on globally distributed virtual teams (see Powell, Piccoli, & Ives, 2004) and IT outsourcing (see Dibbern, Goles, Hirschheim, & Jayatilaka, 2004; Yadav & Gupta, 2008), very few studies address the critical requirements analysis phase of GSD (Yadav, Nath, Adya, & Sridhar, 2007).

Requirements analysis refers to that stage of the system development life cycle wherein the information and information processing services needed to support select objectives and functions of the organization are (i) determined and (ii) coherently represented using well defined artifacts such as entity-relationship diagrams, data flow diagrams, use cases, and screen prototypes (Hoffer, George, & Valacich, 1999). Typically in GSD this phase is conducted at the client location since this phase requires significant interaction between users and developers. Business and systems analysts are physically located at the client site to perform this activity. Depending on the nature of the project, high-level design is conducted in both on-site and off-shore mode due to comparatively lower interaction needs with the client. Detailed design, coding, and testing are executed at the off-shore site (Carmel & Tijia, 2005).

Damian and Zowghi (2002) report that in global projects consultant teams from the off-shore location travel to the user site to gather and analyze requirements in face-to-face meetings. The consultants then communicate the requirements to the development staff at the offshore locations. An emerging stream of research, on the other hand, puts forward the phenomenon of distributed requirements engineering (Bhat, Jyoti, Gupta, & Murthy, 2006; Edwards & Sridhar, 2005; Evaristo et al., 2005; Nath, Sridhar, Adya, & Malik, 2006). An interesting alternative being considered by software companies is the possibility of off-shoring a larger part of the software development process. Specifically, is it possible to effectively conduct the requirements analysis phase from offshore location which is traditionally done on-site? In such a scenario, analysts and developers located at the off-shore location would interact in a virtual mode with the clients located at their premises to determine and structure the requirements. Such a shift could potentially improve the cost arbitrage of the projects for instance, by cutting down the travel costs incurred for sending analysts to the client site for face-to-face meetings and reduced staffing needs at the client end. It would also provide an opportunity to build client and developer relationships using computer-mediated communication.

Recent years have also witnessed growth of the agile movement that focuses on producing a working solution in conjunction with changing user requirements. The flexibility and responsiveness of the agile approach makes it attractive for adaptation in globally distributed software work. Flexibility in GSD can be incorporated by adapting some of the principles of agile development like simplified project planning, acknowledging requirements change, lesser emphasis on processes and documentation, and supporting informal as well as formal communication (Yadav et al., 2007).

In the requirements analysis phase of offshore GSD projects, the absence of analysts and developers at customer premises is likely to create a need to exercise control even in a flexible environment to ensure that the project meets defined goals. Offshore vendors often deploy liaisons who coordinate activities between on-site users and offshore development team. These liaisons are critical for effective communication and coordination between users and developers (Battin, Crocker, Kreidler, & Subramanian, 2003).

This study proposes to examine two research questions related to flexible GSD: what are the antecedents of requirements analysis success in a flexible GSD environment? How do these antecedents impact success? Founded on control theory, this article posits a research model examining relationships between process facilitation (by client/vendor site-coordinators), computer-mediated communication, control, change in requirements, and requirements analysis success.

Our interactions with managers in client and vendor firms engaged in GSD indicate that "total" offshoring of requirements engineering is still uncommon. However, they assert that in some smaller projects, up to 75% of the requirements analysis is carried out in offshore mode. For this reason, it might not be feasible to analyze "total" offshoring of requirements analysis phase in a real-life setting. Furthermore, as client nations face a growing shortage of business and systems analysts, organizations may be compelled to consider offshoring of early GSD phases. Given these arguments, we designed exploratory quasi-experimental research studies in an academic setting involving management students enrolled in a graduate level information systems course at Management Development Institute (MDI), India, and management students enrolled in a graduate level IT Project Management course at Marquette University (MU), USA. MU students role-played clients while MDI students role-played systems analysts.

The article is organized as follows. In the next section we review the background literature. Subsequently, the theoretical foundation, research hypotheses, and conceptual model are presented, followed by research methodology, and an overview of the findings. The article concludes with implications and directions for future research.

REQUIREMENTS ANALYSIS IN FLEXIBLE GSD PROJECTS

One of the most challenging aspects of system development is ascertaining "what the system should do," that is in determining the system requirements (Crowston & Kammerer 1998, p. 227). Globally distributed requirements analysis generally includes a team of analysts and users working together using technologies like computer-mediated conferencing, instant messaging, e-mails, teleconferencing, and Web-based group support systems.

There is a growing debate on *what can be and what cannot be offshored?* One school of thought suggests that certain activities, like coding, are a better fit for offshore locations while other activities, like requirements gathering, are better to be carried out onshore within the client's country (Carmel & Tijia, 2005). On the other hand, there is a growing stream of researchers who reason in favor of distributed requirements engineering. Few studies have examined the use of virtual and globally distributed teams for requirements analysis. Edwards and Sridhar (2005) studied the effectiveness of virtual teams in a collaborative requirements analysis practice. In this study virtual GSD teams at near and far locations participated in requirements analysis phase of the project. This typically is applicable in collaborative global product development exercises as described in Battin et al. (2003). However, in our research we study the requirements analysis phase of off-shored software projects consisting of (i) users of the *client* who specify the requirements, and (ii) developers/analysts of the *vendor* located at an offshore development center who determine and document these requirements. We define a virtual GSD team to comprise these two protagonists who rarely meet face-to-face and who work together using computer mediate communications.

Damian and Zowghi (2002) studied the interplay between culture and conflict and the impact of distance on the ability to reconcile different viewpoints with respect to "requirements negotiation" processes. They find that lack of a common understanding of requirements, together with reduced awareness of local context, trust level, and ability to share work artifacts significantly challenge effective collaboration among remote stakeholders in negotiating a set of requirements that satisfies geographically dispersed customers. Damian, Eberlein, Shaw, and Gaines (2000) examined the effect of the distribution of various stakeholders in requirements engineering process. They found that highest group performance occurred when customers were separated from each other and collocated with the facilitator or system analyst. Our study aims to contribute to the literature on globally distributed virtual teams engaged in off-shored software requirements analysis.

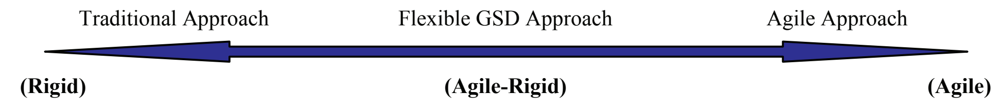
FLEXIBILITY IN GSD

Continued dissatisfaction with the traditional plan-driven (*heavyweight)* software development methodologies have led to the introduction of various agile (*lightweight)* methodologies, like eXtreme programming, Scrum, Crystal, and so forth (Fruhling & Vreede, 2006; Lindstrom & Jeffries, 2004). Practice-led agile methods have been proposed as a solution that addresses problems, such as budget/schedule overruns and poor quality levels, by promoting communication, flexibility, innovation, and teamwork (Agerfaulk & Fitzgerald, 2006; Augustine, Payne, Sencindiver, & Woodcock, 2005). The agile alliance movement was motivated by the observation that software teams in many corporations are entrapped in an ever-increasing amount of process and documentation (Fruhling & Vreede, 2006). Agile approaches focus on fast deliverables, dynamic management of requirements, and fast iterations and increments (Fruhling & Vreede, 2006). While many benefits of these newer approaches have been proposed, very few field studies have empirically operationalized agile GSD (Fruhling & Vreede, 2006) and developed theories in this area (Agerfaulk & Fitzgerald, 2006).

Our informal interactions with client and vendor organizations in the U.S. and India also indicate that in reality what exits is something in between the spectrum of the traditional and agile approaches. Though industry continues to debate whether or not agile processes are appropriate for distributed teams, let alone large and offshore distributed teams, organizations like Sapient have been successful in tailoring the agile approach to incorporate flexibility using a mixed focus on people, process, and tools (Barnett, 2006). Therefore on a spectrum, flexible GSD can be visualized as an "agile-rigid" approach that lies in between the traditional and agile approaches (see Figure 1).

To highlight the differences, the key characteristics of the traditional, agile, and flexible GSD environments adapted from a current stream of research (Furhling et al., 2006; Holmstrom, Fitzgerald, Agerfalk, Conchuir, & Eoin, 2006; Lee, Delone et al., 2006; Lee, Banerjee et al., 2006; Ramesh et al., 2006;) are presented in Table 1. Flexible GSD offers "rigor" of the traditional approaches and "flexibility" of the

Figure 1. Flexibility spectrum



agile approaches within the teams (Yadav et al., 2007). Rigor is provided by incorporating formal structures of the traditional approach, such as development of a project plan, communication plan, and project status tracking. Agility is allowed through simplified project planning. Elaborate project management techniques are tailored to make them "lightweight." "Simple rules" (Augustine et al., 2005) are adopted. Formal as well as informal channels of communication are encouraged. Additionally, it adopts the agile philosophy of embracing requirements change. The agile principle states that we should welcome changing requirements in software projects as they harness change for the customer's competitive advantage (Lindstrom & Jeffries, 2004). However, Fruhling and Vreede (2006) indicate that the impact of requirements change has not been studied empirically.

UNDERLYING THEORETICAL FOUNDATION

Global software development is not just a technical process of building software or information systems but also a social process involving stakeholders from multiple organizational units. Our article draws upon *control theory* to study the impact of antecedents on success during requirements analysis in a flexible GSD setting. Academic (Kirsch & Cummings, 1996) and practitioner (PMBOK, 2000) literature suggests that control plays an effective role in managing

Table 1. Characteristics of the traditional, agile, and flexible approaches

	Traditional **Development Approach**	***Agile*** **Development Approach**	***Flexible*** **GSD Approach**
Fundamental Assumption	Systems are fully specifiable, predictable, and can be built through meticulous and extensive planning.	High-quality, adaptive software can be developed by small teams using principles of continuous design improvement and testing based upon rapid feedback and change.	High-quality, adaptive software can be developed by globally distributed teams using principles of continuous improvement based upon feedback and change having some amount of planning and control.
Communication	Formal	Informal	Formal and informal
Project Management	-Process-centric -Processes over people -Extensive milestone planning - Extensive documentation	-People-centric -People over processes -Respond to change over following a plan - Lack of documentation	-Equal importance to people and processes - Medium project planning -Medium documentation
Requirements	-Knowable early; largely stable -Detailed specification of requirements	-Largely emergent; rapid change - Iterative development that produce working solutions at the end of each iteration to capture emerging requirements	- Emergent - Use prototypes or incremental working solutions to capture emerging requirements
Size	Larger teams (>10 team members)	Smaller teams (2-8 team members).	Smaller teams or large teams broken down to small sub-teams (<10 team members).

projects. Control theory attempts to explain how one person or group ensures that another person or group works toward and attains a set of organizational goals. Aligned with prior research on control (Choudhury & Sabherwal, 2003; Kirsch, 1997), our study views control broadly as attempts to ensure that individuals act in a manner consistent with achieving desired project goals. Control modes can be "formal or "informal" (Crisp, 2003) in nature, where former are documented and initiated by management, and the latter are often initiated by employees themselves.

Control theories suggest that controllers utilize two modes of formal control: behavior and outcome (Eisenhardt, 1985; Kirsch, Sambamurthy, Dong-Gil, & Russell, 2002). In behavior control, appropriate steps and procedures for task performance are defined by controllers and then controllees' performance is evaluated according to their adherence to the prescribed procedures. In outcome control, controllers define appropriate targets and allow controllees to decide how to meet those output targets. Controllees' performance is evaluated on the degree to which targets were met, and not the processes used to achieve the targets (Kirsch et al., 2002). In this study, we focus on the impact of formal modes of control (outcome and behavior) on success of GSD projects during the requirements analysis phase.

Kirsch et al. (2002) extended the control theory to the role of client liaisons/coordinators exercising control of IS project leaders to ensure that IS projects meet their goals. Lee et al. (2006) also proposed assigning "point persons"/ coordinators to offshore sites for effective management of GSD projects. We draw upon this literature to study the effect of process facilitation by both the client and vendor site coordinators.

RESEARCH MODEL

To reiterate, this article proposes to examine the following research questions—what are the antecedents of requirements analysis success in a flexible GSD environment? How do these antecedents impact requirements analysis success? Specifically, we explore how incorporating discipline through formal modes of control, process facilitation by site-coordinators (at both the client and vendor sites), and task related computer-mediated communication in a flexible GSD environment impacts requirements analysis success. We also explore how change in requirements, which is an inherent assumption behind the agile philosophy, impacts requirements analysis success. Control theory guides our hypotheses and model development process (see Figure 2). The research model variables and hypotheses specifying relationships between these variables are presented in the subsequent sections.

Control

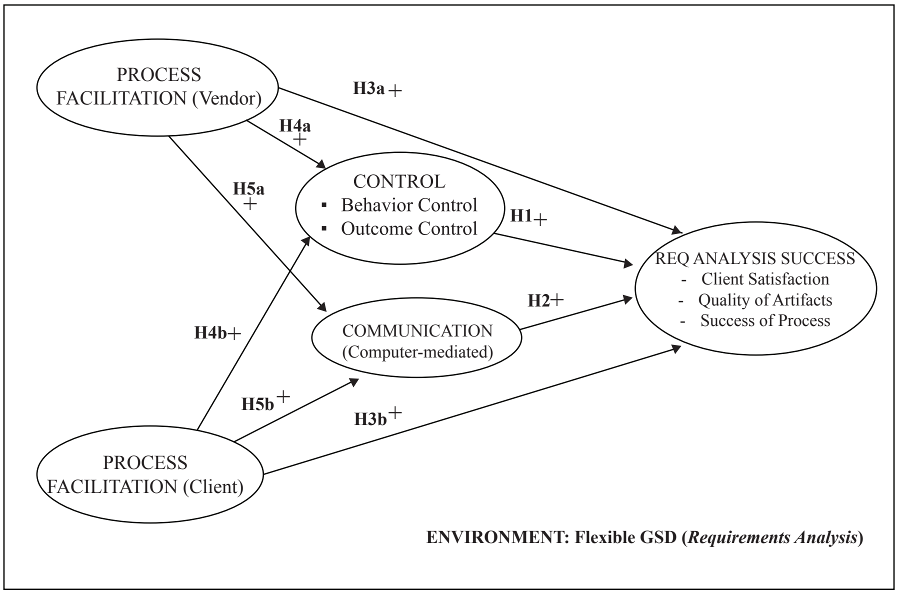
Outsourced projects in GSD pose unique problems that make the task of controlling them particularly challenging (Choudhury & Sabherwal, 2003). In the case of outsourced GSD projects, the controller and controllee may not be single individuals but teams of individuals representing the client and vendor organizations at globally distributed locations. Lee, Delone et al. (2006) suggest that agile methods should be tailored to embrace more discipline in GSD. Derived from control theory, we hypothesize that incorporating discipline by using formal modes of control (outcome and behavior) during requirements analysis in flexible GSD projects is likely to help in achieving success (Yadav et al., 2007).

H1: *Formal modes of control are positively related to requirements analysis success in a flexible GSD environment.*

Computer-Mediated Communication

Computer-mediated communication uses computers to structure and process information, and uses telecommunication networks to facilitate its exchange (e.g., e-mails, computer conferenc-

Figure 2. Research model



ing, e-groups). Rice (1987) indicates that computer-mediated communication is preferred in cross-location interdependency tasks because of greater freedom from temporal and geographic constraints (e.g., offshoring). Computer-mediated communication allows group members to collaboratively create meaning out of diverse sources of information leading to better outcomes (DeSanctis & Gallupe, 1987).

The virtual GSD environment presents considerable challenges to effective communication including time delays in sending feedback, lack of a common frame of reference for all members, differences in salience and interpretation of written text, and assurance of participation from remote team members (Crampton, 2001). Hulnick (2000, p. 33) noted that "if technology is the foundation of the virtual business relationship, communication is the cement." Information processing perspective of communication indicates that task uncertainty and work flow interdependence lead to higher frequency of interaction between work units (Putnam & Cheney, 1985). Extending this to a GSD scenario during requirements analysis there exits work flow interdependence between the remote client and the vendor teams for accurately capturing and documenting requirements. This is likely to lead to frequent task related computer-mediated communication between globally distributed team members for successful completion of requirements analysis. Thus we hypothesize that:

H2: *Task-related computer-mediated communication is positively related to requirements analysis success in a flexible GSD environment.*

Process Facilitation

Lee, Delone et al. (2006) indicate that assigning "point persons" in offshore software development plays pivotal role in sensing and responding to emergent problems on a real time basis. Borrowing from IS Literature on Group Support Systems (GSS) process facilitation is defined as the provision of procedural structure and general support to groups (Miranda & Bostrom, 1999). Our research acknowledges

Crisp's (2003) view on structuring borrowed from control theory and applies it in the context of GSD process facilitation where structuring refers to "any explicit or implicit means of developing structures for control." In the case of outsourced GSD projects, process facilitation can be provided by assigning point persons/liaisons/site-coordinators at both the client and vendor sites. We hypothesize that process facilitation provided by site-coordinators at offshore sites (client/vendor) can be a considered as a structure that is more likely to assist productive outcomes (Yadav et al., 2007).

H3a: *Process facilitation by vendor site-coordinator is positively related to requirements analysis success in a flexible GSD environment.*
H3b: *Process facilitation by client site-coordinator is positively related to requirements analysis success in a flexible GSD environment.*

Structures are formal and informal procedures, techniques, skills, rules, and technologies that organize and direct group behavior and processes (Anson, Bostrom, & Wynne, 1995). We therefore hypothesize that process facilitation provided by site-coordinators (client/vendor) at offshore sites can be a considered as a structure that is more likely to assist in formal modes of control:

H4a: *Process facilitation by vendor site-coordinator is positively related to formal modes of control during requirements analysis in a flexible GSD environment.*
H4b: *Process facilitation by client site-coordinator is positively related to formal modes of control during requirements analysis in a flexible GSD environment.*

Ramesh et al. (2006) report that a primary "point of contact"/a project lead, for each location in GSD helped in facilitating communication across the teams. Griffith, Fuller, and Northcraft (1998) assert the fundamental role of a process facilitator is to improve the effectiveness and efficiency of communication and interaction of group members in order to help the group achieve outcomes. Therefore, we hypothesize that process facilitation by vendor site-coordinator and also by client site-coordinator is likely to lead to increased computer-mediated communication:

H5a: *Process facilitation by vendor site-coordinator is positively related to task-related computer-mediated communication during requirements analysis in a flexible GSD environment.*
H5b: *Process facilitation by client site-coordinator is positively related to task-related computer-mediated communication during requirements analysis in a flexible GSD environment.*

Requirements Change

The task of specifying requirements has "high dynamic complexity" (Briggs & Gruenbacher, 2002). This complexity stems from the evolutionary nature of requirements, which are clarified only through multiple iterations of information gathering (Evaristo et al., 2005). As organizations become more global and stakeholders more distributed, getting the requirements right will pose a greater challenge (Damian et al., 2000).

Flexible perspective borrowing from Agile philosophy states that "changing requirements are not necessarily bad but are welcomed as an opportunity to satisfy customer needs even better than inflexibly sticking to old requirements" (Turk et al., 2005). Although many positive benefits have been speculated for dynamic management of requirements and fast iterations, few have been empirically examined (Fruhling & Vreede, 2006). Founded on the agile philosophy of considering requirements change as good opportunity to satisfy customer needs, we hypothesize:

H6a: *Members of teams that have changes in requirements will perceive higher level of requirements analysis success than those who have no changes.*

When requirements change, it is assumed that client team members are likely to experience a greater need to communicate and monitor vendor team members' behavior to ensure changes are incorporated. Therefore, it is likely that changes in requirements would probably lead to increase in control and task-related communication.

H6b: *Members of teams that have changes in requirements will perceive a higher level of control than those who have no changes.*
H6c: *Members of teams that have changes in requirements will perceive a higher level of task related communication than those who have no changes.*

Tan and Teo (2007) recently pointed out that project team using agile methodology could be effective in responding to change in user requirements if it stressed collaboration among members and users; thus it is likely that changes in requirements leads to increased process facilitation by site coordinators (client/vendor).

H6d: *Members of teams that have changes in requirements will perceive a higher level of process facilitation by vendor site-coordinator than those who have no changes.*
H6e: *Members of teams that have changes in requirements will perceive a higher level of process facilitation by client site-coordinator than those who have no changes.*

RESEARCH METHODOLOGY

Faculties in many universities and business schools have set up distributed software engineering laboratories for conducting virtual team exercises in their courses (Edwards & Sridhar, 2006; Nath et al., 2007). Powell et al. (2004) have listed a number of studies involving students in global virtual teams. A controlled experimental approach provides three benefits. First, it makes available several teams that work in parallel thereby generating rich data for drawing conclusions. Second, it permits researchers to experiment with newer approaches which may not yet have been explored by the industry. Finally, it equips and trains software engineering students to understand and to handle the challenges of working in global software teams (Favela & Pena-Mora, 2001).

We conducted a quasi-experiment in a globally distributed academic setting involving MBA students from two countries—India and the USA. Students from MDI, India, posed as analysts from vendor side while those from MU, USA, posed as clients. Vendor role was assigned based upon the rationale that India is still the preferred sourcing destination with a 58% share in worldwide offshore IT-BPO market in spite of the expansion of global sourcing arena (NASSCOM, 2007). Similarly, client role was assigned based upon the rationale that the U.S. alone accounts for about two-thirds of the software and services exports from India (NASSCOM, 2007).

Defining quasi-experimental designs, Campbell and Stanley (1966, p. 34) state that there are many natural settings in which a research person can introduce something like experimental design into his scheduling of data collection procedures (e.g., the when and to whom of measurement), even though he lacks full control over the scheduling of experimental stimuli (the when and to whom of exposures) which makes a true experiment possible.

We designed a post-test control group quasi-experiment design of the following form:

$$\begin{array}{lll} M & X & O_1 \\ M & & O_2 \end{array}$$

"M" stands for matching (a priori equalization of the two groups for the factors that have to be controlled), "X" stands for treatment and "O" stands for observation or measurement.

Marquette University has a service learning office which obtains IS development projects from nonprofit organizations and small businesses in and around Milwaukee. These real life projects at Marquette University were used to create the simulated flexible GSD requirements analysis projects. This enabled the projects to closely mirror real business environments. Examples of these projects include a donation management system for a nonprofit organization, a volunteer management system, an alumni Web site, a tracking system for battered and abused women, and a book inventory management system. Only high level requirements were provided, such as that the system must be secure and accurate, it must track certain information, and so forth. Many of the detailed level requirements were expected to emerge only through remote team member communications for requirements gathering and analysis.

The Experiment

The clients in the U.S. enrolled for a course in IT Project Management and the analysts in India enrolled for Management Information Systems (MIS) course, having comprehensive coverage of systems analysis and design, in January 2007. This quasi-experiment was designed as a part of the course project and its duration was 8 weeks. Students developed project artifacts iteratively using structured software development methodology. A flexible offshore GSD project environment was simulated based upon characteristics highlighted in Table 1. Each client team was paired with an analyst team. The teams were controlled in terms of age and work experience of team members and team size (see Table 2).

MDI teams elicited project requirements from MU teams using Web-based communication technology like e-groups (Google/yahoo groups), text/voice/video chat (Skype/msn/yahoo), and e-mail (see Table 3 and Figure 3). The gathered requirements were then structured using the process modeling tools such as Context Analysis Diagram (CAD), Data Flow Diagrams (DFDs), and Process Specifications. MDI teams also modeled the data and associated relationships using Entity Relationship Diagrams (ERDs). Further, to give the users a feel of what the final system would look like, MDI teams also created screen-based prototypes as part of the requirements analysis exercise. All these artifacts were submitted by the MDI teams to MU user teams in two iterations (see Table 4).

All the GSD teams had appointed site-coordinators at both the client (USA) and vendor (India) sites. The quasi-experimental design was a post-test control group design. The treatment for this experiment was "requirements change" where noncontrol groups had major changes in requirements and control groups did not have changes in requirements. The analysts in the noncontrol group developed the first iteration artifacts based on a set of high level and ambiguous requirements. A second set of more detailed requirements were then given to the MU client teams in the noncontrol group by the course faculty and the analysts then created the second iteration incorporating the changed set of requirements. The control group teams also developed the projects in two iterations but they were given detailed and clearly specified requirements at the start of the project.

Table 2. ANOVA results

Variable	Levene Test (p>.05)	F-value	Significance*
Age (years)	.908	0.782	0.726
Total Work Experience	.286	1.592	0.908
IT Work Experience	.083	0.490	0.964

** Significance >.05 indicates no difference between the GSD teams for the variables that were controlled*

Table 3. Experiment setting and treatment

Setting	Non-control Group (Treatment: Changes in Requirements)	Control Group (No Treatment)
Flexible GSD All teams matched in terms of age, size, work experience, technology, standard development methodology	Sample Size= 90 Analysts=59, Clients=33 10 client-analyst GSD teams, each team having 5-6 analysts (1 analyst appointed, by consensus, as MDI site-coordinator) and 3-4 clients (1 client appointed, by consensus, as MU site-coordinator)	Sample Size= 91 Analysts=56, Clients=33 10 client-analyst GSD teams, each team having 5-6 analysts (1 analyst appointed, by consensus, as MDI site-coordinator) and 3-4 clients (1 client appointed, by consensus, as MU site-coordinator)

Figure 3. Experiment design

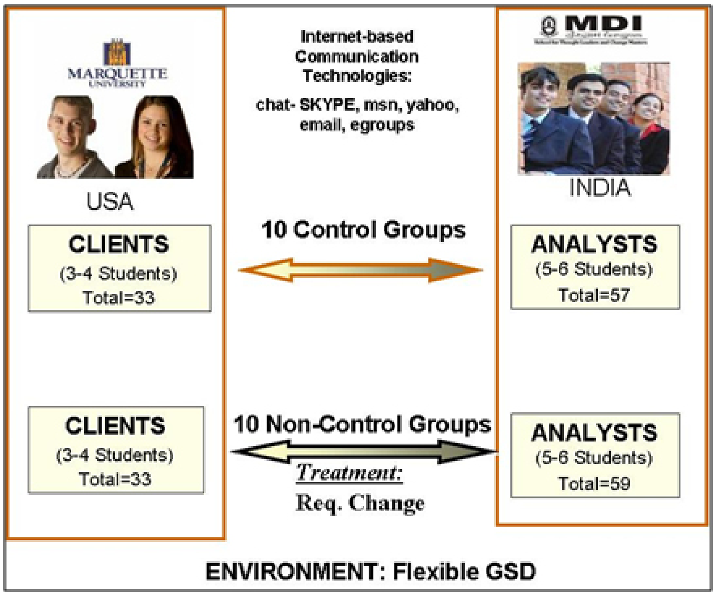


Table 4. Project artifacts

MDI Analyst Project Deliverables	MU Client Project Deliverables
Week 1: Simplified Project Management Plan (to MU clients with a copy to MDI faculty and researcher). No formal resource allocation at the analyst end.	**Week 1:** Simplified Project Charter, Project Schedules, Resource Allocation and Communication Plans (to the MU faculty).
Week 3: Simplified Project Status Reports to MU Clients.	**Week 3:** Simplified Risk Assessment and Contingency Plans (to the MU faculty).
Week 4: First Iteration (Context Analysis Diagrams, Data Flow Diagrams, Entity Relationship Diagrams, Process Specifications and Screen-based Prototypes of the business IS) to MU Clients.	**Week 4:** Feedback to MDI analysts.
End of Week 4 **Main Experiment :** TREATMENT- Changes in Requirements for the Non-control Group	
Week 6: Simplified Project Status Reports to MU Clients.	**Week 6:** Simplified Project Status Reports to MU faculty.
Week 8: Second Iteration (Context Analysis Diagrams, Data Flow Diagrams, Entity Relationship Diagrams, Process Specifications, and Screen-based Prototypes of the business IS) to MU Clients.	**End of Week 8:** Simplified Project Closure Report to the MU faculty.

Measures

Requirements Analysis Success: Mahaney and Lederer (2006) developed a comprehensive instrument for measuring IS project success based on three dimensions—client satisfaction, perceived quality of the project, and success with the implementation process. Baroudi and Orlikowski (1988) presented a short-form measure of User Information Satisfaction (UIS). Extending the dimensions of project success to the success of a particular phase of a project (requirements analysis), we define requirements analysis success in terms of client satisfaction with the requirements analysis phase, perceived quality of the requirements analysis deliverables, and perceived success of the requirements analysis process. This research refers to the items developed by Mahaney and Lederer (2006) and Baroudi and Orlikowski (1988) to measure requirements analysis success. Specifically, this study proposes to measure team members' perception of success in flexible GSD requirements analysis projects.

Control: Items to measure control for this study have been adapted from literature on formal modes of control (behavior and outcome) in information systems development projects (Kirsch, 1996; Kirsch et al., 2002; Piccoli et al., 2004).

Computer-mediated communication: We extend the task related communication items developed by Espinosa (2002) to measure task related computer-mediated communication for this study.

Process Facilitation: Items to measure process facilitation for this study have been adapted from GSS literature on process facilitation (Anson et al., 2004; Miranda et al., 1999). The items on process facilitation were used twice. First, the items were used to measure process facilitation by the client site-coordinator and then they were used to measure process facilitation by the vendor site-coordinator.

Requirements Change: This variable was introduced as a treatment in the experiment to study whether there is an impact of changing requirements on the proposed model variables. Requirements change was thus treated as a dichotomous variable (1=changes in requirements and 0=no changes).

ANALYSIS

A survey instrument was used to collect data pertaining to the above measures at the end of the quasi-experiments. Two separate versions were developed for client and vendor team members. Both versions included the same items for each construct but were worded differently to conform to the participant roles. The items were derived from available literature as described earlier and adapted for this study. Questions were randomized prior to instrument administration to counter possible order effects in the responses. All items were measured on a seven point Likert-type scale, where one indicated strong disagreement and seven indicated strong agreement with the item. Items of the vendor version are given in Appendix 1 for reference. Demographic data was also collected through direct questions and analyzed.

Our unit of analysis was at the individual level. We measured the effect of predictor variables on the outcome variable as perceived by the individual team members. A majority of research in organizational behavior had been conducted at the individual level of analysis (Schnake & Dumler, 2003). For example, leadership style had been examined at both individual and group levels in leadership research, but primarily at the individual level in organizational citizenship behavior research (Schnake & Dumler, 2003). Similarly, task scope (Griffin, 1982) and work context (Comstock & Scott, 1977) have individual and group level effects. Our view is consistent with the assertion by Choudhury and Sabherwal (2003) that in an outsourced software project although the overall context is the contract between the two firms (client and vendor), the focus is still on individual(s) evaluating and influencing the actions of other individual(s).

Standard psychometric techniques were employed to validate measures. For construct validity Cronbach alpha was used and all constructs that had Cronbach alpha closer to or greater than 0.7 confirmed construct validity (Cheung & Lee, 2001). Factor analyses was conducted to examine convergent and discriminant validity. Principle component method of extraction with varimax rotation was used. The items that did not load well were removed (see Appendix 1). For ensuring convergent and discriminant validity we retained the indicators that loaded onto their proposed factors for the study.

Pilot Testing

As a first step, we carried out a pilot study to gain an initial understanding and to pilot test the questionnaire items. Subsequently, we conducted the main experiment to test our hypothesized model. The pilot study was designed as a part of MU and MDI course projects and its duration was 8 weeks (see Table 5). The client teams in the U.S. enrolled for an undergraduate course in IT Project Management and the analyst teams in India enrolled for a graduate course in Systems Analysis and Design in October of 2006. Each client team was given a set of requirements and the analyst team was required to develop project artifacts and screen-based prototypes of a business information system requested by the client team. This study was a simple post-test quasi-experiment design intended to pilot test the data collection instrument and to comprehend the flexible GSD environment.

The Experiment

Subsequently, in our main experiment, we estimated the complete hypothesized structural model using Arbuckle's (2006) AMOS 7.0 program. A common practice used in conducting SEM analyses with latent variables involves creating "item parcels" based on sums or means of responses to individual items and then using scores on these parcels in the latent variable analysis (Russell, Kahn, & Altmaier, 1998). We created item parcels for success and control based upon rationale grounds (Kline, 2005) for our structural model analysis. For success (total seven questionnaire items) we created three item parcels—client satisfaction (two items), perceived quality (three items), and success of implementation process (two items). For control, measured by a total of six questionnaire items, we created two parcels—behavior control (three items) and outcome control (three items).

RESULTS

Survey responses for 20 items were generated from 181 respondents (client team members and vendor analysts) for the experiment. Demographic data was also collected through direct questions and examined. Four items to measure process facilitation and two additional items to measure control were added to the same instrument used in the pilot study. The descriptive statistics is outlined in Table 6 and Pearson's product-moment correlation matrix and reliability analysis is shown in Table 7.

Reliability of the measures of (i) success, (ii) control, (iii) communication, (iv) process facilitation (vendor), and (iv) process facilitation (client) had Cronbach Alpha values above 0.70 indicating construct reliability. The dependent variable perceived success showed

Table 5. Pilot study setting

Setting	Sample
***Flexible* GSD Requirements Analysis** All teams matched in terms of age, size, work experience, technology, standard development methodology	Total Sample Size= 102 Analysts=52, Clients=50 (16 client-analyst GSD teams. Each having 3-4 analysts and 2-3 clients)

Table 6. Descriptive statistics

	Total	Std. Dev.	Analyst	Client
Sample Size (Control + Non-control)	181	0.48	115	66
Age (mean value in years)	22.8	1.9	23.5	21.6
Total Work Experience (mean value in years)	2	2	1.2	3.3
IT Work Experience (mean value in years)	0.7	1.3	0.72	0.76

Table 7. Correlation matrix and reliability

	Items	1	2	3	4	5
1. CONTROL	6	(0.837)***				
2. COMMUNICATION	3	.178*	(0.828)***			
3. PROCESS FACILITATION (CLIENT)	2	.168*	.464**	(0.755)***		
4. PROCESS FACILITATION (VENDOR)	2	.584**	.207**	.178*	(0.789)***	
5. SUCCESS	7	.612**	.337**	.584**	.504**	(0.790)***

**** Reliability Analysis (Cronbach alpha) on the diagonal*
*** Correlation is significant at the 0.01 level (2-tailed)*
** Correlation is significant at the 0.05 level (2-tailed)*

significant correlations with all the antecedent variables proposed in the model, that is, control, communication, process facilitation vendor, and process facilitation client. There are significant correlations between the antecedent variables themselves which needs to be explored further.

Multigroup Analysis

As stated earlier, our experiment was a control group quasi-experiment design. One of the methods to incorporate group membership (treatment vs. control) into the model involves separating the data from members of the treatment and the control groups and conducting a multiple-group analysis (Russell et al., 1998; Sorbom, 1981). We referred to the multigroup analysis specified by Byrne (2001, pp. 226-243) to test for invariant latent mean structures and Ho (2006, pp. 321-356) to estimate our hypothesized structural equation model for the control group and noncontrol groups.

Byrne (2001) suggests that the usual test for multigroup comparisons typically focuses on the extent to which differences are statistically significant among observed means (calculable from raw data) representing the various groups. In contrast, means of latent variables, as in our case, are unobservable. Thus, our focus is on testing for differences in the latent means for hypotheses 6a-e, that is, team members having changes in requirements will have higher perceptions of the latent variables than team members having no changes in requirements. Specifically, we test for differences in the latent means of control, computer-mediated communication, process facilitation by vendor site-coordinator, process facilitation by client site-coordinator, and requirements analysis success across control and noncontrol groups.

In testing for differences in latent means, our baseline measurement model for each group is shown in Figure 4. The variances of the five latent factors are freely estimated in each group. Means of the error terms are not estimated and remain constrained to zero. Except for those fixed to 1.00, all factor loadings are constrained equal across groups. All intercepts for the observed measures are constrained equal across groups. The five factor means are freely estimated for noncontrol group and constrained equal to zero for the control group. The latent mean estimates indicate that team members having changes in requirements have significantly higher perceptions of control (H6b), computer-mediated communication (H6c), process facilitation by vendor site-coordinator (H6e). But there appears to be little difference in perception for requirements analysis success (H6a) and process facilitation by client site-coordinator (H6d). These results are summarized in Table 8.

For our multigroup analysis, there were two data sets (control and noncontrol groups), each having 11 measurement variables. The two covariance matrices generated from the two data sets contained 132 sample moments. In multigroup confirmatory factor analysis (measurement) model, the critical ratio test for control and noncontrol group differences among regression weights yielded no significant difference for the 16 regression weights. Therefore, we constrained 16 regression weights to equality in the multigroup path analysis model. The computation of degrees of freedom and chi-square goodness-of-fit statistics for the group-invariant and group-variant model are outlined in Appendix 2. The baseline comparison fit indices of NFI, RFI, IFI, TLI, and CFI for both the models are close to or are above 0.90 (see Table 9). These values show the improvement in fit of both models relative to the null model. Root mean square error of approximation (RMSEA) fit index values for group-invariant (0.074) and group-variant path models (0.077) indicated adequate fits for both the models. RMSEA

Figure 4. Structured means model for control and noncontrol groups

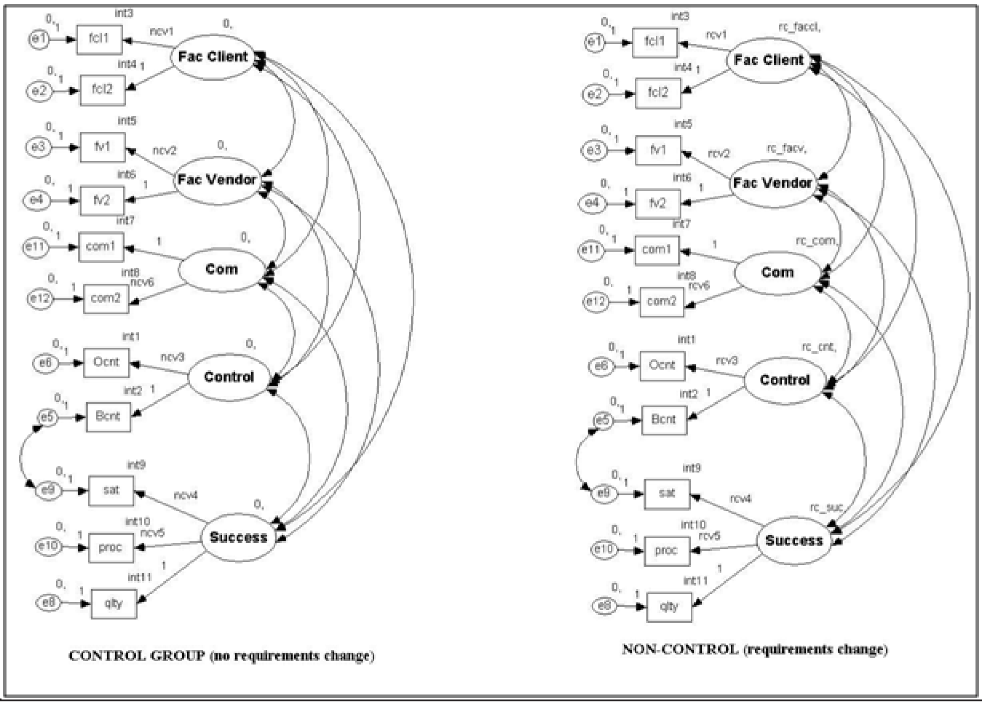


Table 8. Results summary (latent mean estimates)

Hypo-thesis	Latent Variable	Estimate	Critical Ratio (CR>±1.96)	Sig. (p<.05)	Hypothesis Supported?
H6a	Requirements analysis success	.232	1.760	.078	Not Sup-ported
H6b	Control	.364	2.337*	.019*	**Supported**
H6c	Computer-mediated communication	.510	2.227*	.026*	**Supported**
H6d	Process facilitation (vendor site-coordinator)	.334	2.186*	.029*	**Supported**
H6e	Process facilitation (client site-coordinator)	-.036	-.217	.828	Not Sup-ported

Table 9. Baseline comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Group Invariant	.859	.811	.925	.897	.923
Group Variant	.867	.802	.927	.887	.924
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

values ranging from 0.05 to 0.08 are deemed acceptable (Ho, 2006, pp. 349).

The nested model comparisons statistics indicate that chi-square difference value for the two models is 8.847. This value is not significant (p< .05) with eight degrees of freedom (see Table 10). Thus the two models do not differ significantly in their goodness-of-fit. The AIC measure for group-invariant model (261.380) is lower than that for the group-variant model (268.532), indicating that group-invariant model is more parsimonious and better fitting than the group-variant model. Hence we refer to the estimates of the group-invariant model for our analysis.

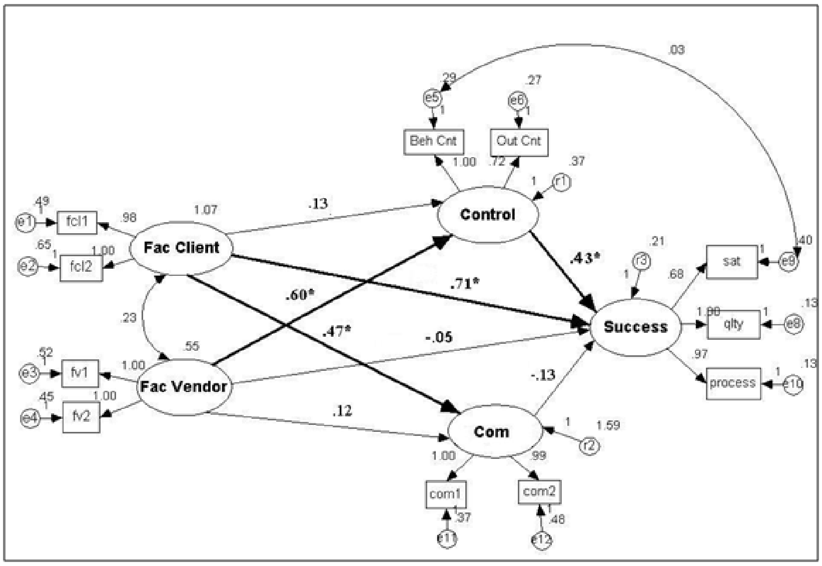
Figures 5 and 6 present the path models for the control and noncontrol groups together with standardized regression weights (beta coefficients) associated with the hypothesized paths. First, we analyzed critical ratios for differences test for experimental treatment impact on the path coefficients. Table 11 shows results of the individual hypotheses for both control and noncontrol groups. Appendix 2 presents the control and noncontrol group estimates in detail. H1 was supported which posits that formal modes of control are positively related to perceived success during requirements analysis in a flexible GSD environment (control group β= .55 and noncontrol group β= .43). Surprisingly, as proposed in H2, frequent task-related communication was not found to be significantly related to perceived success (control group β= -.13, noncontrol group β= -.13). Though process facilitation by vendor site-coordinator did not have a positive impact on success (H3a: control group β= .08, non-control group β= .05), the positive impact of process facilitation by client site-coordinator was found to be significant (H3b: control group β= .60, non-control group β= .71).

The proposed positive relationship between process facilitation by vendor site-coordinator and control was found to be significant (H4a: control group β= .70, noncontrol group β= .60) but was insignificant for process facilitation by

Table 10. Nested model comparisons (assuming model group variant to be correct)

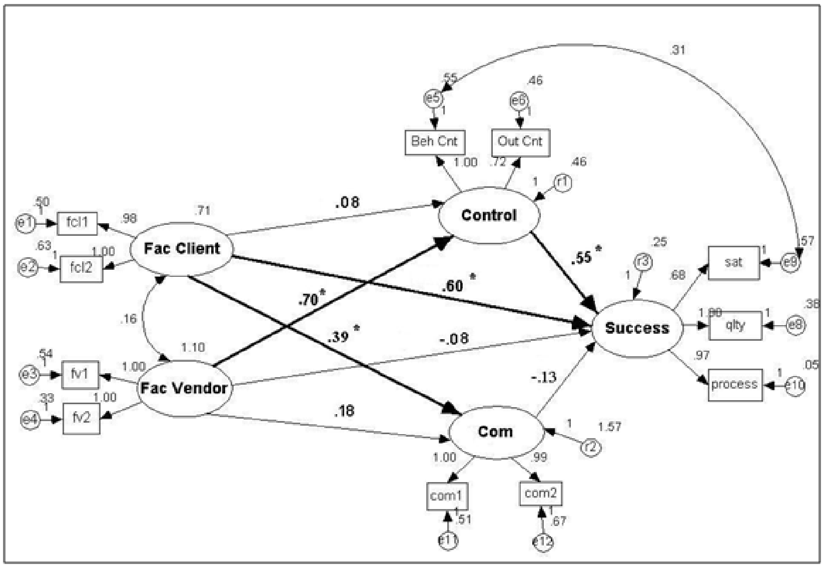
Model	DF	CMIN	P	NFI Delta-1	IFI Delta-2	RFI rho-1	TLI rho2
Group Invariant	8	8.847	.355	.008	.008	-.009	-.010

Figure 5. Noncontrol group (req. change) structural path model



**Standardized estimates and significant relationships (p<.05, CR>±.96)*

Figure 6. Control group (no req. change) structural path model



**Standardized estimates and significant relationships (p<.05, CR>±.96)* client site-coordinator and control (H4b: control group β= .09, noncontrol group β= .13). Again, process facilitation by vendor site-coordinator did not have a positive impact on frequent task-related communication (H5a: control group β= .18, noncontrol group β= .12) but the positive impact of process facilitation by client site-coordinator was found to be significant (H5b: control group β= .40, noncontrol group β= .47). Based on the results displayed in Table 11, it can be concluded that for both the control and noncontrol groups, process facilitation by vendor site-coordinator is related indirectly to perception of success, being mediated by formal modes of control. Furthermore, the greater the process facilitation by client site-coordinator, the greater is task-related communication, and perception of success.

Table 11. Experiment 2 results summary

Hypothesis	**Path**	**Hypothesized Relationship**	**Path Coefficient** (Standardized beta)	**Critical Ratio** (CR>±1.96)	**Sig.** (p<.05)	**Hypothesis Supported?**
H1	control → req analysis success *Control Group:* *Noncontrol Group:*	+	 .547 .434	 4.079* 4.079*	 .000* .000*	**Supported**
H2	computer-mediated communication → req analysis success *Control Group:* *Noncontrol Group:*	+	 -.131 -.131	 -1.746 -1.746	 .081 .081	Not Supported
H3a	process facilitation(vendor) → req analysis success *Control Group:* *Noncontrol Group:*	+	 -.079 -.054	 -.607 -.607	 .544 .544	Not Supported
H3b	process facilitation (client) → req analysis success *Control Group:* *Noncontrol Group:*	+	 .599 .710	 6.754* 6.754*	 .000* .000*	**Supported**
H4a	process facilitation (vendor) → control *Control Group:* *Noncontrol Group:*	+	 .702 .603	 6.509* 6.509*	 .000* .000*	**Supported**
H4b	process facilitation (client) → control *Control Group:* *Noncontrol Group:*	+	 .088 .132	 1.274 1.274	 .203 .203	Not Supported
H5a	process facilitation (vendor) → computer-mediated communication *Control Group:* *Noncontrol Group:*	+	 .177 .120	 1.768 1.768	 .077 .077	Not Supported
H5b	process facilitation (client) → computer-mediated communication *Control Group:* *Noncontrol Group:*	+	 .399 .471	 4.631* 4.631*	 .000* .000*	**Supported**

DISCUSSION

This study was driven by the need to better understand which antecedent factors impact requirements analysis success in flexible GSD projects and how. We proposed a conceptual model grounded in control theory to find preliminary answers to our research questions—what are the factors that are of importance in the requirements analysis phase of flexible GSD projects? How do they relate to requirements analysis success?

We find that *control* (both behaviour and outcome) positively impacts success during requirements analysis. Prior studies have primarily focused on behavior and outcome controls in internal software projects. Few studies, such as Choudhury and Sabherwal (2003), reported that outcome control in outsourced IS projects resembled that of internal IS development projects. They also state that behavior control entailed monitoring behavior that was "explicitly" as well as "not explicitly" prescribed and requires further investigation in other contexts. Consistent with their view, in a flexible GSD context, our study reports that having some amount of structure in the form of formal modes of controls positively impacts success.

Applying the information processing perspective of communication (Putnam & Cheney, 1985) to a GSD scenario, we suggest that there exits work flow interdependence between the remote client and the vendor teams for accurately capturing and documenting requirements. This is likely to lead to frequent task related computer-mediated communication for successful completion of requirements analysis. Surprisingly, the results show that increased task-related communication did not positively impact success. A likely explanation for such a finding can be that informal means of communications across the teams could have probably sufficed the need of task-related online information exchange.

Consistent with prior literature and practice, we find that increased process facilitation by client site-coordinators in a flexible GSD environment increases task-related communication and also leads to greater success of requirements analysis projects. However, increased process facilitation by vendor site-coordinators did not lead to greater task-related communication. Rather, increased process facilitation by vendor site-coordinators lead to increased control which further impacted requirements analysis success. Consequently, the effect of process facilitation by vendor site-coordinators on requirements analysis success is found to be mediated by control whereas process facilitation by client site-coordinators has a direct impact on requirements analysis success. Further, increased process facilitation by client site-coordinators did not lead to increased control.

An inherent assumption behind flexible (agile) philosophy is that changes in requirements are good since requirements evolve over time and are best clarified through multiple information gathering iterations. In our experiment we introduced "changes in requirements" as a treatment for the noncontrol group. Our findings suggest that team members who experienced changing requirements also experienced greater control, greater computer-mediated communication, and greater process facilitation by vendor site-coordinator. However, these team members did not experience greater process facilitation by client site-coordinator. Since changes in requirements are client initiated, it is likely that the increased role of the client site-coordinator was perceived to be less significant. The latent mean scores also indicated lower difference in perception of requirements analysis success. A probable explanation in this regard could be that changes in requirements might not have a direct impact on the success of requirements analysis phase. However, it is likely that the changes have greater impact on subsequent phases of software development and hence on the complete project. Also, there is likely to be an indirect impact via mediating factors like control, communication and process facilitation. This needs to be further explored by including requirements change as a model variable.

LIMITATIONS AND FUTURE PROPOSITIONS

Use of Experiments

Literature in the area of virtual teams has mainly followed three research methodologies—case studies, industry survey, and experiments. Experimental methods make possible the careful observation and precise manipulation of independent variables, allowing for greater certainty with respect to cause and effect, while holding constant other variables that would normally be associated with it in field settings (Damian et al., 2000). They also encourage the investigator to try out novel conditions and strategies in a safe and exploratory environment before implementing them in the real world (McGrath, 1984). The industry is yet to adopt off-shoring of the requirements analysis phase. This precludes the use of case study or industry survey for this research. Hence, we used experiments where we can try out this new method. While this limits the generalizablity of our findings, our approach provides a foundation from which to build a future empirical industry assessment as the time is ripe.

Use of Students as Surrogates

There are criticisms for the use of students in academic experiments as surrogates. However, MBA students have been used as surrogate users in experiments conducted by Hazari (2005) and Briggs, Balthazard, and Dennis (1996). Even in the requirement negotiation phase, students with work experience were taken as users for developing a small system (Damian et al., 2000). Remus (1986) argued that graduate students could be used as surrogates for managers in experiments on business decision making. Students often represent a typical working professional and organizational member due to the variety of backgrounds and goals (Dipboye & Flanagan, 1979). Studies in industrial organization psychology and organization behavior suggest that results obtained from students are similar to those from managers (see for example, Locke, 1986). Despite the fact that clients and analysts in our experiments had 2-4 years of work experience, limitations of using students as surrogates are still applicable in our study.

The potential lack of realism in laboratory experiments using student surrogates can be addressed through multiple methods (McGrath, 1984) so that the strengths of some compensate weaknesses of others (Jarvenpaa, 1988). Simulated laboratory negotiations could be complemented by field studies or validations, if the lack of realism is an issue. As a next step in our research, we plan to complement the findings of our laboratory experiments with field validations.

Project Complexity

We acknowledge that requirements analysis is an intensive phase and hence is not possible to completely replicate it in student experiments. However, our objective was to study the research questions on comparable relatively well-defined small projects in which complexity of requirements analysis is not high. Though the experiments were carefully designed, the projects done were limited in scope and size compared to large scale industrial projects. However, no formal measures of complexity were used in the study so that we could compare the projects used in the experiments with real world industrial projects. Further research is needed to assess the impact of these findings on large scale industrial projects with complex requirements.

Communication Technology

The communication technology used in our experiment was mainly freely available Internet-based information and communication technology like chat, e-mail, e-groups, and Web conferencing. Moreover, in industry, other technologies like teleconferencing and video conferencing are also used. Further research is required to study the impact of different communication technologies during requirements analysis.

IMPLICATIONS FOR PRACTICE

The use of GSD in organizations is becoming increasingly commonplace as corporations seek to take advantage of geographically dispersed talent for multilocation operations. This study yields several interesting implications for practice that can assist organizations in managing their offshore GSD projects more effectively.

Despite evidence of successful agile software development, its application in GSD warrants some planning. Although there exists some preliminary research on applications of Extreme Programming (XP) in GSD (Nago-The, Hoang, Nguyen, & Mai, 2005), it is a common perception that agile methods are not applicable in GSD. There is a need for increased understanding of the characteristics of agile methods and how they can be applied to mitigate the negative influence of distance (Holmstrom et al., 2006). There are emerging examples of organizations like Sapient that have demonstrated the ability to run complex, large-scale distributed projects and have leveraged the benefits that agile processes offer (Barnett, 2006).

Prior studies indicate that creation of flexible environments by incorporating the principles of agile development can help organizations mitigate communication and control related risks inherent in GSD. Our study also finds that client as well as vendor organizations need to pay adequate attention to incorporating discipline even in flexible GSD projects, specifically during requirements analysis. Our article makes an important contribution of delineating the differences of the traditional, agile, and flexible approaches. In an attempt to portray reality, we explain the hybrid "flexible GSD" approach which most organizations are adopting. This hybrid approach incorporates the discipline offered by the traditional approaches and the flexibility offered by the agile approaches.

Companies that are engaged in offshore GSD have developed strong processes around their global delivery model. However, whether the same processes and project monitoring discipline (control) will lead to success of projects conducted in "flexible and pure offshore mode" in virtual team setting during the early stages of system development work has not been explored. Hence, we examined the antecedents of success during requirements analysis in such an environment. Our research indicates that client site-coordinators play an important role in increasing task related computer-mediated communication and requirements analysis success. Further vendor site-coordinators play a critical role in increasing control which indirectly impacts requirements analysis success.

Agile philosophy advocates that requirements change is a business world reality. Our study provides empirical support for the impact of requirements change even in the early phases of software development like requirements analysis. The results indicate that changes in requirements resulted in greater control, greater computer-mediated communication, and greater process facilitation by vendor site-coordinator. These factors are likely to further impact requirements analysis success in a GSD setting.

Another important message that this study conveys is that site-coordinators need not be project managers or team leads. Any experienced team member who gets nominated by consensus can facilitate project processes and impact success of distributed projects. Further research is needed to confirm our exploratory findings.

IMPLICATIONS FOR RESEARCH

Contributing to existing research, this study empirically demonstrates the direct and indirect relationships between antecedent factors (control, computer-mediated communication, process facilitation by vendor site-coordinator, and process facilitation by client site-coordinator) and success in flexible offshore GSD projects. It may not always be feasible to make experimental and control groups adhere to experimental requirements in a classroom setting, hence a flexible approach is needed in experimental design.

The findings highlight the key role that formal modes of control play even in a flexible GSD environment. The scope of our research was limited to examining only formal modes of control whereas agile philosophy can probably also support informal modes of control, such as self and clan control. Future research is needed to understand the conditions under which self and clan control is used in flexible GSD projects, and hence their impact on success.

By implementing dedicated client as well as vendor site-coordinators at each distributed site we also empirically determined the direct and indirect (via control) effects of process facilitation on success. Contrary to our belief, we found that there was no significant impact of task-related computer-mediated communication on success. Informal communication and socialization is one probable explanation that could have met the need for such information exchange. Also, given the fact that students were used as surrogates, informal online interaction is more likely to occur rather than planned formal interaction. This needs further investigation by researchers in field settings.

Although several benefits have been speculated, our research is one of the first studies to empirically validate the impact of changes in requirements, which resulted in greater perception of control, computer-mediated communication, and process facilitation by vendor site-coordinator. However, requirements change calls for more detailed investigation as we studied this using a dichotomous variable in our multigroup analysis. Future research can involve measuring the level of requirements change and further adding it as a variable in our research model. Moreover, to further our knowledge about success of flexible offshore GSD projects and their subphases, additional studies are needed that move beyond presently conceptualized variables, such as impact of motivation, cohesion and trust between offshore GSD team members, and emotional intelligence of individual team members.

REFERENCES

Agerfalk, P.J., & Fitzgerald, B. (2006). Flexible and distributed software processes: Old petunias in new bowls? *Communications of the ACM, 49*(10), 27-35.

Anson, R., Bostrom, R., & Wynne, B. (1995). An experiment assessing group support system and facilitator effects on meeting outcomes. *Management Science, 41*(2), 189-208.

Arbuckle, J.L. (2006). *AMOS 7.0 computer software*. Chicago: SmallWaters.

Augustine, S., Payne, B., Sencindiver, F., & Woodcock, S. (2005). Agile project management: Steering from the edges. *Communications of the ACM, 48*(12), 85-89.

Barnett, L. (2006). Scaling agile worldwide: Sapient's distributed agile methodology. *Agile Journal*. Retrieved July 27, 2008, from http://www.agilejournal.com

Baroudi, J.J., Orlikowski, W.J. (1988). A short-form measure of user information satisfaction: A psychometric evaluation and notes on use. *Journal of Management Information Systems*, *4*(4), 44-59.

Battin, R., Crocker, R., Kreidler, J., & Subramanian, K. (2003, March/April). Leveraging resources in global software development. *IEEE Software*, 70-77.

Beath, C.M., & Orlikowski, W.J. (1994). The contradictory structure of systems development methodologies: Destructuring the IS user relationship in information engineering. *Information Systems Research, 5*(4), 350-77.

Bhat, Jyoti M., Gupta, Mayank, Murthy, & Santhosh, N. (2006, September). Overcoming requirements engineering challenges: Lessons from offshore outsourcing. *IEEE Software,* 38-43.

Briggs, R.O, Balthazard, P.A, & Dennis, A.R. (1996). Graduate business students as surrogates in the evaluation of technology. *Journal of End User Computing, 8*(4), 11-17.

Briggs, R.O., & Gruenbacher, P. (2002). Easy winwin: Managing complexity in requirements negotiation with GSS. In *Proceedings: 35th Annual Hawaii International Conference on Systems Science,* Hawaii.

Byrne, B.M. (2001). *Structural equation modeling with AMOS*. London: Lawrence Erlbaum Associates.

Campbell, D.T., & Stanley, J.C. (1966). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally.

Carmel, E. (1999). *Global software teams: Collaborating across borders and time zones*. Upper Saddle River, NJ: Prentice Hall.

Carmel, E., & Tjia, P. (2005). *Offshoring information technology: Sourcing and outsourcing to a global workforce*. Cambridge, UK: Cambridge University Press.

Cheung, C., & Lee, M. (2001). Trust in Internet shopping: Instrument development and validation through classical and modern approaches. *Journal of Global Information Management, 9*(3), 23-35.

Choudhury, V., & Sabherwal, R. (2003). Portfolios of control in outsourced software development projects. *Information Systems Research, 14*(3), 291-314.

Cockburn, A., & Highsmith, J. (2001, September). Agile software development: The business of innovation. *IEEE Computer*, 120-122.

Comstock, D.E., & Scott, W.R. (1977). Technology and the structure of subunits: Distinguishing individual and workgroup effects. *Administrative Science Quarterly, 22,* 177-202.

Crampton, C. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organization Science*, *12*(3), 346-371.

Crisp, C.B. (2003). *Control enactment in global virtual teams.* UMI published doctoral dissertation, University of Texas, Austin.

Crowston, K., & Kammerer, E.E. (1998). Coordination and collective mind in software requirements development. *IBM Systems Journal, 37*(2), 227-241.

Damian, D.E, Eberlein, A., Shaw, M.L.G., & Gaines, B.R. (2000, May/June). Using different communication media in requirements negotiation. *IEEE Software*, 28-36.

Damian, D.E., & Zowghi, D. (2002). An insight into interplay between culture, conflict and distance in globally distributed requirement negotiations. In *Proceedings: 36th Hawaii International Conference on System Sciences,* Hawaii.

DeSanctis, G., & Gallupe, R.B. (1987). A foundation for the study of group decision support systems. *Management Science, 35*(5), 589-609.

Dibbern, J., Goles, T., Hirschheim, R., & Jayatilaka, B. (2004). Information systems outsourcing: A survey and analysis of the literature. *The DATABASE for Advances in Information Systems, 35*(4), 6-102.

Dipboye, R.L., & Flanagan, M.F. (1979). Research setting in industrial and organization psychology: Are findings in the field more generalizable than in laboratory. *American Psychologist, 32*, 141-150.

Edwards, K., & Sridhar, V. (2005, April-June). Analysis of software requirements engineering exercises in a global virtual team setup. *Journal of Global Information Management, 13*(2), 21-41.

Edwards, K., & Sridhar, V. (2006). Collaborative software requirements engineering exercises in a distributed virtual team environment. In G. Hunter & F. Tan (Eds.), *Advanced topics of global information management* (Vol. 5., pp. 178-197). Hershey, PA: Idea Group Publishing

Eisenhardt, K.M. (1985). Control: Organizational and economic approaches. *Management Science, 31*(2), 134-49.

Espinosa, A.J. (2002). *Shared mental models and coordination in large-scale, distributed software development.* UMI published doctoral dissertation, Carnegie Mellon University.

Evaristo, R., Watson-Manheim, M. B., & Audy, J. (2005). E-collaboration in distributed requirements determination. *International Journal of E-Collaboration, 1*(2), 40-55.

Favela, J., & Pena-Mora, F. (2001, March/April). An experience in collaborative software engineering education. *IEEE Software,* 47-53.

Fruhling, A., & Vreede, G.-J. De (2006). Field experiences with e-xtreme programming: developing an emergency response system. *Journal of Management Information Systems, 22*(4), 39-68.

Griffin, R.W. (1982). *Task design: An integrated approach.* Glenview, IL: Scott Foresman.

Griffith, T.L., Fuller, M.A., & Northcraft, G.B. (1998). Facilitator influence in group support systems: Intended and unintended effects. *Information Systems Research, 9*(1), 21-35.

Hazari, S.I. (2005). Perceptions of end-users on the requirements in personal firewall software: An exploratory study. *Journal of Organizational and End User Computing*, *17*(3), 47-65.

Ho, R. (2006). *Handbook of univariate and multivariate data analysis and interpretation with SPSS*. Boca Raton, NY: Chapman & Hall.

Hoffer, J., George, J., & Valacich, J. (1999). *Modern systems analysis and design*. USA: Addison Wesley.

Holmstrom, H., Fitzgerald, B., Agerfalk, P.J., Conchuir, & Eoin, O. (2006, Summer). Agile practices reduce distance in global software development. *Information Systems Managemen*t, 7-18.

Hulnick, G. (2000). Doing business virtually. *Communication World, 17*(3), 33-36.

Jarvenpaa, S. (1988). The importance of laboratory experimentation in IS research. *Communications of the ACM, 31*(12), 1502-1505.

Kirsch, L.J. (1997). Portfolios of control modes and IS project management. *Information Systems Research, 8*(3), 215-39.

Kirsch, L.J., & Cummings, L.L. (1996). Contextual influences on self-control of IS professionals engaged in systems development. *Accounting, Management Information Technology, 6*(3), 191-219.

Kirsch, L.J., Sambamurthy, V., Dong-Gil, K., & Russell, L.P. (2002, April). Controlling information systems development projects: The view from the client. *Management Science, 48*(4), 484-498.

Kline, R.B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York: Guilford.

Lee, O.-K. Banerjee, P., Lim, K.H., Hillegersberg, J.V., & Wei, K.K. (2006). Aligning IT components to achieve agility in globally distributed system development. *Communications of the ACM, 49*(10), 49-54.

Lee, G., Delone, W., & Espinosa, J.A. (2006). Ambidextrous coping strategies in globally distributed software development projects. *Communications of the ACM, 49*(10), 35-40.

Lindstrom, L., & Jeffries, R. (2004, Summer). Extreme programming and agile software development methodologies. *Information Systems Management,* 41-52.

Locke, E.A. (1986). *Generalizing from laboratory to field setting: Research finding from industrial organization, organization behavior, and human resource management.* Lexington, MA: Lexington Books.

Mahaney, R.C., & Lederer, A.L. (2006). The effect of intrinsic and extrinsic rewards for developers on information systems project success. *Project Management Journal, 37*(4), 42-54.

McGrath, J. (1984). *Groups: Interaction and performanc*e. New Jersey: Prentice-Hall.

Meso, P., & Jain, R. (2006, Summer). Agile software development: Adaptive systems principles and best practices. *Information Systems Management*, 19-30.

Miranda, S.M., & Bostrom, R.P. (1999). Meeting facilitation: Process vs. content interventions. *Journal of Management Information Systems, 15*(4), 89-114.

Nago-The, A., Hoang, K., Nguyen, T., & Mai, N. (2005). Extreme programming in distributed software development: A case study. In *Proceedings: International Workshop on Distributed Software Development,* Paris.

Nath, D., Sridhar, V., Adya, M., & Malik, A. (2006). The effect of user project monitoring on the performance of virtual teams in the requirements analysis phase of off-shored software projects. In *Proceedings: INFORMS Conference on Information Systems and Technology (CIST),* Pittsburgh, PA.

National Association of Software and Service Companies (NASSCOM). (2007). *Strategic review: The IT industry in India.* Retrieved July 27, 2008, from http://www.nasscom.org/

PMBOK® (2000). *A guide to project management body of knowledge (PMBOK)*. Newtown Square, PA: Project Management Institute.

Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: A review of current literature and directions for future research. *The DATABASE for Advances in Information Systems*, *35*(1), 6-36.

Putnam, L.L., & Cheney, G. (1985). Organizational communication: Historical development and future directions. In T.W. Benson (Ed.), *Speech communication in the 20th century* (pp. 130-156). Carbondale, IL: Southern Illinois University Press.

Ramesh, B., Cao, L., Mohan, K., & Xu, P. (2006). Can distributed software development be agile? *Communications of the ACM, 49*(10), 41-46.

Remus, W.E. (1986). An empirical test of the use of graduate students as surrogates for managers in experiments on business decision making. *Journal of Business Research*, *14*(1), 1986, 19-25.

Rice, R.E. (1987). Computer-mediated communication and organizational innovation. *Journal of Communication, 37*(4), 65-94.

Russell, D.W., Kahn, J.H. & Altmaier, E.M. (1998). Analyzing data from experimental studies: A latent variable structural equation modeling approach. *Journal of Counseling Psychology, 45*(1), 18-29.

Schnake, M.E., & Dumler, M.P. (2003). Levels of measurement and analysis issues in organizational citizenship behavior research. *Journal of Occupational and Organizational Psychology, 76,* 283-301.

Sorbom, D. (1981). Systems under indirect observation: Causality, structure and prediction. In K.G. Joreskog & H. Wald (Eds.), *Structural equation models with structured means*. Amsterdam: North-Holland.

Tan, C., & Teo, H. (2007). Training future software developers to acquire agile development skills. *Communications of the ACM, 50*(12), 97-98.

Yadav, V., & Gupta, R. (2008). A paradigmatic and methodological review of research in outsourcing. *Information Resource Management Journal, 21*(1), 27-43.

Yadav, V., Nath, D., Adya, M., & Sridhar, V. (2007). Investigating an agile-rigid approach in globally distributed requirements analysis. In *Proceedings: 11th Pacific-Asia Conference on Information Systems (PACIS),* Auckland, New Zealand.

APPENDIX A: QUESTIONNAIRE ITEMS

Two separate versions of the same questionnaire were created having identifiers, such as “MU” for the client questionnaire and “MDI” for the vendor questionnaire. The items were the same; only the identifiers (MU/MDI) were different for the client and vendor team members. The items presented in the appendix are from the MDI vendor questionnaire.

Response Scale: “Please answer each of the following questions related to the globally distributed development project by encircling the appropriate response”

Seven point scale, with 1= “Strongly Disagree,” 4= “Neutral,” and 7= “Strongly Agree”

PROCESS FACILITATION

Process Facilitation- Vendor

1. The MDI site-coordinator helped coordinate the workflow between MDI and MU team members.

2. My team members could have prepared as good project deliverables even if the MDI site-coordinator had not been present.*
3. The MDI site-coordinator constructively responded to our team's needs for assistance.

Process Facilitation- Client

1. The MU site-coordinator helped coordinate the workflow between MDI and MU team members.
2. My team members could have prepared as good project deliverables even if the MU site-coordinator had not been present.*
3. The MU site-coordinator constructively responded to our team's needs for assistance.

COMPUTER-MEDIATED COMMUNICATION

1. We had frequent online-meetings with MU team members for coordination and planning.
2. We had frequent online-meetings with MU team members for requirements analysis.
3. We had frequent online formal review meetings with MU team members.
4. I participated actively in the online discussions with MU team members.*

CONTROL

Behavior Control**

1. The MU team members insisted on complete and on-time submission of project status reports.
2. The MU team members insisted on complete and on-time submission of intermediate project deliverables.
3. The MU team members insisted on complete and on-time submission of final project deliverables.

Outcome Control**

4. The MU team members regularly monitored the project progress.
5. A detailed project management plan was developed between our MDI team members and MU team members.
6. The communication process between our MDI team members and MU team members was well defined.

SUCCESS

Perceived Quality**

1. MDI team members have been able to come out with the best possible deliverables for capturing MU client requirements.

2. The final project deliverables were readily accepted by the MU team members.
3. The project deliverables clearly specified MU client requirements.

Client Satisfaction**

4. The MU team members clearly understood the project deliverables submitted by MDI team members.
5. The commitment of the MU team members in favor of the project directed goals and tasks were positive.

Success of Implementation Process**

6. The virtual team project was completed within its original schedule.
7. MU client was satisfied with the process by which this project was completed.

** Item dropped from analysis*
*** Entered as item parcels in the model for analysis*

APPENDIX B: RESULTS OF MULTIGROUP ANALYSIS

Computation of Degrees of Freedom and Chi-Square Goodness-of-fit Statistics for the Models

Model (Group-Invariant)	Model (Group-Variant)
Computation of degrees of freedom (Group-Invariant) Number of distinct sample moments :132 Number of distinct parameters to be estimated: 50 Degrees of freedom (132 - 50) : 82 Result (Group-Invariant) Minimum was achieved Chi-square = 161.380 Degrees of freedom = 82 Probability level = .000	Computation of degrees of freedom (Group-Variant) Number of distinct sample moments :132 Number of distinct parameters to be estimated: 58 Degrees of freedom (132 - 58) : 74 Result (Group-Variant) Minimum was achieved Chi-square = 152.532 Degrees of freedom = 74 Probability level = .000

Estimates (Group Invariant)

CONTROL GROUP (No Req. Change)									NONCONTROL GROUP (Req. Change)								
Scalar Estimates (Maximum Likelihood Estimates) **Regression Weights**									Scalar Estimates (Maximum Likelihood Estimates) **Regression Weights**								
			Estimate	S.E.	C.R.	P	Label					Estimate	S.E.	C.R.	P	Label	
Com	<---	Fac Vendor	.238	.135	1.768	.077	nc1		Com	<---	Fac Vendor	.238	.135	1.768	.077	nc1	
Contrl	<---	Fac Client	.102	.080	1.274	.203	nc6		Contrl	<---	Fac Client	.102	.080	1.274	.203	nc6	
Contrl	<---	Fac Vendor	.653	.100	6.509	***	nc3		Contrl	<---	Fac Vendor	.653	.100	6.509	***	nc3	
Com	<---	Fac Client	.672	.145	4.631	***	nc4		Com	<---	Fac Client	.672	.145	4.631	***	nc4	
Success	<---	Contrl	.476	.117	4.079	***	nc7		Suc-cess	<---	Contrl	.476	.117	4.079	***	nc7	
Success	<---	Com	-.078	.045	-1.746	.081	nc8		Suc-cess	<---	Com	-.078	.045	-1.746	.081	nc8	
Success	<---	Fac Client	.605	.090	6.754	***	nc5		Suc-cess	<---	Fac Client	.605	.090	6.754	***	nc5	
Success	<---	Fac Vendor	-.064	.105	-.607	.544	nc2		Suc-cess	<---	Fac Vendor	-.064	.105	-.607	.544	nc2	
fac2	<---	Fac Vendor	1.002	124	.8.075	***	ncv2		fac2	<---	Fac Vendor	1.002	.124	8.075	***	ncv2	
outcnt	<---	Contrl	.717	.085	8.426	***	ncv3		outcnt	<---	Contrl	.717	.085	8.426	***	ncv3	
fac1	<---	Fac Client	.984	.110	8.924	***	ncv1		fac1	<---	Fac Client	.984	.110	8.924	***	ncv1	
fac5	<---	Fac Client	1.000						fac5	<---	Fac Client	1.000					
fac6	<---	Fac Vendor	1.000						fac6	<---	Fac Vendor	1.000					
behcnt	<---	Contrl	1.000						behcnt	<---	Contrl	1.000					
com4	<---	Com	.992	.115	8.652	***	ncv6		com4	<---	Com	.992	.115	8.652	***	ncv6	
com3	<---	Com	1.000						com3	<---	Com	1.000					
uis	<---	Success	.684	.067	10.225	***	ncv4		uis	<---	Success	.684	.067	10.225	***	ncv4	
proc	<---	Success	.967	.058	16.565	***	ncv5		proc	<---	Success	.967	.058	16.565	***	ncv5	
qlty	<---	Success	1.000						qlty	<---	Success	1.000					

continued on following page

Estimates (Group Invariant) continued

CONTROL GROUP (No Req. Change)				NONCONTROL GROUP (Req. Change)			
Standardized Regression Weights				**Standardized Regression Weights**			
			Estimate				Estimate
Com	<---	Fac Vendor	.177	Com	<---	Fac Vendor	.120
Contrl	<---	Fac Client	.088	Contrl	<---	Fac Client	.132
Contrl	<---	Fac Vendor	.702	Contrl	<---	Fac Vendor	.603
Com	<---	Fac Client	.399	Com	<---	Fac Client	.471
Success	<---	Contrl	.547	Success	<---	Contrl	.434
Success	<---	Com	-.131	Success	<---	Com	-.131
Success	<---	Fac Client	.599	Success	<---	Fac Client	.710
Success	<---	Fac Vendor	-.079	Success	<---	Fac Vendor	-.054
fac2	<---	Fac Vendor	.819	fac2	<---	Fac Vendor	.717
Out cnt	<---	Contrl	.717	Out cnt	<---	Contrl	.742
fac1	<---	Fac Client	.761	fac1	<---	Fac Client	.824
fac2	<---	Fac Client	.726	fac2	<---	Fac Client	.788
fac6	<---	Fac Vendor	.877	fac6	<---	Fac Vendor	.742
Beh cnt	<---	Control	.797	Beh cnt	<---	Control	.831
com4	<---	Com	.864	com4	<---	Com	.904
com3	<---	Com	.892	com3	<---	Com	.925
sat	<---	Success	.611	sat	<---	Success	.691
proc	<---	Success	.962	proc	<---	Success	.923
qlty	<---	Success	.808	qlty	<---	Success	.926

continued on following page

Estimates (Group Invariant) continued

CONTROL GROUP (No Req. Change)		NONCONTROL GROUP (Req. Change)	
Squared Multiple Correlations		**Squared Multiple Correlations**	
	Estimate		Estimate
Com	.216	Com	.270
Control	.522	Control	.427
Success	.649	Success	.735
proc	.925	proc	.852
com3	.795	com3	.856
Out cnt	.514	Out cnt	.551
Beh cnt	.635	Beh cnt	.690
sat	.373	sat	.478
qlty	.652	qlty	.858
com4	.747	com4	.817
fac2	.672	fac2	.514
fac6	.769	fac6	.551
fac1	.580	fac1	.680
fac5	.527	fac5	.621

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