Investigating Task Coordination in Globally Dispersed Teams: A Structural Contingency Perspective

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Task coordination poses significant challenges for globally dispersed teams (GDT). While various task coordination mechanisms have been proposed for such teams, there is a lack of systematic examination of the appropriate coordination mechanisms for different teams based on the nature of their task and the context that they operate under. Prior studies on collocated teams suggest matching their levels of task dependence to specific task coordination mechanisms for effective coordination. This research goes beyond the earlier work by also considering additional contextual factors of GDT (i.e., temporal dispersion and time constraints) in deriving their optimal IT-mediated task coordination mechanisms. Adopting the structural contingency theory, we propose optimal IT-mediated task coordination portfolios to fit the different levels of task dependence, temporal dispersion, and perceived time constraint of GDT. The proposed fit is tested through a survey and profile analysis of 95 globally dispersed software development teams in a large financial organization. We find that, as hypothesized, the extent of fit between the actual IT-mediated task coordination portfolios used by the surveyed teams and their optimal portfolios proposed here is positively related to their task coordination effectiveness that, in turn, impacts the team's efficiency and effectiveness. The implications for theory and practice are discussed.

Categories and Subject Descriptors: **H.4.3 [Information Systems Application]**: Communications Applications, **J.4 [Social and Behavioral Sciences]**: Sociology

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1. INTRODUCTION

Globally dispersed teams[2] (GDT) have emerged to become a common feature in the work environment. Such teams are popular in the software development context [Kiely et al. 2010; Smite et al. 2008] where they allow organizations to exploit time zone differences to extend the working day. Nevertheless, GDT may not produce the desired benefits if they are unable to overcome the challenges in this form of work, particularly task coordination across dispersed members. Prior studies on distributed software development teams have consistently reported problems related to task coordination, such as unnoticed changes of code and communication delays, resulting in time and cost overruns that may erase much of the possible productivity benefits from this work structure [Cataldo et al. 2007; Denning et al. 2010]. In fact, 81% of enterprises surveyed by Forrester Research reported that they had coordination issues with their distributed software development teams to the extent that some of them would re-architect their software to reduce interdependencies between geographically dispersed members if possible[3]. Task coordination issues were also mentioned as reasons for some GDT to take longer (even 2.5 times longer) to complete software development work than collocated teams [Herbsleb and Mockus 2003; Sangwan et al. 2006]. Thus, effectiveness of task coordination has been suggested as salient for performance in distributed teams [Espinosa et al. 2012; Kraut and Streeter 1995].

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[2] This term is used synonymously with global virtual team (GVT) in this study and in the literature.
[3] http://www.serena.com/docs/repository/solutions/software-change-mana.pdf

Task coordination is the act of managing interdependent work activities among team members [Wittenbaum et al. 1998]. While various mechanisms have been proposed for coordinating tasks in GDT, such as frequent communications and standardization [Cataldo et al. 2007; Smite et al. 2008], there is a lack of systematic examination and understanding of the appropriate coordination mechanisms for different teams based on the nature of their tasks and the context that the team operates under. Prior studies on collocated teams suggest the need to match their levels of task dependence to specific task coordination mechanisms for effective coordination [Andres and Zmud 2002; Kraut and Streeter 1995], where *task dependence* denotes the extent to which team members are dependent upon one another to carry out their work [Van de Ven et al. 1976; Van der Vegt and Van de Vliert 2002].

However, GDT operate under other conditions besides task dependence. A key contextual factor for these teams is members' temporal dispersion or members' time zone differences [Espinosa et al. 2012; Riopelle et al. 2003]. Through creating coordination problems, temporal dispersion can negatively impact global team performance [Espinosa and Carmel 2003; Espinosa et al. 2012]. Particularly, large time zone differences may hamper the use of certain task coordination mechanisms e.g., those that are based on a common working time for all members [Cummings et al. 2009]. These conditions are exacerbated by the fact that such teams often face time pressures in their work i.e., the coordination must take place under time constraints [Espinosa et al. 2012].

By considering these contextual factors for GDT (i.e., temporal dispersion and time constraint) beyond task dependence, this study conceptualizes and extends the notion of task coordination fit from collocated teams [Andres and Zmud 2002; Kraut and Streeter 1995] to GDT. Specifically, the objective is to theoretically derive the appropriate *task coordination portfolios* (i.e., sets of task coordination mechanisms) for different levels of task dependence, temporal dispersion, and perceived time constraint[4] of GDT in order to effectively coordinate their tasks. Further, considering that GDT rely predominantly on IT to accomplish their work, IT should be taken into account in designing their task coordination portfolios. GDT perform task coordination through two major forms of IT i.e., electronic repositories and communication technology. While *electronic repositories* e.g., online bulletin boards [Chen et al. 2003; Malone and Crowston 2003], allow users to store information on a long term basis and offer indexing features to organize and retrieve the information, *communication technology* e.g., electronic mail and video conferencing [Malone and Crowston 2003; Montoya-Weiss et al. 2001], permits users to exchange information through asynchronous (without the need to be present at the same time) or synchronous means.

Taking into account the form of IT to support task coordination mechanisms, this study aims to answer the following two research questions: (1) What are the optimal IT-mediated task coordination portfolios (i.e., the set of IT-mediated task coordination mechanisms) for GDT with different levels of task dependence, temporal dispersion, and perceived time constraint, for their effective task coordination? (2) Does a better fit (between the actually used IT-mediated task coordination portfolio and the proposed optimal IT-mediated task coordination portfolio for the team) lead

[4] Given that team members respond more to the perceived time constraint rather than the objective time constraint [Maynard et al. 2012], this study considers perceived time constraint as a key contextual factor for task coordination.

to better team performance for the GDT through improved task coordination effectiveness? To address these questions, we adopt the systems approach of structural contingency theory to propose the fit between IT-mediated task coordination portfolios and GDT's task dependence, temporal dispersion, and perceived time constraint. The proposed fit is tested through a survey of members and project managers from 95 globally dispersed software development teams in a large financial organization, and found to be empirically supported.

Besides contributing to the theoretical development on task coordination in GDT, answers to these research questions are significant for software engineering practice considering the growing number of large global software organizations such as IBM and SAP setting up centres of excellence in different geographical locations [Siebdrat et al. 2009], and the consistently reported task coordination challenges in such teams [Cataldo et al. 2007; Denning et al. 2010; Espinosa et al. 2012]. To better highlight the contributions of our study, we next review prior research on GDT before proceeding to the conceptual background of the study.

2. EXTANT STUDIES ON GDT TASK COORDINATION

We reviewed the previous studies on GDT task coordination to position our study with respect to the previous literature and highlight its contributions (see Table A.I in the Appendix). Table A.I is divided based on whether the prior studies examined explicit or implicit coordination. Within each coordination category, the studies are grouped according to whether they investigated GDT in general or global software development teams. Past studies have distinguished *implicit* task coordination based on unspoken expectations and intentions e.g., Espinosa et al. [2007a, 2007b], from *explicit* task coordination through formally adopted plans that designate who should do what at which point in time e.g., Cummings et al. [2009], and Hinds and McGrath [2006]. While both forms of task coordination are important, our study examines explicit task coordination for the following reason. Effective implicit task coordination can occur mainly when team members have prior shared work experience or are familiar with one another. However, since GDT members are largely chosen due to their expertise and may not necessarily have shared work experience, relying solely on implicit task coordination can be challenging.

In terms of the unit of analysis, previous studies have compared the coordination mechanisms between collocated and dispersed teams or examined the coordination mechanisms across dispersed teams. While it is valuable to compare how collocated teams and dispersed teams can accomplish task coordination differently, it is also important to understand how different GDT can effectively perform task coordination as is done in this study. Further, most prior studies have typically focused on either spatial or temporal dispersion of distributed teams. Espinosa et al. [2012] showed that temporal dispersion is more critical than spatial dispersion in impacting team performance, supporting our focus on temporal dispersion in this study. Finally, instead of using a *dichotomous measure* of dispersion (0 if all team members were at the same location/time zone and 1 otherwise) as is often done, this study adopts a continuous measure of temporal dispersion normalized by team size [O'Leary and Cummings 2007] that can more accurately account for time zone differences among team members.

Overall, the review finds lack of study and understanding of task coordination portfolios (set of task coordination mechanisms) that fit key contingencies of GDT. As an exception, Sutanto et al. [2011] qualitatively explored the task coordination portfolios used for 13 tasks in 3 student global teams through a case study. While the findings are useful, they are limited by the types of the tasks and the student teams under study. The current study proposes optimal profiles for GDT task coordination through matching sets of IT-mediated task coordination mechanisms to key contingencies of the teams (task dependence, temporal dispersion, and perceived time constraint). The proposed profiles are empirically validated through measuring the coordination profiles of 95 organizational GDT and the resultant task coordination outcomes. After highlighting the differences between prior studies of GDT task coordination and this study, we now explain the conceptual foundation for our proposed optimal task coordination profiles.

3. CONCEPTUAL FOUNDATION

In this section, we first discuss IT-mediated task coordination mechanism design based on task dependence and then add the two GDT contextual factors to finally derive the optimal IT-mediated task coordination portfolios for GDTs.

3.1 Task Dependence and IT-mediated Task Coordination Mechanisms

Structural contingency theory holds that the organization structure that is most effective is the structure that fits its contingencies or contextual factors [Pennings 1992]. As per the information processing view under this theory, contextual factors are viewed as determining the information processing requirements, while organization structure is viewed as providing the information processing capability to meet these requirements. The theory proposes that the fit between the information processing requirements of the context and the information processing capacity of the organizational structure should lead to better performance [Tushman and Nadler 1978]. Relevant to our study, the communication requirements of a team or work structure determined by its context have been considered as its information processing needs in the organization design and IS literatures [Andres and Zmud 2002; Premkumar et al. 2005]. On the supply side, the set of IT-mediated task coordination mechanisms (i.e., the IT-mediated task coordination portfolio) used by a team determines the communication requirements that the team can process, which we consider as the information processing capability. Previous literature on task coordination for collocated teams has suggested that coordination would be effective if the information processing needs of the team defined by the level of task dependence fits the information processing capability associated with its task coordination strategies [Andres and Zmud 2002; Kumar and van Dissel 1996]. Adopting the information processing view under the structural contingency theory, we propose that the IT mediated-task coordination mechanisms that are most effective are the ones that fit the communication requirements of the GDT determined by its contextual conditions. Based on this view and the previous task coordination literature, we argue that the first essential step in designing optimal task coordination portfolios for GDT is to match the communication requirements for each type of task dependence of the teams with the IT mediated-task coordination mechanisms that can satisfy these requirements. We now describe the levels of task dependence followed by the types of IT-mediated task coordination mechanisms that can match them.

Four levels of task dependence have been suggested to determine a work structure's communication requirements i.e., pooled, sequential, reciprocal, and team or intensive [Grandori 1997; Maynard et al. 2012; Van de Ven et al. 1976]. In a *pooled dependence task*, each team member performs his/her work independently before the task is completed by aggregating the work of the members. For example, during software development, each team member may code a few modules independently before they are integrated together. In a *sequential dependence task*, each team member has to complete his/her work before passing on the work to the next team member. For example, in the context of software development, team members may specialize in different types of test cases for software testing. In developing the overall test plan, each member could design and add test cases pertaining to his/her specialization before passing the list of test cases to the next team member to add to. In a *reciprocal dependence task*, the work will flow back and forth among team members. For example, during software debugging, work can flow back and forth between a member who is responsible for coding certain modules and another member who is responsible for testing those modules. When completing a *team dependence task*, all team members concurrently diagnose the problem and create the solution. There is no temporal lapse in the flow of work among team members. For example, in the context of software requirement analysis, all team members may meet to brainstorm about the needs of the user when creating the set of software requirements. The four levels of task dependence can be placed on a continuum of communication requirements, with pooled tasks having the lowest and team tasks having the highest requirements [Cataldo et al. 2007; Grandori 1997].

Task coordination mechanisms, too, have been categorized in various ways. A categorization that has been found useful and validated in a number of studies is based on the extent of intervention required i.e., standards and plans, bi-lateral interactions, and team meetings [Sabherwal 2003; Smite et al. 2008]. Coordination through *standards and plans* typically occurs in the form of blueprints for action that are specified prior to commencement of the task [Gittell 2002, Van de Ven et al. 1976]. Human discretion is rarely called for here. Rather, roles are formally prescribed in the blueprints based on what actions would be taken. Since *pooled or sequential dependence tasks* tend to have low communication requirements or low information processing needs, they can be well coordinated with standards and plans [Gresov 1989, Thompson 1967]. *As it is important that GDT members can easily find and retrieve the plans and schedules, electronic repositories are proposed to be the appropriate form of IT that can support coordination through standards and plans* for these tasks.

Further, while communication among team members may be redundant when performing pooled or sequential dependence tasks, the project manager should monitor and keep the team updated of the progress made by each member to avoid redundant or duplicate work [Smite et al. 2008]. Coordination via *bi-lateral interactions* relies on the interpersonal communication that occurs when team members are working on the task [Sabherwal 2003]. This can take the form of *vertical interactions* between superiors and subordinates or *horizontal interactions* between peers. Accordingly, horizontal interactions may be redundant in pooled or sequential dependence tasks, while vertical interactions would be necessary to coordinate these tasks in GDT. The vertical interactions need to occur as frequently as there is significant progress made by members. When frequent interactions occur between the project manager and the project members, communication speed would be valuable for such task coordination necessitating use of synchronous technology, whereas asynchronous communication may be sufficient otherwise. Thus, *communication technology (asynchronous and synchronous) is proposed to be the appropriate form of IT to support coordination through bi-lateral vertical interactions for pooled and sequential tasks*.

In contrast, coordination via *bi-lateral horizontal interactions* is needed in *reciprocal dependence* tasks as the intensity and nature of interaction in such tasks usually cannot be planned in advance and by the project manager alone [Sabherwal 2003]. *Bi-lateral horizontal interactions* occur as frequently as there are work changes affecting either party. When there are frequent back and forth interactions between members, communication speed is valuable for coordination requiring use of synchronous technology, whereas asynchronous communication may be adequate otherwise. Thus, *communication technology (asynchronous and synchronous) is proposed to be the appropriate form of IT to support coordination through bi-lateral horizontal interactions for reciprocal interdependence tasks*. Since reciprocal dependence tasks possess task elements at a lower level of dependence, i.e., pooled or sequential dependence elements [Kumar and van Dissel 1996], work on reciprocal dependence tasks can also benefit from using standards, plans, and bi-lateral vertical interactions for coordination.

Finally, coordination via *team meetings* is characterized by the simultaneity of multilateral interactions [Malone and Crowston 2003; Van de Ven et al. 1976]. Whereas mutual adjustments through bi-lateral interactions are done by pairs of individuals, team meetings involve the entire team (or a significant subset of the team) in the coordination effort, which are appropriate for *team dependence tasks* that require team members to work simultaneously on the same issues together [Grandori 1997; Maynard et al. 2012]. Because of the frequent need to communicate among members to coordinate via team meetings in team dependence tasks, team members may want to spend less time crafting their communication. Hence, *synchronous communication technology is proposed to be the appropriate form of IT to support coordination through team meetings for team dependence tasks*. Further, since team dependence tasks include task elements at a lower level of dependence (i.e., pooled, sequential, or reciprocal dependence task elements), work on team dependence tasks can also benefit from using standards and plans as well as bi-lateral vertical and horizontal interactions. Table I summarizes the optimal IT-mediated task coordination portfolio (or optimal set of IT-mediated task coordination mechanisms) for each level of task dependence proposed above.

Table I. Optimal IT-mediated Task Coordination by Type of Task Dependence

Task Dependence	**Optimal IT-mediated Task Coordination Portfolio**
Pooled or Sequential	Standards and plans (electronic repository) Bi-lateral vertical interactions (asynchronous and synchronous communication technology)
Reciprocal	Standards and plans (electronic repository) Bi-lateral vertical and horizontal interactions (asynchronous and synchronous communication technology)
Team	Standards and plans (electronic repository) Bi-lateral vertical and horizontal interactions (asynchronous and synchronous communication technology) Team meetings (synchronous communication technology)

3.2 Temporal Dispersion and Perceived Time Constraint

For GDT, it is essential that key contextual factors which influence the behavior of these teams i.e., temporal dispersion and perceived time constraint, be considered in addition to task dependence [Sutanto et al. 2011]. *Temporal dispersion* can pose challenges for distributed team members as they try to develop congruent work patterns and establish mutual expectations [Griffith et al. 2003] because they tend to be less aware of what other team members are doing [Boh et al. 2007]. Hence, it increases the information processing needs of GDT because members have to expend extra effort to track what other team members are working on [Herbsleb and Grinter 1999; Wakefield et al. 2008]. Additionally, temporal dispersion limits the information processing capability of GDT by restricting the use of certain task coordination mechanisms. If team members are located in different time zones around the world, they would have little overlap in terms of work hours thereby making the use of team meetings with synchronous communication technology arduous [Sutanto et al. 2011]. Therefore, by increasing information processing needs and limiting the information processing capability, temporal dispersion can impose significant challenges to task coordination in GDT.

The challenges posed by temporal dispersion can be amplified when GDT work under *time constraints*. Under high time pressure, members have to put in more effort to track what other team members are working on in order to avoid unnecessary or duplicate work (that would take up extra time). This would increase the information processing needs of the GDT. To track the activities of other team members, it would be effective to use synchronous communication technology. Yet, the temporal dispersion of GDT members can limit the use of synchronous communication technology. Hence, by increasing the information processing needs while restricting the information processing capability, time constraint, too, can exacerbate the challenges of task coordination in GDT. Given that team members respond more to the perceived time constraint rather than the objective time constraint [Maynard et al. 2012], this study models perceived time constraint as a key contextual factor for GDT task coordination. Team members form such a perception based on what they think is the amount of time available relative to the amount of time needed to complete their task [Benson and Beach 1996]. Thus, we propose that these key factors i.e., temporal dispersion and perceived time constraint, enhance the information processing needs (determined by task dependence) and constrain the information processing capability (determined by the task coordination portfolio) of GDT (see Figure 1).

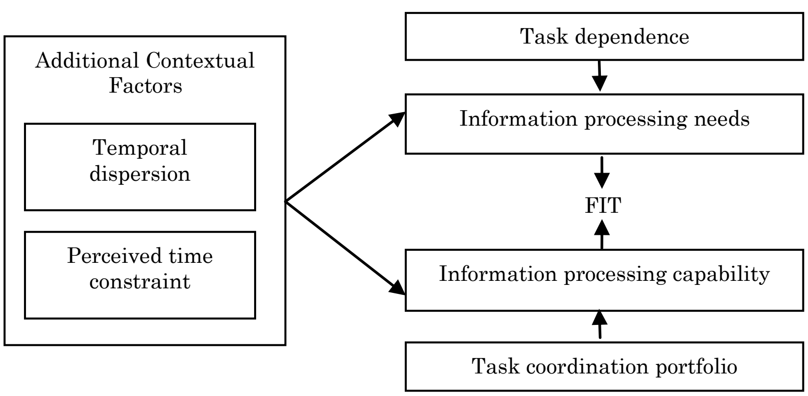

Fig. 1. Task Coordination in GDT

3.3 Optimal IT-mediated Task Coordination Portfolios for GDT

Taking into consideration the key contextual factors of GDT discussed above, we propose sets of optimal IT-mediated task coordination mechanisms (optimal IT-mediated task coordination portfolios) for GDT under different combinations of task dependence, temporal dispersion, and perceived time constraint (see Table II). This table is derived by adding temporal dispersion[5] and perceived time constraint contextual factors of GDT to Table I portfolios as described below.

Table II. Optimal Task Coordination in GDT

Task Dependence	**Temporal Dispersion**	**Perceived Time Constraint**	**Optimal Task Coordination Portfolio**	**Profile**
Pooled	Low or High[6]	Low	Standards and plans (electronic repository) Bi-lateral vertical interactions (asynchronous communication technology)	1A
		High	Standards and plans (electronic repository) Bi-lateral vertical interactions (synchronous communication technology)	1B
Sequential	Low or High	Low	Standards and plans (electronic repository) Bi-lateral vertical interactions (asynchronous communication technology)	2A
		High	Standards and plans (electronic repository) Bi-lateral vertical interactions (synchronous communication technology)	2B
Reciprocal	Low or High	Low	Standards and plans (electronic repository) Bi-lateral vertical interactions (asynchronous communication technology) Bi-lateral horizontal interactions (asynchronous communication technology)	3A
	Low	High	Standards and plans (electronic repository) Bi-lateral vertical interactions (synchronous communication technology) Bi-lateral horizontal interactions (synchronous communication technology)	3B
Team	Low or High	Low	Standards and plans (electronic repository) Bi-lateral vertical interactions (asynchronous communication technology) Bi-lateral horizontal interactions (asynchronous communication technology) Team meetings (synchronous communication technology)	4A
	Low	High	Standards and plans (electronic repository) Bi-lateral vertical interactions (synchronous communication technology) Bi-lateral horizontal interactions (synchronous communication technology) Team meetings (synchronous communication technology)	4B

Pooled dependence tasks (Profiles 1A and 1B): As shown in Table I, the optimal task coordination portfolio for pooled dependence tasks should include standards and

[5] We use the degree of GDTs' temporal dispersion for better precision, instead of whether they are collocated or not (temporal dispersion = 0 or 1). A dichotomous measure of temporal dispersion would modify the proposed optimal task coordination portfolio.
[6] When temporal dispersion is indicated as low or high, it means that the level of temporal dispersion does not play an important role in the design of the optimal task coordination portfolio.

plans through electronic repository as well as bi-lateral vertical interactions (between the project manager and team members). When perceived time constraint is low, the bi-lateral vertical interactions can be accomplished via asynchronous communication technology (*Profile 1A*). On the other hand, when perceived time constraint is high, the bi-lateral vertical interactions are best performed through synchronous communication technology (*Profile 1B*) which allows fast information processing (see Table II). If the suggested optimal task coordination portfolios are adopted by such teams, this should provide sufficient member awareness for this type of task and prevent duplicate work. For these two profiles, temporal dispersion does not have much bearing on the optimal portfolio design since this kind of task may not require synchronous communication among team members, mainly the communication between the relevant member and the project manager.

Sequential Dependence Tasks (Profiles 2A and 2B): Similar to pooled dependence tasks, as shown in Table I, when GDT work on sequential dependence tasks, the optimal task coordination portfolio for such tasks should include standards and plans through electronic repository as well as bi-lateral vertical interactions (between the project manager and team members). When perceived time constraint is low, these bi-lateral vertical interactions can be conducted via asynchronous communication technology (*Profile 2A*). However, when perceived time constraint is high, the bi-lateral vertical interactions are best performed via synchronous communication technology (*Profile 2B*) which increases information processing speed (see Table II). The suggested optimal portfolios can provide adequate member awareness for this type of task and prevent duplicate work. For these two profiles as well, temporal dispersion may not influence the optimal portfolio design since this kind of task may not require synchronous communication among many team members, mainly the communication between the relevant member and the project manager.

Reciprocal dependence tasks (Profiles 3A and 3B): For reciprocal dependence tasks, the work flows back and forth among team members. Thus, bi-lateral horizontal interactions are suggested for such tasks in addition to the standards and plans through electronic repository as well as bi-lateral vertical interactions proposed for sequential dependence tasks (see Table I). When perceived time constraint is low, the required bi-lateral vertical and horizontal interactions can be carried out via asynchronous communication technology since information processing speed is not critical (*Profile 3A*) regardless of temporal dispersion. When perceived time constraint is high, it would be necessary to conduct the required bi-lateral vertical and horizontal interactions via synchronous communication technology because information processing speed is critical [Payne et al. 1996]. Such extensive use of synchronous communication technology for both vertical (project manager- team member) and horizontal interactions (peer-to-peer) works best when there is little temporal dispersion of members (*Profile 3B*). If the proposed optimal task coordination portfolios are followed, this can provide sufficient member awareness for this type of task and prevent duplicate work. However, extensive use of synchronous communication technology for such interactions can be challenging in the presence of large temporal dispersion and little overlap of working hours. Hence, reciprocal dependence tasks in the presence of high temporal dispersion and high perceived time constraint may not have an optimal task coordination portfolio. When there is no ideal design, the task coordination outcome may be suboptimal [Gresov and Drazin 1997].

Team dependence tasks (Profiles 4A and 4B): Similar to reciprocal dependence tasks, team members need to be kept updated about the progress made in team dependence tasks through standards and plans as well as bi-lateral vertical and horizontal interactions. However, additionally in these tasks, members must mutually coordinate their work through team meetings as they share their work with each other (see Table I). Thus, GDT working on team dependence tasks need to frequently conduct team meetings through synchronous communication technology so that members can coordinate their work with others. When perceived time constraint is low, this works out fine for GDT. Even when temporal dispersion is high and may limit the use of team meetings, this need not hinder task completion since information processing speed is not critical under these conditions (*Profile 4A*). On the other hand, when perceived time constraint is high, the use of synchronous communication technology for team meetings is suitable for low temporal dispersion contexts (*Profile 4B*). For both these profiles, the suggested optimal task coordination portfolios should be able to provide adequate member awareness for this type of task and prevent duplicate work. However, high perceived time constraint coupled with high temporal dispersion makes implementing team meetings through synchronous communication technology necessary but arduous. Therefore, team dependence tasks with high temporal dispersion and high perceived time constraint may not have an optimal task coordination portfolio.

4. RESEARCH MODEL AND HYPOTHESES

In response to our research questions, we theorize the best fit between IT-mediated task coordination portfolios (i.e., the set of IT-mediated task coordination mechanisms) and the contextual factors (i.e., task dependence, temporal dispersion, and time constraint) of GDT in Table II, and propose that a better fit leads to enhanced team performance through task coordination effectiveness (see Figure 2).

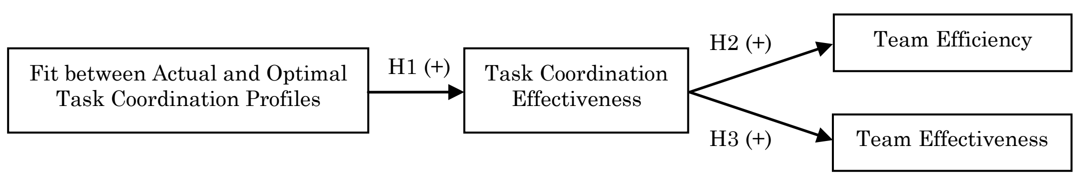

Fig. 2. The Research Model

As per structural contingency theory, there are three conceptual approaches to fit i.e., selection, interaction, and systems [Drazin and Van de Ven 1985]. In the selection approach, fit is an assumed premise underlying the context-design relationship. In other words fit is an unquestioned axiom, where better performers adopt designs that fit their situations relatively better than worse performers. Thus, this approach does not explicitly test the outcome of matching the design to the context, but assumes it. We do not adopt the selection approach in our study as that would imply taking for granted that teams with better fit between their IT mediated-task coordination portfolio and their contextual factors would have more effective task coordination without testing it.

In the interaction approach to fit, the contingency is seen as an intervening variable between the predictor (e.g., structure) and criterion (e.g., performance). This requires testing the interactions among all independent variables on the dependent variable. Thus, adopting the interaction approach in our study would require the testing of four-way interactions of task dependence, temporal dispersion, perceived time constraint, and task coordination portfolio on the outcome (i.e., task coordination effectiveness). Four-way interactions consist of four original variables, six two-way interactions, and four three-way interactions. As could be surmised from this example, when more than two independent variables are incorporated, the interaction approach of fit may suffer from spurious multicollinearity (which affects the reliability of the findings) and lack of precision (which makes the interpretation of the findings challenging) [Venkatraman 1989]. Therefore we do not find the interaction approach of fit to be suitable for our study.

In the systems approach, fit is a conformance measure where strong performers do not deviate from the optimal profiles [Premkumar et al. 2005]. Unlike the interaction approach, the systems approach involves profile matching where each profile has a specific combination of contextual factors (in our case, task dependence, temporal dispersion, and perceived time constraint) and design factors (in our case, task coordination portfolio). Deviation from the optimal profile implies a weakness in the context-design alignment, which negatively affects the outcome. In other words, the systems perspective allows researchers to specify optimal profiles and to demonstrate that adherence to such profiles would have positive implications for performance [Venkatraman 1989]. Here, we adopt the systems approach because of its comprehensive treatment of fit and because it allows us to test if the adherence to the 8 optimal profiles that we theorized (profiles 1A until 4B in Table II) will lead to better task coordination. As we have argued till now, a GDT's distance from the optimal profile should reduce its task coordination effectiveness, which is defined in terms of the awareness of other members' work and the avoidance of duplicate work [Hoegl et al. 2004]. Conversely, the lower the distance (the greater the fit), the greater would be the task coordination effectiveness. Thus, we hypothesize,

H1: Within its context of task dependence, temporal dispersion, and perceived time constraint, the greater the fit between the actual task coordination portfolio of a GDT and the optimal task coordination portfolio for that context, the greater the task coordination effectiveness

Previous research has suggested that task coordination effectiveness can lead to better team performance in GDT (e.g., [Hinds and Mortensen 2002; Maznevski and Chudoba 2000]). Team performance may be conceptualized in the form of efficiency and effectiveness [Montoya-Weiss et al. 2011]. Team efficiency refers to the team being able to adhere to its budget and schedule and not expend extra time or resources. While some studies noted that GDTs take longer to complete software development work than collocated teams (e.g., [Herbsleb and Mockus 2003; Sangwan et al. 2006]), others reported that distributed software development does not introduce significant delays compared to same-site development [Nguyen et al. 2008] and in fact dispersion may lead to higher productivity [Ramasubbu et al. 2011]. An explanation for these contradictory findings could be because task coordination effectiveness can mitigate the negative effect of member dispersion on work completion time. Indeed, better task coordination has been associated with project resolution time in GDTs [Cataldo et al. 2006], especially when GDT members are not familiar with each other [Espinosa et al 2007a]. Thus, when task coordination is effective, this implies that members of the GDT are managing their work activities well, with member awareness as required for the task, and avoiding duplicate work. This minimizes extra effort and facilitates the team to keep within their budget and schedule. Hence, *H2: The greater the task coordination effectiveness in a GDT, the greater the team efficiency*

Team effectiveness refers to the achievement of project objectives including the quality of work. Here, too, there have been conflicting findings about the effect of team dispersion on work quality. While some studies suggested that dispersion has a negative effect on the quality of GDTs' work [Espinosa et al. 2007a; Gopal et al. 2011], others found that dispersion has no significant effect on work quality [Cataldo 2010], and may even lead to better work quality as dispersion allows developers to take time to focus on the problems at hand [Colazo and Fang 2010]. Investigating 80 GDTs, Siebdrat et al. [2009] concluded that the overall effect of dispersion is not necessarily detrimental, but rather depends on the team's task-related process, including those that help coordinate work and ensure that each member is contributing fully. Thus, when task coordination is effective, members of a GDT can attain a shared understanding of their work (e.g., project goals, problem definitions, and solution approaches), thereby minimizing confusion and mistakes [Sutanto et al. 2011]. This helps them to deliver high quality outputs and achieve their objectives. Hence,

H3: The greater the task coordination effectiveness in a GDT, the greater the team effectiveness

5. RESEARCH METHODOLOGY

To empirically test the research model, data was collected through a survey of globally dispersed software development teams. In most major software engineering models (e.g., waterfall, agile, and synch-and-stabilize), common phases of software development are requirements analysis, design, coding, systems integration testing, and user acceptance testing [Kogut and Meitu 2000; Zhang et al. 2010]. In order to focus on particular tasks and their coordination rather than an entire project, we chose the *unit of analysis* in our study as the most recently completed software development phase of the team. Below, we first discuss the measurement of the main variables, followed by the control variables, and then move on to describe the survey administration.

5.1 Measurement of Main Variables

The four main variables in the research model (see Figure 2) are the fit between actual and optimal task coordination profiles (FIT), task coordination effectiveness (TCEF), team efficiency (EFFI), and team effectiveness (EFFE). The survey items for all model variables can be found in Table A.II in the Appendix. The other three variables' (TCEF, EFFI, and EFFE) measures are relatively straightforward and hence not elaborated. The most important variable here is FIT, whose measurement is explained below.

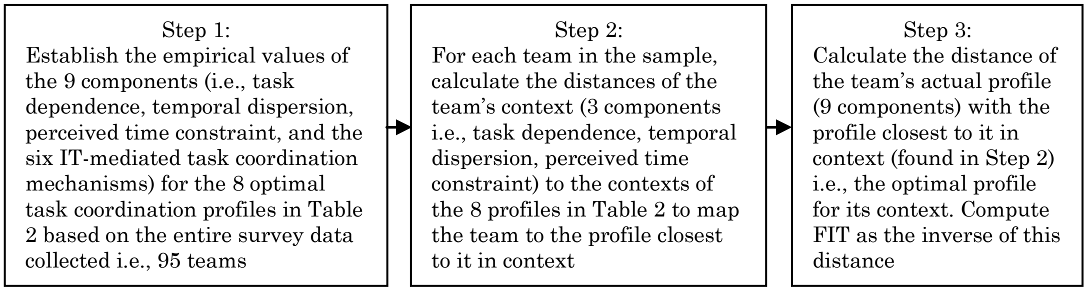

Fig. 3. Three-Step Analysis to Measure Fit between Actual and Optimal Task Coordination Profiles

Fit between actual and optimal task coordination profiles was measured based on the similarity between the *actual* task coordination portfolio used by the GDT and its *optimal* task coordination portfolio given its context (as shown in Table II). The fit value is computed based on a three-step procedure of profile analysis [Van de Ven and Drazin 1985] as summarized in Figure 3 and described in detail below.

In Step 1 we computed empirical values for the 9 components (3 contextual factors + 6 IT-mediated task coordination mechanisms / design factors) for the 8 task coordination profiles shown in Table II based on the survey data collected. This was accomplished using the procedure outlined in Premkumar et al. [2005], as now described for each of the 9 components.

The first contextual factor, *task dependence*, was a single measure derived from responses to four questions (TDEP1-4 in Table A.II), each pertaining to a level of task dependence. Given that the level of task dependence increases from pooled dependence tasks to sequential, reciprocal, and team dependence tasks (in that order), the responses for pooled, sequential, reciprocal, and team dependence task items were weighted by 1, 2, 3, and 4 respectively to compute the aggregate measure of task dependence for each team as per previous research [Doty et al. 1993]. Hierarchical clustering was then applied to determine the number of different clusters for the task dependence variable in our dataset. Next, k-means clustering was used to derive the central value of each task dependence cluster [Kennedy et al. 1998].

The second contextual factor, *temporal dispersion*, was computed from the responses to two questions (MDIS1-2 in Table A.II) using the formula proposed by O'Leary and Cummings [2007], which accounted for time zone differences between team members normalized by team size:

$$TemporalDispersion = \frac{\sum_{i-j}^{k}\left(TimeZones_{i-j} * n_i * n_j\right)}{\left(N^2 - N\right)/2}$$

where $TimeZones_{i-j}$ = number of time zones between sites i and j, k = total number of sites represented in the team, n_i = number of team members in the i^{th} site, n_j = number of team members in the j^{th} site, N = total number of team members across all sites. K-means clustering was then used to obtain the central values of two clusters representing the high and low levels of the temporal dispersion variable.

The third contextual factor, perceived time constraint, was measured using three questions (TCON1-3 in Table A.II). Here, too, k-means clustering was used to obtain the central values of two clusters representing the high and low levels of the perceived time constraint variable.

The remaining 6 components of the profiles were assessed using 6 questions (ATCP1-6 in Table A.II) about the degree of usage for each of the 6 IT-mediated task coordination mechanisms (standards and plans - electronic repository, bi-lateral vertical interactions - asynchronous comm. technology, bi-lateral vertical interactions - synchronous comm. technology, bi-lateral horizontal interactions - asynchronous comm. technology, bi-lateral horizontal interactions - synchronous comm. technology, team meetings - synchronous comm. technology) by each surveyed team for their last completed task/phase. For each of the 6 IT-mediated task coordination mechanisms in Table II, the central values representing the high and low levels of usage were computed using k-means clustering as before. These central values provided assessments for the components of the profiles shown in Table II for subsequent Euclidean distance calculation.

As an illustration, Table III shows the central values for Profiles 4A and 4B computed from our survey data using the above procedure. This first step is performed only once at the start of the analysis to obtain the central values for all 8 profiles in Table II. The next two steps are performed for each GDT to calculate its FIT after the first step is done.

Table III. Empirical Values for Profiles 4A and 4B

	Profile 4A		**Profile 4B**	
Context	**Level**	**Central Value**	**Level**	**Central Value**
Task dependence	Team	8.66	Team	8.66
Temporal dispersion	Not applicable	Not applicable	Low	0.08
Perceived time constraint	Low	2.24	High	4.66
Task Coordination Mechanism	**Level**	**Central Value**	**Level**	**Central Value**
Standards and plans (electronic repository)	High	4.06	High	4.06
Bi-lateral vertical interactions (asynchronous communication technology)	High	3.88	Low	1.43
Bi-lateral vertical interactions (synchronous communication technology)	Low	1.27	High	3.90
Bi-lateral horizontal interactions (asynchronous communication technology)	High	3.73	Low	1.14
Bi-lateral horizontal interactions (synchronous communication technology)	Low	1.21	High	3.72
Team meetings (synchronous communication technology)	High	3.79	High	3.79

In Step 2 we compute the Euclidean distance between the context (3 components i.e., task dependence, temporal dispersion, and perceived time constraint) of the GDT and the contexts of all the 8 profiles (1A – 4B) shown in Table II to identify the optimal profile that is closest (i.e., least distance) to the GDT in terms of context i.e., it should follow the task coordination portfolio of this profile for optimal coordination. The formula is:

$$D_{io}^{c} = \sqrt{\sum_{j=1}^{J}\left(X_{ij}^{c} - X_{oj}^{c}\right)}^{2}$$

where D_{cio} = Euclidean distance between the context of profile i and the context of team o, X_{cij} = empirical value of profile i on contextual factor j, X_{coj} = empirical value of team o on contextual factor j, J = number of contextual factors (which was three in this study).

For example, if a GDT has empirical values of 8.88 for task dependence, 0.10 for temporal dispersion, and 4.00 for perceived time constraint, then the Euclidean distances between the context of this team and those of Profiles 4A and 4B would be 1.77 and 0.69 respectively (computed as follows):

$$D^{c}_{4Ao} = \sqrt{(8.66-8.88)^2 + (2.24-4.00)^2} = 1.77$$

$$D^{c}_{4Bo} = \sqrt{(8.66-8.88)^2 + (0.08-0.1)^2 + (4.66-4.00)^2} = 0.69$$

The results suggest that the context of this team resembles that of Profile 4B more than Profile 4A. If this is the lowest distance among all 8 profiles for this team, then the IT-mediated task coordination portfolio of Profile 4B should be optimal for this team. Thus, the fit value would be computed for this team with respect to Profile 4B in the next step.

In Step 3 we compute the fit value based on the Euclidean distance between the profile of a GDT and its optimal profile (i.e., the profile that is closest to this team in terms of context as per Step 2). Each optimal profile has a specific combination of levels of contextual and design factors (9 components). Thus, the formula to compute the fit value is:

$$Fit = 1/D_{io}$$

$$D_{io} = \sqrt{\sum_{j=1}^{J}\left(X_{ij} - X_{oj}\right)^2}$$

where D_{io} = Euclidean distance between the contextual factors and design factors of optimal profile i and the contextual factors and design factors of team o, X_{ij} = empirical value of optimal profile i on contextual or design factor j, X_{oj} = empirical value of team o on contextual or design factor j, J = the total number of contextual and design factors (which is nine in this study).

Continuing the example from Step 2, we now show how its FIT value is computed based on the above formula. For this step, we also need the values of the 6 design factors i.e., IT-mediated task coordination mechanisms usage, for the team from ATCP1-6 (the values range from 0: not at all to 5: to a large extent). Suppose that the GDT has empirical values of 3.00 for standards and plans (electronic repository), 4.00 for bi-lateral vertical interactions (asynchronous communication technology), 2.00 for bi-lateral vertical interactions (synchronous communication technology), 3.00 for bi-lateral horizontal interactions (asynchronous communication technology), 3.00 for bi-lateral horizontal interactions (synchronous communication technology), and 3.00 for team meetings (synchronous communication technology). The FIT value for this team would be computed (with respect to Profile 4B) as follows:

$$1/\sqrt{(8.66-8.88)^2 + (0.08-0.1)^2 + (4.66-4)^2 + (4.06-3)^2 + (1.43-4)^2 + (3.9-2)^2 + (1.14-3)^2 + (3.72-3)^2 + (3.79-3)^2} = 0.25$$

While step 1 is performed once at the start of the data analysis, steps 2 and 3 are performed for each team in the sample to compute their FIT values.

5.2 Measurement of Control Variables

With research on collocated teams identifying *team size* and *task uncertainty* as variables that might impact the design of their task coordination (e.g., [Faraj and Sproull 2000; Nidumolu 1995]), we include them as controls in our model. As team size increases, teams tend to use standards and plans to a greater extent - so team size may have an impersonalizing effect on the task coordination portfolio [Van de Ven et al. 1976]. This may, in turn, affect the outcomes arising from using the task coordination portfolio.

The salient dimensions of *task uncertainty* are *task novelty* [Adler 1995; Kraut and Streeter 1995], *task analyzability* [Adler 1995; Sabherwal 2003], and *task variability* [Kraut and Streeter 1995; Nidumolu 1995]. *Task novelty* refers to the newness of the task. When developing a new type of software, GDT may not have a clear sense of the deliverables, leading to ambiguous or incomplete understanding about how to build the software. Moreover, teams may sometimes have to deal with the challenges of using new technology to develop the software. These issues may affect the task coordination effectiveness of the team. *Task analyzability* refers to the extent to which there are established approaches for completing the task. When developing software, GDT may rely on emerging software development paradigms that are not well-established in terms of having standard approaches (e.g., a software development life cycle) that can be easily followed. This issue may affect the task coordination effectiveness of the teams. *Task variability* refers to the extent to which the work of the team changed from what was originally planned. When developing software, GDT may be confronted with the challenges of frequently changing requirements. This variable may also affect the task coordination effectiveness of the teams.

Another control in our model was *technology accessibility* i.e., the extent to which a specific technology is actually available for use. Within their operating contexts, GDT tend to use technologies that are readily accessible [Straub and Karahanna 1998]. Consequently, the decisions of software development GDT to use specific technologies for task coordination mechanisms may be influenced by accessibility considerations. The items for the control variables are provided in Table A.II.

5.3 Survey Administration

The survey was administered to the software development GDT in a large MNC in the financial industry. The use of teams from a single organization helps to minimize variations in the organizational context. The software development methodology for all the teams is the waterfall model. There is a clear sign-off and performance assessment after each development phase of the projects of these teams, which facilitates the test of our model.

To alleviate common method bias, both project managers and team members of the software development GDT were surveyed. Project managers responded to questions measuring team efficiency and team effectiveness because they were the ones assessing each project phase and so would be in the best position to answer these questions. Team members responded to questions measuring perceived time constraint, task coordination effectiveness, and task variability because they carried out the specific tasks and so were cognizant about issues arising from time pressure, redundant or duplicate work, and deviation from planned work. The remaining questions (measuring task dependence, temporal dispersion, task novelty, task analyzability, technology accessibility, and the task coordination portfolio) were answered by project managers as well as team members, who were both knowledgeable on these aspects.

The respondents were asked to complete the surveys based on the most recently completed phase of their software project (i.e., the unit of analysis is the recently completed phase). Of the 200 targeted teams, 112 teams responded, yielding a response rate of 56%. After removing 17 responses with incomplete data, the responses from 95 teams could be used for our analysis. The demographic statistics of the 95 teams in our sample are shown in Table A.III in the Appendix.

6. DATA ANALYSIS

The survey data was first analyzed for reliability and validity. Table A.IV in the Appendix shows adequate reliability and validity for all multi-item constructs i.e., excludes task dependence, temporal dispersion, the 6 IT-mediated task coordination mechanisms, and team size. The Cronbach's alpha for each construct was above 0.7, indicating that all of them had adequate reliability [Nunnally 1978]. The validity of the questions was assessed using factor analysis. Table A.IV shows that all questions measuring a variable loaded highly onto the corresponding factor with eigenvalue exceeding 1. The eight factors corresponded to the eight variables involved in the factor analysis. There was little cross-loading of items onto other factors i.e., well below 0.5. Thus, all questions were deemed to have adequate validity [Hair et al. 2009].

For questions that were answered by both project managers and team members, the agreement between the answers from them were determined using the method proposed in James et al. [1984]. Results showed that the within-group inter-respondent agreement between project managers and team members exceeded the satisfactory threshold of 0.7 for all variables (the average inter-respondent agreements for task dependence, temporal dispersion, task coordination portfolio, task novelty, task analyzability, and technology accessibility were 0.91, 1.00, 0.93, 0.95, 0.94, and 0.96 respectively). With satisfactory inter-respondent agreement for all variables, the answers from project managers and team members could be aggregated by taking their arithmetic mean.

To conduct profile analysis, the three-step procedure described in the previous section and shown in Figure 3 was used. First, the empirical values for the components of the 8 profiles shown in Table II were established using the survey data collected. The application of hierarchical clustering to the data for task dependence yielded three clusters. An examination of qualitative descriptions provided by the respondents revealed that none of the teams surveyed had pooled dependence tasks. Hence, the three task clusters corresponded to sequential, reciprocal, and team dependence tasks. For all the other factors (contextual and design) in Table II, the data was separated into two clusters (low and high). The central values for all clusters pertaining to the 3 contextual and 6 design factors were then computed (see Table IV). These central values provided operational definitions for the profiles shown in Table II.

Table IV. Central Values of Clusters

Variable	**Central Value**		
	Sequential	**Reciprocal**	**Team**
Task dependence	3.05	6.65	8.66
	Low	High	
Temporal dispersion	0.08	0.54	
Perceived time constraint	2.24	4.66	

Standards and plans (electronic repository)	2.91	4.06
Bi-lateral vertical interactions (asynchronous communication technology)	1.43	3.88
Bi-lateral vertical interactions (synchronous communication technology)	1.27	3.90
Bi-lateral horizontal interactions (asynchronous communication technology)	1.14	3.73
Bi-lateral horizontal interactions (synchronous communication technology)	1.21	3.72
Team meetings (synchronous communication technology)	0.55	3.79

Second, the Euclidean distance between the context (i.e., task dependence, temporal dispersion, and perceived time constraint) of each team and the context of each of the 8 profiles shown in Table II was computed. For each team, the optimal profile was identified as the one out of the 8 that yielded the minimum contextual distance. Third, the FIT value which measured the inverse of the distance between the actual profile of each team and the optimal profile for that team was computed.

The descriptive statistics and correlations for all variables are presented in Tables A.V and A.VI in the Appendix. The hypotheses test results are shown in Table V. The coefficients displayed in Table V are standardized to account for differences in scales of the variables. The fit between actual and optimal task coordination portfolio was positively related to task coordination effectiveness ($p < 0.05$). Thus, H1 was supported. Task coordination effectiveness was positively related to task efficiency ($p < 0.01$) and task effectiveness ($p < 0.01$). Thus, H2 and H3 were supported. Among the control variables, task novelty was negatively related to task coordination effectiveness ($p < 0.01$) and technology accessibility was positively related to team efficiency ($p < 0.05$) and effectiveness ($p < 0.01$).

Table V. Results of Hypotheses Tests

Dependent variables	**TCEF**	**EFFI**		**EFFE**	
	$R^2 = 0.13$	$R^2 = 0.12$	$R^2 = 0.44$	$R^2 = 0.16$	$R^2 = 0.36$
Independent variable					
FIT	0.19*	0.27**	0.15	0.22*	0.13
Mediating variable					
TCEF	-	-	0.61***	-	0.47***
Control variables					
SIZE	0.01	-0.09	-0.10	-0.07	-0.07
TNOV	-0.32**	-0.09	0.10	-0.13	0.02
TANA	-0.14	-0.03	0.06	0.01	0.07
TVAR	-0.03	0.11	0.12	0.07	0.09
TACC	-0.06	0.13	0.16*	0.29**	0.31***

***: $\rho < 0.001$, **: $\rho < 0.01$, *: $\rho < 0.05$

To empirically explore if the theoretically proposed optimal portfolios in our study are indeed optimal, we compared the means of task coordination effectiveness of the top 10% (i.e., 9) teams that had the least distant profiles and bottom 10% (i.e., 9) teams that had the most distant profiles from their optimal profile among the surveyed teams. The results showed a significant difference in the task coordination effectiveness of these two groups (mean diff.: 1.22, p: 0.03). This adds to the credibility of our theorization and findings.

7. DISCUSSION AND IMPLICATIONS

As shown above, the survey results empirically validate our proposed optimal IT-mediated task coordination portfolios for GDT. As hypothesized, the fit between actual and optimal portfolios was positively related to task coordination effectiveness, which in turn increased task efficiency and effectiveness. Thus, the study satisfactorily addresses both research questions that were posed.

Specifically, our study shows that for teams with sequential dependence tasks and low perceived time constraint, standards and plans that are stored in electronic repository and bilateral vertical interactions between the project manager and team members through asynchronous communication technology will be appropriate and result in better task coordination effectiveness, task efficiency, and task effectiveness. The bilateral vertical interactions should be supported by synchronous communication technology if the team has high perceived time constraint.

Our study also indicates that if the team faces a reciprocal dependence task under low perceived time constraint, then in addition to standards, plans, and asynchronous bilateral vertical interactions, bilateral horizontal interactions among pairs of members through asynchronous communication technology is appropriate for effective task coordination, and efficient and effective task outcomes. The bilateral vertical and horizontal interactions should be supported by synchronous communication technology if the team has low temporal dispersion and high perceived time constraint. There is no ideal portfolio when a team with reciprocal dependence task has high temporal dispersion and high perceived time constraint.

Finally, our findings show that for a team with team dependence task and low perceived time constraint, standards and plans that are stored in electronic repository, asynchronous bilateral vertical and horizontal interactions, and synchronous team meetings, are appropriate for better task coordination effectiveness, task efficiency, and task effectiveness. The bilateral vertical and horizontal interactions should be supported by synchronous communication technology if the team has low temporal dispersion and high perceived time constraint. Here, too, there is no ideal portfolio when the team with team dependence task has high temporal dispersion and high perceived time constraint.

7.1 Limitations and Future Work

These results, however, should be interpreted in light of the limitations of the study. First, the software development GDTs surveyed were from the financial industry. Such teams tend to be used in the financial industry to develop mission critical software within tight time constraints [Hollingshead and Contractor 2002; Koch 2004]. Further, because of the significant amount of regulation, the financial industry continues to use the waterfall method and is hesitant to use newer software development methodologies. Hence, care should be exercised when attempting to apply the results of this study to teams working with different methods and in other industries.

Second, we checked and found a significantly high correlation between spatial and temporal dispersions of the surveyed teams (0.830), which mean that most of the teams either were highly temporally and spatially dispersed or had relatively small temporal and spatial dispersions [O'Leary and Cummings 2007]. Although previous research found that the magnitude of spatial dispersion has negligible effect on coordination process and team performance [Espinosa et al. 2012], there could be situations where there is low correlation between spatial and temporal dispersions where it could be worthwhile to examine spatial dispersion as a contextual factor in the portfolio.

Third, the method used to operationalize fit gave equal weight to the contextual factors (i.e., task dependence, temporal dispersion, and perceived time constraint) since we have no theoretical justification to weight them differently. However, this assumption may not always be satisfied. For example, when teams are working under tight time constraints that are critical to mission success, perceived time constraint may need to be given more weight in the computation of fit than the other contextual factors. The determination of appropriate weights to be assigned to various contextual factors could be a valuable topic for further research.

Fourth, we used broad categorizations of IT i.e., repositories and asynchronous vs. synchronous communication technologies, in our study to keep our theory of IT-mediated task coordination generic. However, the practical implications could be enhanced if more specific IT tools are examined for different task coordination mechanisms. This may also be valuable as different instantiations of an IT category could have differential impacts on the team interaction processes and outcomes [Malhotra and Majchrzak 2012]. Hence, this could be a useful topic for future research.

Finally, the dataset for the model test was obtained by surveying project managers and team members. While the availability of multiple perspectives contributed to triangulation of evidence, it would be useful to collect objective data about the GDT. For example, objective measures of team performance (including efficiency and effectiveness) may be utilized in future. Finally, another avenue for research is examining the implications of over-fit (i.e., use of IT-mediated task coordination portfolio that has higher information processing capability than needed) versus under-fit in task coordination for GDT. In spite of its limitations, the results reported in this study have important implications for theory and practice.

7.2 Implications for Theory

There are three main contributions of this study. First, adopting structural contingency theory, this study adds to the existing body of knowledge about GDT task coordination. Past research involving collocated teams (e.g., [Andres and Zmud 2002]) has suggested that different levels of task dependence (determining information processing needs) should be handled by appropriate task coordination mechanisms (determining information processing capabilities) for coordination success. This study proposes that additional contextual factors of temporal dispersion and perceived time constraint in GDT can alter the fit between information processing needs and information processing capability. While information processing needs are driven by task dependence, these needs may be amplified when there is increased temporal dispersion or severe time constraints. Although information processing capability is provided by the task coordination mechanisms, the capabilities may be reduced when there is increased temporal dispersion or tight time constraints. Taking these contextual factors into account, this study proposes a set of eight profiles that show which IT-mediated task coordination portfolio may work best under what team circumstances.

Second, this study adds to the extant body of literature on media choice. Prior research has suggested that the capabilities and appropriateness of use of a communication medium are perceived differently under different circumstances [Watson-Manheim and Belanger 2007]. Since organizational members are often provided with a wide array of communication media, researchers have investigated how the pattern of use of multiple media develops; which has been referred to as communication media repertoire [Watson-Manheim and Belanger 2007] or communication portfolio [Lee et al. 2007]. Watson- Manheim and Belanger [2007] differentiate between the influence of institutional factors (such as the physical structure of the workplace) and situational factors (such as task characteristics and urgency) in the development of a communication media repertoire, whereas Lee et al. [2007] proposed that perceived communication risk influences the resultant communication portfolio. Further, Watson- Manheim and Belanger [2007] noted that their findings applied to organizations where employees could easily engage in face-to-face communication and remarked that the development of communication media repertoire in GDT could differ, while Lee et al. [2007] called for more research on the action component of the communication process. This study contributes to the understanding of the action component of the communication process in GDT by proposing appropriate IT-mediated task coordination portfolios for GDTs by considering their situational factors (task dependence, temporal dispersion, and perceived time constraint) to effectively deliver task coordination messages, which in turn prevent unintended duplicate and redundant work.

Third, besides proposing the design of IT-mediated task coordination portfolios and conceptually fitting the portfolios to GDT context, this study offers a comprehensive way of viewing and analyzing the notion of fit. The study adopted the systems approach of fit applied to a survey of 95 software development GDT. The systems approach involves profile matching where each profile has a specific combination of contextual factors (in our case, task dependence, temporal dispersion, and perceived time constraint) and design factors (in our case, IT-mediated task coordination portfolio). The systems approach of fit allows researchers to specify optimal profiles and to demonstrate that adherence to such profiles would have positive implications for performance [Venkatraman 1989]. Methodologically, the profile analysis employed in this study has rarely been used in IS research. Given the increasing use of GDT for software development [Kiely et al. 2010; Smite et al. 2008] and the challenges involved, our study can add significantly to the literature.

7.3 Implications for Practice

The results of this study offer useful suggestions for practice. Specifically, GDT can design or compare their task coordination portfolio with that of the optimal profile that corresponds to their context in terms of task dependence, temporal dispersion, and perceived time constraint. If their actual task coordination portfolio does not resemble the proposed optimal portfolio, they can redesign their task coordination mechanisms in the direction of the optimal portfolio i.e., the recommended set of IT-mediated mechanisms. This should help them to attain higher task coordination effectiveness and, through this, better team efficiency and effectiveness.

GDT may not often be able to change their context, with the exception of cases where it may be possible to reorganize their work or change the member dispersion. Hence, these teams should adjust their task coordination portfolio to suit their context. However, Table II reveals that there are two contexts for which no optimal task coordination portfolio exists i.e., teams working on reciprocal or team dependence tasks under the conditions of high temporal dispersion and high perceived time constraint. This is because such teams are required to use synchronous communication technology to complete their tasks but their context constrains the use of such technology. Such scenarios have been examined in a few studies. For example, Davidson and Tay [2003] studied an IT-support GDT which worked mainly on reciprocal dependence tasks, under conditions of high temporal dispersion and time constraints. Due to their limited working time overlap, the members could not rely on synchronous communication technology. Thus, they mainly used asynchronous communication technology (i.e., electronic mail) for task coordination. However, when time pressure made it crucial for them to rapidly exchange information, they would send duplicate emails and occasionally follow up with telephone calls. Consequently, team members were inundated with emails and telephone messages that hampered their work. In summary, if such contexts are unavoidable, GDT may have to be prepared to use a sub-optimal task coordination portfolio, thereby compromising task coordination effectiveness and performance.

Moreover, although we did not find a significant relationship between the software development phase and GDT context, we observed that none of the surveyed GDT had sequential dependence in their requirement analysis phase. Other patterns were also seen in our sample i.e., many of the GDTs had low temporal dispersion, high perceived time constraint, and either a reciprocal or team dependence task. These observations may inform organizations that are considering globally distributed software development of the commonly adopted structures of such teams.

8. CONCLUSION

GDT have become a widely prevalent organizational structure for software development as well as various other organizational tasks. Although GDT can offer several benefits to organizations, they are typically plagued by task coordination problems across their dispersed members. While various task coordination mechanisms have been proposed for such teams, there is a lack of systematic examination of the appropriate coordination mechanisms for different teams based on the nature of their task and the context that they operate under. This study addresses this gap by deriving optimal IT-mediated task coordination portfolios for the various combinations of contextual factors (task dependence, temporal dispersion, and perceived time constraints) that these teams operate under based on structural contingency theory. Specifically, eight profiles are developed and tested that serve as a foundation for building a theory about task coordination in GDT. Such theory can guide practice and enhance the performance of GDT across different contexts. In this manner, this study makes a contribution to both theory and practice. Future work can re-examine the task coordination portfolios as new task coordination mechanisms or new technology that enables these mechanisms become available.

APPENDIX A

Table A.I. Summary and Comparison of This Study with Previous GDT Task Coordination Studies

Focus	Sample Studies	Research Methodology	Main Findings
Explicit mechanisms for coordinating GDT	Cummings and Kiesler [2003], Hinds and McGrath [2006]	*Survey* or *Experiment* (collocated teams versus GDT) Used *dichotomous measure*: 0 if all team members were at the same location and 1 otherwise	GDT periodically need to schedule face-to-face meetings Having relatively more cross-site communication is associated with more coordination problems
	Massey et al. [2003], Montoya-Weiss et al. [2001]	*Experiment* (students teams whose members were spread across two countries)	Scheduling and synchronization leads to higher performance
	Cummings et al. [2009]	*Survey* (team members) Used *dichotomous measure* for spatial dispersion: 0 if all team members were at the same location and 1 otherwise Used *dichotomous measure* for temporal dispersion: 1 if all team members had no overlapping work hour and 0 otherwise	Greater use of synchronous web conferencing and asynchronous e-mail reduce coordination delay for pairs of team members with overlapping work hours (compared with pairs of team members with no overlapping work hours)
	Sutanto et al. [2011]	*Case study* (13 tasks of 3 student GDT; in 2 teams, the members had 1 hour common time frame; in 1 team, the members had 7 hours common time frame)	For pooled and sequential dependence tasks, vertical coordination was useful in addition to standards and plans For reciprocal dependence tasks, the teams needed standards, plans, vertical and horizontal coordination Team dependence tasks required team meeting besides standards, plans, vertical and horizontal coordination. When members had a limited common time frame, structured team meeting was needed.
Explicit mechanisms for coordinating geographically dispersed software development teams	Herbsleb and Grinter [1999], Kiely et al. [2010], Prikladnicki et al. [2004], Sharma and Krishna [2003]	*Interview* (project managers and team members)	Software design, integration plans, and routines are not enough. Developers also heavily rely on informal, ad-hoc communication as a means of coordination Standardization is adopted when the distributed teams are not using the same software development process Coding is the only task that does not exhibit intense discussion. Requirements and design plans, stored in shared repository, coordinate the coding task.
	Cataldo et al. [2007]	*Interview* (core team members), *Archival data*	Lateral communication could be beneficial even in cases where low levels of interdependence existed between remote teams.
	Faraj and Sproull [2000]	*Survey* (stakeholders and team members)	Expertise coordination (compared with administrative coordination) has a strong relationship with team performance
	Espinosa et al. [2012]	*Survey* (project managers, team members, and other stakeholders) Used *continuous measure* for spatial dispersion: for each pair in the team, using a 7-pt scale (1: same room, 2: same hallway, 3: same floor, 4: same building, 5: different building, 6: different city, 7: different country) and then averaged for each team Used *count measures* for temporal dispersion: number of time zones represented in each team and the maximum time zone spanned by each team	Task organization is more effective than communication tools in reducing coordination problems. When coordination is taken care of with effective task organization, the negative effects of time zone span on team performance can be mitigated to some extent
Implicit mechanisms for	Hinds and McGrath [2006]	*Survey* (collocated teams versus GDT) Used *dichotomous measure*: 0 if all	There is no evidence that cross-site social ties or dense social ties facilitate better coordination in distributed teams

coordinating GDT		team members were at the same location and 1 otherwise	
	Maynard et al. [2012]	<u>Survey</u> (external managers and team members) Used *continuous measure*: team virtuality is measured by the % of time that they interacted through non-face-to-face methods	Transactive memory system is positively related to team effectiveness
	Kanawattanachai and Yoo [2007]	<u>*Experiment*</u> (student teams in one country performing a web-based business simulation game)	Although taking a relatively long time to develop, transactive memory system is essential to performing tasks effectively
Implicit mechanisms for coordinating geographically dispersed software development teams	Espinosa et al. [2002, 2007a, 2007b]	<u>*Interview*</u>, <u>*Survey*</u>, <u>*Archival data*</u> (collocated teams versus geographically dispersed teams) Used *dichotomous measure*: 0 if all team members were at the same location and 1 otherwise	The effect of work familiarity is stronger for geographically distributed teams than for collocated teams Shared team knowledge and presence awareness is more important for geographically distributed teams than for collocated members The effects of task and team familiarity are more substitutive than complementary
Fitting explicit task coordination mechanisms to key GDT contingencies (task dependence, temporal dispersion, and perceived time constraint)	This Study	<u>*Survey*</u> (project managers and team members) Used *continuous measure* of temporal dispersion based on O'Leary and Cummings [59], which accounted for time zone differences between team members normalized by team size Empirically test the proposed fit in the context of software development through profile analysis approach	The less deviated the teams' profile are from their optimal task coordination profiles, the more effective their task coordination will be

Table A.II. Survey Items

Survey Items	**Sources**
IT-Mediated Task Coordination Portfolio To what extent did the team achieve task coordination in the most recently completed phase of the software project using the following mechanism - scale of 0 (not at all) to 5 (to a great extent)?	
ATCP1: Pre-determined standards and plans stored in electronic repository	Developed using materials from Van de Ven et al. [1976]
ATCP2: Interactions with project manager using asynchronous communication technology	
ATCP3: Interactions with project manager using synchronous communication technology	
ATCP4: Interactions with other team members using asynchronous communication technology	
ATCP5: Interactions with other team members using synchronous communication technology	
ATCP6: Team meetings using synchronous communication technology	
Task Dependence To what extent were the following types of tasks present in the most recently completed phase of the software project - scale of 0 (not at all) to 5 (to a great extent)?	
TDEP1 (weight = 1): Tasks where team members could work independently	Developed using materials from [Campion et al. 1993; Mohr 1971; Van de Ven et al. 1976]
TDEP2 (weight = 2): Tasks where team members had to work by passing from one to the next	
TDEP3 (weight = 3): Tasks where team members had to work by passing back and forth	
TDEP4 (weight = 4): Tasks where team members had to work together concurrently	
Temporal Dispersion (computed based on the responses to the questions asked using the formula in O'Leary and Cummings [2007]) With respect to the most recently completed phase of the software project:	
MDIS1: How many members were working on the team?	Developed using

MDIS2: What was the location of each member of the team?	materials from O'Leary and Cummings [2007]
Perceived Time Constraint With respect to the most recently completed phase of the software project - scale of 1 (very strongly disagree) to 7 (very strongly agree):	
TCON1: The time available to complete the tasks was insufficient	Developed using materials from Kraut and Streeter [1995]
TCON2: The team had too much work to do in too little time	
TCON3: The team did not have enough time to complete the tasks	
Task Coordination Effectiveness With respect to the most recently completed phase of the software project - scale of 1 (very strongly disagree) to 7 (very strongly agree):	
TCEF1: There was no duplicate work in the team	Developed using materials from Haywood [1998]; Hoegl et al. [2004]; Kraut and Streeter [1995]
TCEF2: No two team members did the same piece of work unnecessarily	
TCEF3: There was no redundant work in the team	
TCEF4: We knew what others in the team were supposed to do	
TCEF5: We knew what others in the team were working on	
TCEF6: We knew the roles and responsibilities of others in the team	
Team Efficiency With respect to the most recently completed phase of the software project, how satisfied were you with the following - scale of 1 (extremely dissatisfied) to 7 (extremely satisfied)?	
EFFI1: The efficiency of the team operations	Developed using materials from Henderson and Lee [1992]
EFFI2: The ability of the team to adhere to schedule	
EFFI3: The ability of the team to adhere to budget	
Team Effectiveness With respect to the most recently completed phase of the software project, how satisfied were you with the following - scale of 1 (extremely dissatisfied) to 7 (extremely satisfied)?	
EFFE1: The quality of work the team produces	Developed using materials from Henderson and Lee [1992]
EFFE2: The quality of deliverables by the team	
EFFE3: The ability of the team to meet the goals	
Task Novelty With respect to the most recently completed phase of the software project - scale of 1 (very strongly disagree) to 7 (very strongly agree):	
TNOV1: The technology used was new to the team	Developed using materials from Adler [1995]; Nidumolu [1995]
TNOV2: Team members had never used a similar technology before	
TNOV3: The application developed was new to the team	
TNOV4: Team members had never developed a similar application before	
Task Analyzability With respect to the most recently completed phase of the software project, to what extent was there already - scale of 0 (not at all) to 5 (to a great extent):	
TANA1: A clearly known way to do the work	Developed using materials from Adler [1995]; Nidumolu [1995]
TANA2: A clearly defined body of knowledge that could guide the work	
TANA3: An understandable sequence of steps that could be followed	
TANA4: An established set of practices to do the work	
Task Variability	

With respect to the most recently completed phase of the software project - scale of 1 (very strongly disagree) to 7 (very strongly agree):	
TVAR1: The actual work fluctuated from what was planned	Developed using materials from Adler [1995]; Nidumolu [1995]
TVAR2: The actual work turned out different compared to what was planned	
TVAR3: The actual work varied from what was planned	
Technology Accessibility With respect to the most recently completed phase of the software project - scale of 1 (very strongly disagree) to 7 (very strongly agree):	
TACC1: The technology used for task coordination was very reliable	Developed using materials from Carlson and Davis [1998]; Goodhue and Thompson [1995]
TACC2: The technology used for task coordination was up and available all the time	
TACC3: The technology used for task coordination had high access speed	

Table A.III. Demographic Statistics of the Sample Teams

Teams' Characteristics		**N (Total = 95 teams)**
Previously Completed Phase	Requirement Analysis	14 (14.74%)
	Design	6 (6.32%)
	Coding	18 (18.95%)
	System Integration Testing	19 (20%)
	User Acceptance Testing	38 (40%)
Team Size	<= 5	39 (41.05%)
	6 – 10	30 (31.58%)
	11 – 15	12 (12.63%)
	16 – 20	2 (2.11%)
	> 20	12 (12.63%)
Time Zone Difference	0 – 2 hours	27 (28.42%)
	>2 – 4 hours	45 (47.37%)
	>4 – 6 hours	1 (1.05%)
	>6 – 8 hours	13 (13.68%)
	>8 – 10 hours	0 (0%)
	>10 – 12 hours	9 (9.47%)

Team Locations#	within South East Asia	12 (12.63%)
	within South Asia	2 (2.11%)
	South East Asia and South Asia	21 (22.11%)
	South East Asia and Greater China	10 (10.53%)
	South East Asia and Europe	13 (13.68%)
	South East Asia and North America	2 (2.11%)
	South Asia and Greater China	6 (6.32%)
	South Asia and North America	3 (3.16%)
	South Asia and Middle East	2 (2.11%)
	South Asia and Africa	2 (2.11%)
	South East Asia, South Asia, and Greater China	13 (13.68%)
	South East Asia, South Asia, and Middle East	2 (2.11%)
	South East Asia, South Asia, and Africa	1 (1.05%)
	South East Asia, Europe, and North America	3 (3.16%)
	South Asia, Middle East, and Africa	1 (1.05%)
	South East Asia, South Asia, Greater China, Middle East	1 (1.05%)
	South East Asia, Greater China, Europe, North America	1 (1.05%)

#: SE Asia: Singapore, Indonesia, Malaysia, Thailand, Philippines; South Asia: India, Pakistan; Greater China: China, Hong Kong, Taiwan; Middle East: UAE; Africa: South Africa, Uganda, Kenya; Europe: United Kingdom; North America: New York

Table A.IV. Reliability and Validity Assessment

Construct	Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Perceived Time Constraint	TCON1	0.00	0.01	-0.12	0.89	0.00	0.09	0.00	-0.21
	TCON2	-0.08	-0.08	-0.12	0.93	0.06	0.12	-0.03	-0.05
	TCON3	-0.03	-0.05	-0.11	0.93	-0.09	0.13	-0.03	-0.02
Task Coordination Effectiveness	TCEF1	0.89	0.04	0.06	-0.13	-0.09	0.11	0.06	0.00
	TCEF2	0.86	0.06	0.14	-0.04	-0.12	-0.13	-0.03	0.06
	TCEF3	0.81	-0.01	0.18	-0.03	-0.15	-0.08	0.08	0.00
	TCEF4	0.84	-0.08	0.20	0.04	-0.06	-0.01	-0.12	0.35
	TCEF5	0.84	-0.13	0.13	0.00	-0.03	-0.08	-0.10	0.34
	TCEF6	0.83	-0.10	0.20	0.05	-0.11	-0.01	-0.10	0.35
Team Efficiency	EFFI1	0.41	0.01	0.30	-0.19	-0.04	0.09	0.06	0.70
	EFFI2	0.33	-0.06	0.33	-0.21	-0.01	0.17	0.12	0.74
	EFFI3	0.47	0.07	0.20	-0.10	-0.02	0.02	0.06	0.73
Team Effectiveness	EFFE1	0.28	0.05	0.90	-0.13	-0.06	0.00	0.15	0.14
	EFFE2	0.29	0.04	0.89	-0.14	-0.02	0.05	0.16	0.21
	EFFE3	0.27	0.06	0.83	-0.17	-0.07	0.04	0.17	0.26
Task Novelty	TNOV1	-0.23	-0.07	-0.15	0.05	0.80	0.18	-0.11	0.15
	TNOV2	-0.24	-0.05	-0.08	0.07	0.80	0.16	-0.21	0.20
	TNOV3	-0.01	-0.30	0.00	-0.14	0.76	0.10	-0.05	-0.24
	TNOV4	-0.06	-0.36	0.08	-0.04	0.77	0.06	0.02	-0.23
Task Analyzability	TANA1	-0.01	0.88	-0.02	0.01	-0.11	-0.06	0.00	-0.10
	TANA2	0.00	0.87	-0.06	-0.10	-0.22	-0.02	0.06	-0.09
	TANA3	-0.02	0.91	0.07	-0.09	-0.14	-0.10	0.11	0.08
	TANA4	-0.08	0.80	0.15	0.03	-0.09	-0.13	0.08	0.11
Task Variability	TVAR1	-0.06	-0.07	0.04	0.07	0.20	0.88	-0.01	0.12
	TVAR2	-0.06	-0.12	0.02	0.15	0.14	0.91	-0.02	0.04

	TVAR3	-0.01	-0.11	0.01	0.12	0.06	0.90	-0.17	0.00
Technology Accessibility	TACC1	-0.10	0.04	0.15	-0.02	-0.07	-0.18	0.84	0.00
	TACC2	0.00	0.10	0.18	-0.01	-0.08	0.07	0.91	0.08
	TACC3	0.01	0.09	0.04	-0.04	-0.11	-0.08	0.93	0.04
Eigenvalue		7.90	4.89	3.09	2.70	2.31	1.40	1.17	1.10
Variance explained %		27.25	16.85	10.65	9.29	7.98	4.81	4.02	3.80
Cumulative var. %		27.25	44.10	54.75	64.04	72.02	76.83	80.85	84.65
Cronbach's alpha		0.95	0.91	0.96	0.94	0.85	0.92	0.90	0.92
ICC (single measures)		0.73	0.72	0.90	0.81	0.70	0.77	0.75	0.79
ICC (average measures)		0.94	0.91	0.96	0.93	0.80	0.91	0.90	0.92

Table A.V. Descriptive Statistics of Model Variables

Variable	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**	**Skewness**
Fit between actual and optimal task coordination profiles	0.15	0.33	0.22	0.04	0.62
Team size (with log transformation)	0.30	2.26	0.87	0.34	1.18
Task novelty	1.00	6.38	3.13	1.35	0.57
Task analyzability	1.13	5.00	3.59	0.63	-1.36
Task variability	1.00	7.00	3.67	1.49	-0.01
Technology accessibility	3.00	7.00	5.65	0.75	-0.92
Task coordination effectiveness	1.00	7.00	5.16	1.32	-1.43
Team efficiency	2.00	7.00	5.65	1.01	-1.55
Team effectiveness	2.67	7.00	5.84	0.96	-0.94

Table A.VI. Correlation Matrix for Model Variables

Variable	**FIT**	**SIZE**	**TNOV**	**TANA**	**TVAR**	**TACC**	**TCEF**	**EFFI**	**EFFE**
Fit between actual and optimal task coordination profiles (FIT)	1.00								
Team size (SIZE)	0.00	1.00							
Task novelty (TNOV)	0.01	0.23*	1.00						
Task analyzability (TANA)	0.14	0.05	-0.41**	1.00					
Task variability (TVAR)	0.12	0.05	0.31**	-0.22*	1.00				
Technology accessibility (TACC)	-0.06	-0.04	-0.22**	0.17*	-0.15	1.00			
Task coordination effectiveness (TCEF)	0.17*	-0.07	-0.27***	-0.04	-0.08	-0.02	1.00		
Efficiency (EFFI)	0.27***	-0.12	-0.10	0.02	0.09	0.12	0.60***	1.00	
Effectiveness (EFFE)	0.21*	-0.11	-0.19*	0.10	0.01	0.29***	0.48***	0.59***	1.00

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