# SYSTEMS DEVELOPMENT RISK FACTORS: THE ROLE OF EMPOWERING LEADERSHIP IN LOWERING DEVELOPERS' STRESS

## Abstract

The success of information systems development (ISD) projects depends on the developers who deliver them. However, developers face many challenges in bringing an ISD project to successful completion. These projects are often large, highly complex, with volatile targets, creating a stressful environment for developers. Although prior literature has considered how technical ISD risk factors, such as project size, complexity and target volatility, impact team- and project-level outcomes, their impact on developers has received limited attention. This gap in the literature is problematic for two reasons: (1) the interplay between individuals and project characteristics are unaccounted for, resulting in an incomplete picture of ISD; and (2) individual-level stress has been shown to reduce team performance. In this research, we examine the role of empowering leadership in reducing developer stress in ISD. We develop a multilevel model of the influence of empowering leadership on the relationship between technical ISD risk factors and developers' role perceptions and explore the consequences for developers' stress. The model was tested in a field study of 350 developers in 73 ISD teams from a large U.S.-based firm. Results showed that empowering leadership ameliorated the negative effects of project size and target volatility on role ambiguity, as well as the negative effects of project size, complexity, and target volatility on role conflict and stress. We also found that empowering leadership reduced role ambiguity, role conflict, and stress directly, and that role ambiguity and role conflict increased stress. Project size, complexity, and target volatility were found to increase empowering leadership behaviors. We conclude that empowering leadership can be an effective means of helping developers cope with technical ISD risk factors and discuss the implications of our findings for research and practice.

*Keywords:* information systems development, project management, empowering leadership, technical risk factors, stress

## 1. Introduction

In 2013, nearly 40% of the $3.7 trillion in global spending on information technology (IT) was spent on information systems development (ISD) and services (van der Meulen and Rivera 2013), underscoring the importance that organizations place on ISD. The success of ISD projects is tightly linked to developers, who are primarily responsible for producing the necessary system components (e.g., constructing software code, designing databases, creating a digital architecture). It is, therefore, of great concern that developers face many challenges to success, including the need to cope with large projects that are highly complex and volatile (Wallace et al. 2004). The challenges are manifested in increasing levels of stress among developers (Brandel 2011), which interferes with the self-regulation of emotions and cognitions (Hancock and Szalma 2008), and negatively affects an individual's performance. This raises a critical question that remains unanswered, namely: how do the effects of technical ISD risk factors manifest themselves in terms of developer stress?

A series of studies on the effects of stress on software quality has found that developer stress is both common and extremely problematic (Brandel 2011, CIO Magazine 2012, Glass 1997, Zhang and Pham 2000). Further, developers' stress can affect team performance due to the reciprocal, interdependent nature of ISD work (Pee et al. 2010). Research shows that 37% of the technical errors made during the development process can be directly attributed to developer stress

(Furuyama et al. 1994, Furuyama et al. 1997). More broadly, Furuyama et al. (1994) indicate that 71% of development errors can be traced to stress-inducing project conditions. Recent reports show that roughly 50% of IS workers report their work to be stressful (Computerworld 2011). Although practitioners and researchers have recognized the impact of developer stress on project outcomes, there is a gap in our understanding of the drivers of stress among developers and methods for mitigating their impact, limiting our ability to address the challenges of developers' stress.

One of the most influential theories informing research on workplace stress is the job demand-control model (JDCM) (Karasek 1979, Van der Doef and Maes 1999). The JDCM focuses on two dimensions of the work environment that drive stress: *job demands*, which refer to workload, and *job control,*[1] which refers to a person's ability to direct or manage their work activities (Karasek 1979, Van der Doef and Maes 1999). Those with high job demands and low control, experience the most stress because their work is more challenging and they have limited authority to determine how to manage the execution of that work. In contrast, those with low demands and high control generally experience the least stress because their work is less challenging and they have the authority they need to manage their work. In the ISD team context, job demands (i.e., workload) are largely dictated by ISD project characteristics. Among the various ISD project characteristics, ISD risks are particularly salient in increasing project-related demands because they can increase the level of workload for developers or make development work more effortful. Wallace et al. (2004) identified social risk, technical risk, and project management risk as major risk categories. They found that social risk (i.e., user risk and organizational environment risk) did not have a significant effect on project management risk that encompasses risk associated with the team's ability to accomplish its work. In contrast, technical risk was found to have a significant direct influence on such risk. Similarly, Gemino et al. (2008) found that teams' ability to accomplish their work was most negatively impacted by a technical ISD risk factor—volatility arising from project size and complexity. This is not to suggest that social risk is unimportant. In fact, research suggests that social risk can derail ISD projects through such factors as conflicting political interests (Ewusi-Mensah and Przasnyski 1991, Jones 1994). Rather, prior work suggests that, in terms of direct proximal influences on ISD teams' ability to execute their work, technical ISD risk factors appear to play a more prominent role

[1] The concept of control from the JDCM literature is distinguished here from the concept of control from control theory. The concept of control from the control theory literature refers to a set of mechanisms designed to motivate individuals toward a desired objective (Kirsch 1996).

(Wallace et al. 2004). Further, project leaders are in a stronger position to enable their ISD project teams to manage the effects of technical ISD risk factors. Hence, we focus on technical ISD risk factors because they are tied to the artifact under construction and thus represent a proximal determinant of job demands.

The literature on ISD has devoted considerable attention to the impact of technical ISD risk factors on team-level and project-level success (e.g., Barki et al. 2001, Gemino et al. 2008, Wallace et al. 2004). Although a focus on the implications of technical ISD risk factors for team- and project-level success is important, the implications for developer stress have been overlooked. Ignoring developers' reactions to technical ISD risk factors and focusing exclusively on project-level outcomes provides an incomplete understanding of the mechanisms by which technical ISD risk factors affect project outcomes. To better understand ISD, we must dig a level below project-level drivers of ISD success to understand the drivers of developer stress, the mechanisms by which they are manifested, and how leaders can mitigate these effects. A multilevel perspective helps to avoid contextual and ecological fallacies that occur when researchers, "obtain spurious results at a lower level…because they fail to account for higher-level factors that impact the relationship," or "incorrectly assume that a relationship found at a higher level…exists in the same way at a lower level" (Burton-Jones and Gallivan 2007, p. 660). A multilevel approach also supports a shift toward conceptualizing people as social actors, rather than isolated entities (Lamb and Kling 2003), an approach that has received renewed attention (Xu and Zhang 2013). Our examination of developer stress is guided by three primary research questions: (1) what are the implications of technical ISD risk factors for developer stress? (2) what mechanisms explain how technical ISD risk factors affect developer stress? and (3) what role do leaders play in enabling developers to cope with the stress caused by technical ISD risk factors?

Project management research has primarily focused on managing technical ISD risk factors from a traditional project management control perspective to provide structure to the complexity of ISD (Gemino et al. 2008, Kirsch 1996, Maruping et al. 2009a, Tiwana and Keil 2010). Project leaders can play a key role in mitigating the effects of technical ISD risk factors via planning and control, clear reporting, and work breakdown structures (Napier et al. 2009). However, there are obvious challenges in executing such measures, particularly for ISD projects that may be large, complex, and volatile. Such characteristics obfuscate the kind of monitoring required by structured project management approaches as well as the intense communication and interaction advocated by flexible, self-managing approaches (Fowler and Highsmith 2001). Moreover, from a job demands-control standpoint, traditional project management approaches may exacerbate stress because they can increase demands and constrain a developer's control (e.g., through more complex reporting requirements). For ISD projects with high technical ISD risk factors, a leadership approach that balances structure with flexibility may provide the necessary support to help developers cope with demands and provide them with a sense of control that results in lower stress.

Although there are many potential leadership approaches, *empowering leadership* represents one approach emphasizing leader behaviors that can support developers in coping with demands as well as enhancing their sense of control (Spreitzer et al. 1999). Empowering leadership is defined as "the process of implementing conditions that enable sharing of power with an employee by delineating the significance of the employee's job, providing greater decision making autonomy, expressing confidence in the employee's capabilities and removing hindrances to performance" (Zhang and Bartol 2010, p. 109). Such leadership encompasses five leader behaviors: leading by example, participative decision making, coaching, informing, and showing concern (Arnold et al. 2000, Srivastava et al. 2006). These behaviors serve to motivate employees and provide them with the means and latitude to act on their own. We believe empowering leadership is well-suited for ISD projects involving high technical ISD risk and potential for high stress because it fosters the necessary flexibility (e.g., via participative decision making), support (e.g., via coaching or showing concern), and motivation (e.g., via leading by example). Empowering leadership has been found to enhance the effectiveness of teams' efforts to develop solutions to unanticipated problems (Magni and Maruping 2013) and is significantly correlated with leader's ratings of team proactivity (Kirkman and Rosen 1999).

To understand the mechanisms by which empowering leadership and technical ISD risk factors impact developer stress, we examine role perceptions. Multiple studies have shown that inadequate definition of roles and responsibilities are among the top concerns regarding ISD projects for both team leaders and developers (Keil et al. 2002, Schmidt et al. 2001). We examine role perceptions for three reasons: (1) the team-oriented nature of ISD; (2) prior research on the antecedents of job stress; and (3) our guiding theory, the JDCM. First, given that ISD is accomplished in development teams, role perceptions represent a useful lens for understanding how developers experience technical ISD risk factors in the team context. This is because the interdependent nature of ISD work requires that developers rely on clearly defined roles, responsibilities, and expectations in executing their work and as we will demonstrate, these role perceptions are shaped by technical ISD risk factors. Second, prior research shows that role ambiguity and role conflict are proximal determinants of stress because they impact people's ability to do their work, and are linked to feelings of helplessness and being out of control (Joseph et al. 2007, Lee 2000, Moore 2000). Role perceptions thus provide a mechanism for understanding how technical ISD risk factors contribute to stress, how leaders can support developers by helping to shape those perceptions and how leaders provide developers with a sense of control. Third, the JDCM literature has invoked role perceptions as a way to conceptualize stress itself. Although overall psychological stress is a more commonly studied outcome (Van der Doef and Maes 1999), role ambiguity and role conflict have been examined as stress-related outcomes related to fulfilling one's job role. For example, Wong et al. (2007) found that greater job control reduced role ambiguity (but not role conflict) when task interdependence was high. Swanson and Power (2001) found that supervisor support had a stronger negative influence on role ambiguity and role conflict for those in more demanding managerial jobs. Thus, given the research linking role perceptions directly to stress and research linking job demands and control to role perceptions, we position role perceptions as a mediational link between technical ISD risk factors and stress. We theorize that empowering leadership can reduce the impact of technical ISD risk factors on role ambiguity and role conflict, as well as the impact of role ambiguity and role conflict on stress.

We expect this work to contribute to the literature in several ways. First, we contribute to the IS project management literature by uncovering the effects of project-level technical ISD risk factors on individual developer stress. We augment prior work on team- and project-level outcomes with consideration for how technical ISD risk factors shape individual-level outcomes to provide a richer, multilevel view of ISD. Second, we contribute to the project management literature by identifying role perceptions as a psychological stressor that links technical ISD risk factors with developer stress. In doing so, we demonstrate that technical ISD risk factors result in developer stress by creating confusion about roles in the ISD project. Third, we contribute to the project management literature by identifying an intervention for managing technical ISD risk factors—empowering leadership. High-risk ISD requires a leadership approach that can provide both structure and flexibility. We identify empowering leadership as a means to manage technical ISD risk factors and reduce stress among developers in ISD teams, responding to calls for greater contextualization in IS research (Avgerou 2001, Tsang and Willliams 2012). In doing so, we add to the literature that examines the joint effect of technical and managerial contextual factors that influence the success of IS initiatives (Dong et al. 2009, Zhu et al. 2006a, Zhu et al. 2006b).

## 2. Theory and Hypotheses

We first review the literature related to leadership in ISD projects and empowering leadership. This sets the stage for hypothesizing the impact of technical ISD risk factors on developer stress and the role of empowering leadership in attenuating the relationship between them.

### 2.1. Leadership in ISD Projects

In a recent analysis of ISD personnel attitudes, Ply et al. (2012, p. 604) note that, "[m]ost organizations, while emphasizing the need for improvement in the software development process, almost completely ignore the human factors." Nelson (2007) finds that challenges in managing people account for 43% percent of project management mistakes while 37% of projects report significant breakdowns in personnel and team management. Nelson (2007, p. 73) concludes that project leaders should be "first and foremost, experts in managing processes and people." Project leaders play an integral role in supporting developers (Ewusi-Mensah 1997), and one way in which they do so is by helping developers to execute team processes. Prior research has found that involved leaders facilitate processes related to interpersonal relationships, production activities, and management of external sources of influence (Guinan et al. 1998). They also monitor and guide developers' behaviors in response to project characteristics. Research has shown that effective leaders are adaptive in using different managerial control strategies (e.g., outcome control, self control) based on the ISD methodology used (Maruping et al. 2009a). Leaders also play a critical role in defining roles (Kelloway et al. 2005). A key takeaway from these studies is that leaders of ISD projects can and should play a central role in enabling, managing, and motivating developers. However, they do not speak to the implications of empowering leadership for developers.

### 2.2. Empowering Leadership

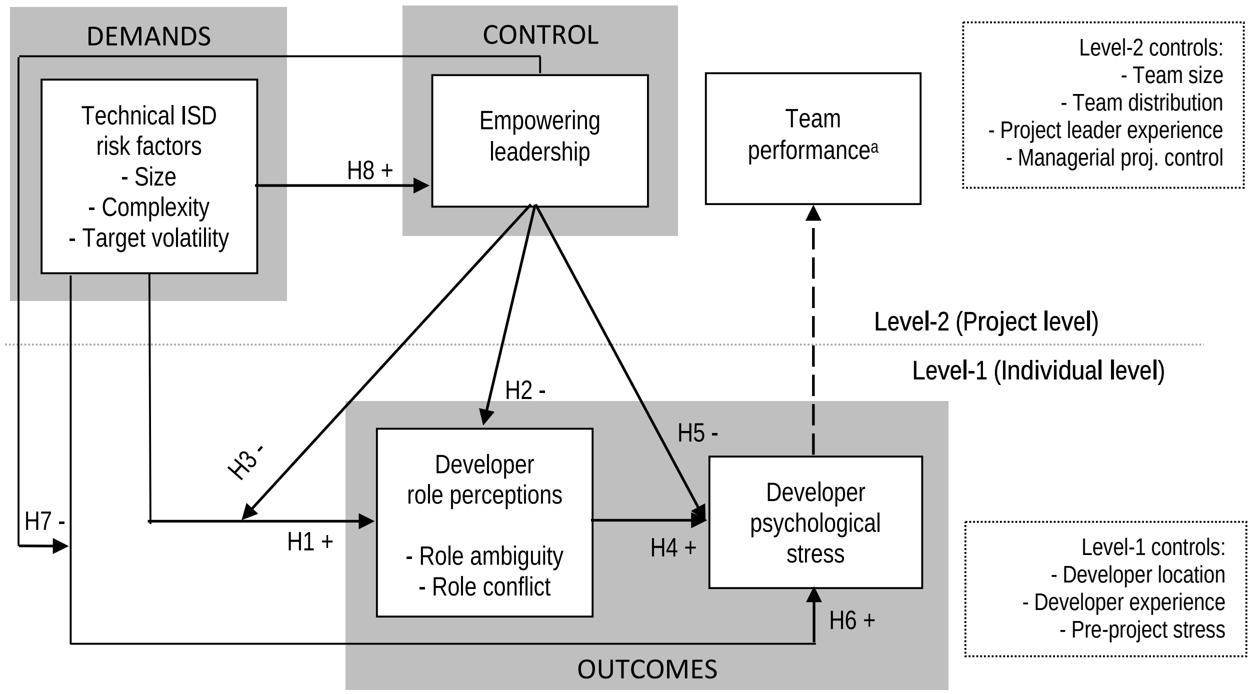
Research has acknowledged the need for more motivation-based, delegative leadership strategies for ISD project teams and by extension, the developers of whom they are composed (Faraj and Sambamurthy 2006, Hertel et al. 2005). This is evidenced by the growing number of studies that have reported a trend toward self-managed teamwork (Black and Lynch 2004, Taylor 2011, Thamhain 2004). Despite this evidence, entirely self-managed teamwork does not address motivational needs and does not provide the significant measure of oversight that large-scale ISD projects require. Empowering leadership, however, facilitates motivation, sharing of decision making responsibility, and building of self-reliance under supervision by a formal project leader (Chen et al. 2007, Faraj and Sambamurthy 2006, Magni and

Maruping 2013, Srivastava et al. 2006, Zhang and Bartol 2010). This is reflected in the five behaviors that make up empowering leadership. Leading by example, involves behaviors that demonstrate the leader's commitment to the work (Arnold et al. 2000). Showing concern represents the extent to which leaders exhibit a regard for developers' well-being. Leaders exhibit participative decision making when they solicit and follow-up on developers' input in making decisions. Coaching refers to leader behaviors that show developers how to be self-reliant in seeking solutions and solving problems. Finally, informing involves leaders' efforts to keep developers apprised of project-relevant issues (Arnold et al. 2000). Taken together, these behaviors have been argued to motivate individuals to persist in the face of obstacles, be proactive in identifying solutions to problems, and to be self-reliant in managing assigned tasks, making empowering leadership ideal for challenging work environments (Faraj and Sambamurthy 2006, Magni and Maruping 2013, Srivastava et al. 2006, Zhang and Bartol 2010).

The project management literature acknowledges that different leadership styles are appropriate for different types of projects (Müller and Turner 2007) and there is some evidence that empowering leadership may be particularly well-suited for ISD. For example, Thite (2000) found that in highly technical projects, effective leaders act as a catalyst to empower and encourage free thinking and exploration among developers. Faraj and Sambamurthy (2006) found that higher task uncertainty and availability of expertise in an ISD project both interact with empowering leadership to enhance its effect on team performance. Project management scholars also highlight a need to move toward devolved, collective decision making (Sauer and Reich 2009). This approach is characteristic of empowering leadership and recognizes that, in highly technical projects, leaders will not have sufficient expertise relevant to many project decisions (Sauer and Reich 2009). As one of the leaders in their study notes, "We talk about…delegating the authority to the team and getting the hell out of their way…My role then becomes not one of directing their work, my role becomes one of removing road blocks" (Sauer and Reich 2009, p. 187). Collectively, by highlighting the various ways that empowering leaders facilitate task accomplishment, these studies point to the important role that empowering leaders play in helping developers cope with technical ISD risk factors.

We theorize that technical ISD risk factors will affect empowering leadership, role ambiguity, role conflict, and developer stress. Empowering leadership is expected to moderate the relationship between technical ISD risk factors and role perceptions, as well as between role perceptions and developer stress. Empowering leadership is theorized to directly reduce role conflict and role ambiguity. Our research model is shown in Figure 1.

Figure 1. Research Model




[a] *The dashed line between developer psychological stress and team performance represents a relationship that is not hypothesized but used as a criterion variable. Though not shown, developer psychological stress is aggregated to the team level prior to testing its impact on team performance. The constructs shaded in gray show how the model maps to the job demand-control model.*

## 2.3. Technical ISD Risk Factors

The extant research on ISD projects has highlighted an abundance of risk factors that contribute to cost overruns, schedule delays, and unmet user requirements (for a review, see Schmidt et al. 2001). These negative project outcomes are likely to place a great deal of stress on the developers whose evaluations and professional reputations are tied to the success of their team's project. Technical ISD risk factors (e.g., system complexity, target volatility), in particular, shape the interdependent work of developers and are directly tied to the software artifact under construction. Moreover, because this type of risk is tied to the IT artifact, it affects developers' workload (e.g., requiring greater cognitive effort to integrate across multiple platforms, more requirements to satisfy), representing an increase in demands that can lead to stress (Karasek 1979, Van der Doef and Maes 1999). Frequently-studied technical ISD risk factors are project size, complexity, and target volatility (Banker et al. 1998, Gopal et al. 2002, Griffin 1997, Jiang et al. 2000, Sarker and Sarker 2009, Schmidt et al. 2001). *Project size* refers to the general scope of the project in terms of resources required (Sauer et al. 2007), *project* *complexity* refers to the degree to which the project consists of varied and interrelated parts (Baccarini 1996), and *target volatility* is defined as the extent to which project constraints (i.e., schedule, budget, and scope) change after the initial user requirements are obtained (Gemino et al. 2008). A study by Sarker and Sarker (2009) found that these three factors are the key project characteristics that affect an ISD project.

### 2.4. Role Perceptions

The JDCM argues that job demands affect role perceptions (Swanson and Power 2001, Wong et al. 2007). Consistent with this theoretical relationship, we expect technical ISD risk factors to influence role perceptions—specifically, role ambiguity and role conflict. One reason why project size, complexity, and target volatility are considered risk factors is that they increase the workload demands placed on developers (Schmidt et al. 2001). In order to complete requirements, developers need to understand their role and coordinate inputs when working together. For example, research on ISD finds that developers' understanding of code ownership is an important mechanism for coordinating developer inputs (Maruping et al. 2009b). Code ownership helps to define the role each developer plays in the team and facilitates management and application of needed expertise (Maruping et al. 2009b). Role ambiguity and role conflict affect coordination capabilities and thus provide a theoretically useful way of understanding how technical ISD risk factors translate into difficulties for developers.

*Role ambiguity* refers to the degree to which a developer's role expectations are unclear (Rizzo et al. 1970). For example, imagine a team of developers is tasked with creating a software module, but are not provided with any guidance about each developer's role. Developers will be unsure about the level of responsibility they each have for overseeing the team's work, managing inputs and outputs, and coordinating internal and external communication. Moreover, they may be uninformed about how their work will be evaluated and by whom. Such uncertainties translate into role ambiguity. *Role conflict* refers to the degree to which the behaviors expected of an individual are inconsistent (Rizzo et al. 1970). For example, a project leader might be told that she is responsible for the professional development of less experienced developers. At the same time, she is required to ensure that the software her team develops is of the highest quality. She may experience role conflict when faced with pressure to put a less experienced developer in a developmental position where they would learn much but would not perform as well as a more experienced developer. Role ambiguity and role conflict have been linked to job dissatisfaction, work overload, and ultimately, turnover intention (Joseph et al. 2007, Lee

2000, Moore 2000), and are of particular interest given our examination of project teams. Clarity and congruity in developer roles are important if the team is to perform at a high level, as both role ambiguity and role conflict are shown to negatively impact role performance (Beauchamp et al. 2002, Bray and Brawley 2002). Based on the interdependent nature of project teamwork, a developer's ability to effectively understand and execute their role will impact the work that is shared among interdependent developers (Bray and Brawley 2002, Thompson 1967).

In interdependent project teams, the performance of each person is a function not only of individual-level processes, but also of the project-level factors that can constrain or enable an individual's behaviors, cognitions, or emotions. As we elaborate below, the context in which developers work is expected to impact their role perceptions. We explore the multilevel influence of context by theorizing the effect of technical ISD risk factors on individual developers within ISD project teams. Theorizing top-down effects (i.e., constructs at a higher level of analysis influencing constructs at a lower level of analysis) involves consideration of contextual influences that allow researchers to explicate the enablers and constraints imposed by higher-level constructs on lower-level constructs (Kozlowski and Klein 2000). Enablers and constraints are especially pronounced when levels are tightly coupled, as with developer roles that are tied to or determined by a project's characteristics (Kozlowski and Klein 2000). Due to this tight coupling and the constraints on developer behavior imposed by project-level factors, we theorize that project-level technical ISD risk factors contribute to role ambiguity and role conflict at the individual level, for a direct, cross-level effect.

Project management approaches to ISD typically involve implementing managerial controls that aim to ensure developers are working according to an agreed-upon strategy (Kirsch 1996). Behavior controls (i.e., specifying tasks and activities) and outcome controls (i.e., specifying desired outputs and rewards for their achievement) serve to reduce role ambiguity because they help alleviate confusion by clarifying expectations (Ply et al. 2012). However, the feasibility and success of these project management approaches are a function of project characteristics (Kirsch 1997). When projects are large, complex, and volatile, implementing managerial controls is difficult, behavior and/or outcome specificity is reduced, and role ambiguity is more likely. Consistent with the JDCM, these technical ISD risk factors place increasing demands on individual developers and affect their role perceptions. Larger projects introduce more resources that developers must coordinate in order to accomplish their objectives (Baccarini 1996). Projects larger in size typically have more complex reporting structures (i.e., a top-down constraint) that have been shown to lead to greater role ambiguity because individuals have more difficulty determining from whom they should seek direction (Baroudi 1985). Further, role ambiguity is particularly probable on larger projects, when multiple developers may be assisting with the responsibilities of a particular role. This could contribute to a lack of clarity about one's responsibilities, as there may be different interpretations and information about which developers fulfill various duties associated with a role. Compounding this problem is an individual's diminishing sense of urgency and engagement resulting from increases in a project's size (Zafiropoulos et al. 2005). A lack of urgency or engagement may result in greater ambivalence on the part of developers in understanding their role on the team (Sonnentag and Kruel 2006). Target volatility is also likely to impact role ambiguity, as changes in targets may alter the responsibilities that a developer has, leading to ambiguity regarding their current role. For example, ISD teams are often structured such that one developer who is most knowledgeable in a particular area is recognized as the 'senior developer' or 'lead programmer'—a technical expert with some authority and responsibility for decisions concerning software design. A change in scope could involve added functionality that requires a new type of technical expertise, say knowledge of a different programming language. In response to this change, a new technical expert may be added to the team, thus obfuscating the role of the original expert and resulting in role ambiguity for both developers.

Consistent with the JDCM, we expect technical ISD risk factors to produce role conflict as well. As with role ambiguity, technical ISD risk factors place constraints on a developer's behaviors, cognitions, and emotions, and thus impact developers' ability to interpret and perform their role. Technical ISD risk factors impact role conflict due to the lack of congruity about one's expectations and responsibilities. When there are multiple, conflicting interpretations of one's role, developers will face difficulty determining what they are supposed to do. Larger and more complex ISD projects often require developers to be assigned multiple tasks, which can lead to conflicts of priority and commitment of resources, as well as multiple or conflicting reporting structures. Moreover, greater project complexity and target volatility create more significant interdependencies among developers. This may require communication across departmental boundaries to access or share resources and gather, update, and disseminate new information as changes occur, leading to a lack of congruity in expectations. For example, enterprise systems serve the needs of many organizational units. Developing, maintaining, or configuring such a system would require developers to gather requirements from several sources across the organization. As developers span these intra-organizational boundaries, they are likely to be met with expectations and orientations that differ or conflict with one another. Indeed, the extant literature has consistently supported the link between boundary spanning and role conflict (Baroudi 1985, Bettencourt and Brown 2003, Joseph et al. 2007, Marrone et al. 2007, Speier and Venkatesh 2002). More recently, Ply and her colleagues (2012) highlight the difficulty in implementing managerial controls and the resulting role conflict that arises in ISD projects when developers span boundaries. Developers can be caught in the middle between project leaders pushing for process adherence and customers who question the value of the overhead these processes require (Herbsleb et al. 1997, Hyde and Wilson 2004). In sum, project size, complexity, and target volatility can lead to situations in which there are multiple, incongruent sources of information or expectations about a developer's role. Thus:

*H1: Project-level technical ISD risk factors will have a cross-level, positive effect on developers' role ambiguity and role conflict.*

In addition to technical ISD risk factors, we expect another project-level factor to have a direct, cross-level influence on role ambiguity and role conflict. Like technical ISD risk factors, empowering leadership is considered a project-level characteristic of ISD because it "operates to reduce the variability of individual differences and perceptions, facilitating common interpretations of the climate" (Kozlowski and Klein 2000, p. 11). Unlike technical ISD risk factors, which represent the demand component of the JDCM (Karasek 1979, Van der Doef and Maes 1999), empowering leadership represents a means to provide developers with a sense of control that can help minimize role ambiguity and role conflict. In sharing decision making authority with the team, empowering leaders imbue developers with the power to make choices that may help them avoid role ambiguity or role conflict. Through coaching, project leaders help developers identify their weaknesses and suggest ways to improve task performance. This facilitates a greater sense of control through self-determination and skill development. Research has shown that self-determination leads to more initiative in work-related situations (Deci and Ryan 1985), allowing developers to be proactive about gathering information that can be used to define their role. Moreover, intrinsic motivation is an important determinant of continuance behavior, particularly when self-efficacy is high (Sun et al. 2012). As changes to project targets may necessitate reassessment of one's role on the team, such persistence will be important in ensuring that developers continue to seek out information that clarifies their role. Informing enables the transfer of mission-critical knowledge that may impact role definitions (Lander et al. 2004). Consistent with the JDCM, the sense of control provided through empowering leadership should reduce role ambiguity and role conflict. Thus:

*H2: Project-level empowering leadership will have a cross-level, negative effect on developers' role ambiguity and role conflict.*

The JDCM suggests that control can reduce the stress-inducing effects of increasing demands. This suggests that control moderates the relationship between demands and stress-related outcomes (Häusser et al. 2010, Van der Doef and Maes 1999). Consistent with the theory, we expect empowering leadership to moderate the relationship between technical ISD risk factors and role perceptions for a cross-level interaction. This interaction suggests that the top-down effects of project-level technical ISD risk factors on developers' role perceptions can be altered to some extent by the sense of control that empowering leadership imparts. Although technical ISD risk factors should influence role perceptions by way of constraining a developer's behaviors, cognitions, and emotions, we expect empowering leadership to enable developers to perform by providing them with the control to meet project demands. Collectively, empowering leadership behaviors provide developers with the opportunities and motivation to seek out clarification and make decisions regarding project demands (Chen et al. 2007). In turn, this should reduce the effect of technical ISD risk factors on role ambiguity and role conflict.

Empowering leaders share decision making responsibility with developers (Manz and Sims 1987). These behaviors should stimulate greater engagement with the project. By sharing decision making responsibility, leading by example, and informing about project-related issues, leaders encourage developers to actively process project-related information and to make positive contributions, rather than passively observe the team's course of action (Vecchio et al. 2010). As mentioned, cognitive engagement is important in motivating individuals to understand and seek clarification regarding their role (Sonnentag and Kruel 2006). Empowering leaders enable developers to reduce the impact of technical ISD risk factors on role conflict through coaching, which equips them with the ability to negotiate or coordinate roles. This can facilitate productive negotiation of roles, a process that can be continuously revisited during the course of a large, complex project. Thus, to the extent that role ambiguity or role conflict is an impediment to work, stronger project engagement and ownership should motivate developers to expend more effort to seek out clarification about their role on the project team and resolve inconsistent expectations that interfere with their progress. This should allow for better management of large, complex, and volatile projects, and reduce the impact of these factors on role ambiguity and role conflict. Thus:

*H3: Project-level empowering leadership and technical ISD risk factors will have a cross-level, interactive effect on developers' role ambiguity and role conflict, such that the relationship between technical ISD risk factors and role ambiguity and role conflict will be weaker when empowering leadership is high compared to when it is low.*

## 2.5. Psychological Stress

We expect role ambiguity and role conflict to increase stress among developers. A meta-analysis of the correlates of role ambiguity and role conflict found that they are moderately to strongly correlated with a variety of negative affective reactions, including job dissatisfaction, tension/anxiety, reduced organizational commitment, and propensity to leave (Tubre and Collins 2000). These negative psychological and behavioral reactions have even been observed to have physical manifestations. Several studies have found that role ambiguity and role conflict increase heart rate and blood pressure (e.g., Perrewé et al. 2004). The link between role perceptions and stress is grounded in classical organization theory based on chain-of-command and unity-of-command principles (Cummings et al. 1975, Rizzo et al. 1970). According to these principles, employees expect and are more satisfied with a hierarchical relationship in organizations. This hierarchy should have a clear and single flow of authority in which employees receive direction from only one person, who is above them in the hierarchy (Fayol 1949). These principles allow top management to reduce uncertainty, increase accountability, and help to ensure systematic and consistent reporting, evaluation, and management of work and resources. Role ambiguity and role conflict violate these principles by obfuscating the clear and single flow of authority and introducing expectations from multiple sources (Rahim 2011, Rizzo et al. 1970).

In the ISD context, this principle is frequently violated due to the boundary spanning activities performed by developers. Research has found that high levels of role conflict and role ambiguity occur among those who have more contact with others (Boles et al. 1997). Boundary spanning activities are prevalent in ISD work and expose developers to multiple sources of influence regarding their role in the team and project, including users, managers, and vendors (Baroudi 1985). The need to collect and resolve role-related information from these various sources places an additional burden on the developer with respect to role perceptions (Ahuja et al. 2007, Joseph et al. 2007, Moore 2000). When developers are unclear about their role, they will hesitate in their decision making and have to rely on trial-and-error in meeting expectations (Pettijohn et al. 2001). Moreover, because of task interdependence, challenges understanding one's role can lead to increasing stress and pressure for interdependent developers who rely on a focal individual's output as input into their own tasks. In this way, role ambiguity and role conflict create anxiety because they reduce one's sense of control over their work and one's ability to execute responsibilities. This is particularly consequential, and thus stressful, when deadlines, performance evaluations, or pay-for-performance incentives are on the line. Thus:

*H4: Role ambiguity and role conflict will positively influence developers' stress.*

Prior empirical studies of the JDCM find that greater control reduces stress (Häusser et al. 2010, Van der Doef and Maes 1999). Consistent with the JDCM, we expect that empowering leadership behaviors should lower developers' psychological stress. Empowering leaders engage in coaching and leading by example, which provides developers with guidance on how effective performance can be achieved (Arnold et al. 2000, Srivastava et al. 2006). This guidance should reduce stress by helping developers to feel more in control because it provides them with a road map for their performance. By keeping developers informed about the project (e.g., explaining project goals, decisions) empowering leaders help developers set appropriate expectations about their work and broader project environment. This can help developers to align their efforts with evolving project goals and to avoid stressful mistakes that occur due to inaccurate assumptions or outdated information. Finally, empowering leaders express concern for their developers' personal problems and well-being (Arnold et al. 2000, Srivastava et al. 2006). Social and emotional support, particularly from supervisors, have been shown to be effective in lowering stress (Babin and Boles 1996). Such support provides an outlet for expressing and resolving concerns. Moreover, as role models, when empowering leaders demonstrate their concern for developers, they help cultivate an open, compassionate team climate that increases the likelihood that developers can turn to fellow teammates for support. Thus:

*H5: Project-level empowering leadership will have a cross-level, negative effect on developers' psychological stress.*

Per the JDCM, we also expect technical ISD risk factors to have a direct, cross-level effect on developer stress because they introduce demands on emotions and cognitions with respect to role-related responsibilities. Projects of greater size, complexity, and target volatility are more demanding of developer's emotional and cognitive resources as they require them to manage more "moving pieces"—i.e., changing knowledge structures, human and technical resources (Baccarini 1996, Banker et al. 1998). Larger projects require developers to expend cognitive resources keeping track of their many outputs and how they fit into the broader project. This process of tracking inputs and outputs is more difficult when projects are large and there are many developers and inputs at play. Similarly, projects of greater complexity require developers to expend cognitive resources addressing multiple code dependencies and meeting multiple, interrelated objectives. Moreover, a high degree of target volatility places a heavier cognitive load on developers keeping track of shifting output expectations and their potential cascade effects on interrelated code modules. In these ways, the top-down influence of technical ISD risk factors constrains the behavior of a developer by limiting their ability to perform the task at hand, due to increased cognitive and emotional load (Pennington and Tuttle 2007). As a result, project-level technical ISD risk factors are likely to evoke an imbalance between the demands of the project and role-related capabilities and needs of developers. Thus:

*H6: Project-level technical ISD risk factors will have a cross-level, positive effect on developers' stress.*

As previously noted, JDCM research suggests that control moderates the relationship between demands and stress. Drawing on the theoretical mechanisms supporting H3 and H5, we expect empowering leadership to moderate the relationship between technical ISD risk factors and stress for a cross-level interaction. Stimulated by participative decision making, coaching, and informing (Chebat and Kollias 2000, Vecchio et al. 2010), higher project engagement and adaptability ensures that developers track and respond to technical ISD risk factors. This engagement should lower the impact of technical ISD risk factors on stress. For example, changing requirements should not induce as much stress because developers will be more effective in adapting their work to meet new demands. Perceptions of efficacy and control that arise from participative decision making, coaching, and role modeling should promote both initiating behaviors and task persistence (Bandura 1997, Srivastava et al. 2006). Technical ISD risk factors should induce less stress when developers are proactive and persistent in seeking out information and resources that will help them execute their work. This is because when they are more persistent and proactive in acquiring the resources they need to meet demands they are better equipped to manage challenges stemming from technical ISD risk factors. Finally, when empowering leaders show concern for the well-being of developers, they provide an outlet for developers to process their anxiety and concerns. This should lighten the "emotional burden" of high-risk ISD, reducing the impact of technical ISD risk factors on stress. Thus:

*H7: Project-level empowering leadership and technical ISD risk factors will have a cross-level, interactive effect on developers' psychological stress, such that the relationship between technical ISD risk factors and psychological stress will be weaker when empowering leadership is high compared to when it is low.*

Finally, we expect technical ISD risk factors to have a positive, direct effect on empowering leadership. Decisions about leadership approaches do not occur in a vacuum. Effective leaders are adept at surveying the project landscape, identifying the needs of those they lead, and adapting their leadership approach to fit those demands (Bass and Bass 2008, Denison et al. 1995, Hooijberg et al. 1997). Thus, a project leader taking an empowerment approach may represent a managerial response to an assessment of technical ISD risk factors. That assessment will likely involve recognition that their ability to monitor and direct project execution is diminished when projects are large. Empowering leaders can enhance motivation and share decision making authority as a way to address this constraint and ensure developers are on task. When projects are highly complex, an effective project leader should recognize that they will not be sufficiently versed in all knowledge relevant to many project decisions (Sauer and Reich 2009). Empowering leaders can address this constraint by sharing decision making responsibility and informing developers of project-related developments that affect their performance. When target volatility is high, an effective project leader should recognize the need for agility, persistence, and motivation on the part of developers. An empowering leadership approach addresses these needs by enabling agility through leading by example to enhance motivation and persistence. Given the prior research demonstrating that leaders adapt their approach to meet situational demands (Bass and Bass 2008, Hooijberg et al. 1997), as well as the potential alignment between the demands of high-risk ISD projects and empowering leadership, we expect that technical ISD risk factors may drive leaders to an empowerment approach. Thus:

*H8: Technical ISD risk factors will have a positive effect on empowering leadership.*

## 3. Methodology

### 3.1. Setting and Participants

Our research model was tested in a year-long field study of ISD project teams. The data collection site was a large U.S.-based firm specializing in the development of software for technologies used in consumer electronics, networking and telecommunications equipment, and computer systems. The firm had about 5,000 employees and the revenue for 2013 was over U.S.$1 billion. Participants were members of software development teams, distributed across China, India, and the U.S, using an agile development approach. The sampling frame was 1,140 developers in 119 teams working on ISD projects. From this sampling frame, 350 developers and 73 leaders provided usable responses. Respondents were fairly evenly distributed across the three locations, with 101 developers working in China, 118 in India, and 131 in the U.S. The average team size was 10, with an average of 4.8 responses per team (48% response rate), which is an acceptable level for statistical representativeness of the team (Faraj and Sproull 2000, Warwick and Lininger 1975).

The average age of developers and team leaders was 32 years and 44 years, respectively. Approximately 49% of the developers were women and 46% of team leaders were women. Each team's project was an independent module of a larger organization-wide development effort. Thus, all projects started at the same time, but finished at different times, though most projects lasted about 1 year, with a range from 10 months to 14 months. Although participation was voluntary, response rates were bolstered by strong support of the study by top management and team leaders.

### 3.2. Data Collection Procedure

The surveys were administered by an external research firm. Each survey had a barcode to allow a participant's responses to be linked across measurement points (i.e., the same barcode appeared on all three versions of a participant's survey), yet maintain anonymity. Three waves of data collection were conducted, with measurement points at the beginning, midpoint, and end of the project. Data were collected from participants distributed across three countries, which included both developers and their project leaders. This multiwave, multisource, and multinational approach follows prior exemplars of field study design to bolster the validity of the results (e.g., Hsieh et al. 2011, Zhu et al. 2006a). Wave 1 captured data that is not dependent on team interaction, such as developer characteristics and technical ISD risk factors.[2] Wave 2 captured empowering leadership behaviors, role perceptions, and psychological stress. These measures were taken at the midpoint of the project, when teams had adequate opportunity to establish role perceptions, be impacted by empowering leadership, and experience stress, but before the project had started to wind down. Wave 3 captured team performance. We assessed team performance in wave 3 to temporally separate measurement of the predictors and criterion. Although not hypothesized, we believe that the inclusion of team performance as a criterion variable will provide nomological validity and greater credibility to our study and findings. The results of a supplemental analysis to establish

[2] Expectations regarding technical ISD risk factors were measured at the beginning of the projects and actual technical ISD risk factors were measured at the end of the projects. Expected technical ISD risk factors are used in our analysis because they precede the variables they are hypothesized to predict (i.e., empowering leadership, role perceptions, and stress). However, the correlations between expected and actual risk factors were all above .61 ($p < .001$), suggesting that they were assessed fairly accurately at the start of the project. Moreover, technical ISD risk factors and empowering leadership were assessed by both leaders and team members. The correlations between leader and member ratings of technical ISD risk factors at T1 and T3 ranged from .55 to .79 ($p < .001$), while the correlation between leader and member ratings of empowering leadership at T2 was .68 ($p < .001$), suggesting considerable consistency between data sources. We replicated the analyses reported below with different respondents (i.e., member-rated technical ISD risk factors and leader-rated empowering leadership) to determine whether the source of the data influenced the results. The pattern of results is highly consistent. These replication analyses are reported in online Appendix C.

nomological validity are shown in online Appendix A. The measurement points and respondents used in our analysis are depicted in Table 1.

Table 1. Measurement Points and Respondents

| Wave 1 Project Start | | Wave 2 Project Midpoint | | Wave 3 Project End | |
|---|---|---|---|---|---|
| Variable | Source | Variable | Source | Variable | Source |
| Team characteristics (e.g., size) | Project Leader | Empowering Leadership (15 items) | Developer | Team Performance (5 items) | Project Leader |
| Demographics (e.g., location) | Project Leader, Developer | Role Perceptions (18 items) | Developer | | |
| Technical ISD risk factors (9 items) | Project Leader | Psychological stress (8 items) | Developer | | |

### 3.3. Measurement

All items were drawn from previously validated scales and are listed in online Appendix B. Data were collected from multiple sources, including developers and the project leader. This strategy is recommended as a means to alleviate concerns of common method bias (Malhotra et al. 2006). For the purposes of our analysis, we used measures of technical ISD risk factors and team performance that were elicited from the project leader and measures of empowering leadership behaviors, role perceptions, and stress that were elicited from developers.

#### 3.3.1. Technical ISD Risk Factors

*Project size* is a multidimensional construct. It consists of four items, each measuring various facets of size, namely project duration, cost, relative size as compared to other projects, and effort as measured in person-months. The response choice for these items is open-ended. These measures for assessing project size have been used in the extant ISD project literature (Gemino et al. 2008) and allow for a comparison of teams working on projects of different types. *Project complexity* was measured with two items that assess the extent to which the technology is integrated with other systems and must interface with other types of technology (Barki et al. 1993, Gemino et al. 2008). The items were assessed on a 7-point Likert scale, where 1 represents “strongly disagree” and 7 represents “strongly agree.” *Target volatility* involves expected changes in the target objectives related to budget, schedule, and scope of the system. The scale consists of three items that assess the number of times these factors were expected to change over the course of the project and the response choice was open-ended (Gemino et al. 2008).

### 3.3.2. Empowering Leadership

Empowering leadership was measured using a 15-item scale that has multi-item subscales corresponding to five empowering leadership behaviors: leading by example, participative decision making, coaching, informing, and showing concern (Srivastava et al. 2006). The items were measured on a 7-point Likert scale, where 1 represents "strongly disagree" and 7 represents "strongly agree."

### 3.3.3. Individual-level Outcomes

*Role ambiguity* and *role conflict* were measured using a scale adapted to the team context from House, Schuler and Levanoni (1983). These scales are composed of 11 items and 7 items, respectively. These scales were developed to address criticism concerning earlier scales that were confounded with stress and comfort and thus represent more rigorously validated measures. *Psychological stress* was assessed with an 8-item measure adapted to the context of the team project (Stanton et al. 2001). Items related to all three outcomes were measured on a 7-point Likert scale, where 1 represents "strongly disagree" and 7 represents "strongly agree."

### 3.3.4. Team-level Outcome

*Team performance* was measured using a 5-item scale that assesses a project leader's rating of their teams' efficiency, adherence to budgets and schedules, as well as the production of quality work and ability to resolve conflicts (Ancona and Caldwell 1992). The items were measured on a 7-point Likert scale, where 1 represents "strongly disagree" and 7 represents "strongly agree." We used team performance as a criterion variable in our supplemental analysis shown in online Appendix A.

### 3.3.5. Control Variables

Control variables were selected for their ability to eliminate alternative interpretations that may account for variability in the dependent variable. Team size has been linked to team processes (Curral et al. 2001), the efficacy of leadership behaviors (Ancona and Caldwell 1992, Bass 1990), and role perceptions (Savelsbergh et al. 2012) and thus is included in the analysis. Because prior project management literature has primarily focused on managing technical ISD risk factors using managerial project control mechanisms (Gemino et al. 2008, Kirsch 1996, Maruping et al. 2009a, Tiwana and

Keil 2010), we felt it was important to include this to fully capture the nomological network of project management. We thus account for managerial project control mechanisms in our analysis. We used Kirsch et al.'s (2010) specification and evaluation mechanisms of formal control, which assess the extent to which the following managerial control mechanisms are used during the project: formal policies and procedures, project milestones and schedules, project documents and memos, and regularly scheduled meetings. To control for variability in coping and leadership capability, we account for the experience of developers and leaders (Bettin and Kennedy 1991, Huckman et al. 2009), respectively, in terms of the number of years working on similar projects. We also control for pre-project job stress, which represents latent job stress that is specific to the characteristics of one's job. This allows us to partial out the stress associated with one's job from the stress arising from the project. Pre-project job stress was assessed using the same measure used to assess project-related stress (Stanton et al. 2001), but adapted to the job instead of project and assessed prior to the start of the project. To account for differences in how developers may experience stress resulting from unique factors pertaining to their local environment (Cramton 2002), we control for developer location. Finally, the extent to which developers were distributed across different sites may contribute to difficulty with coordination and shared understanding (Cramton 2001, Hinds and Bailey 2003, Polzer et al. 2006), that could affect role perceptions. Thus, we control for team distribution.

### 3.4. Measurement Model

The psychometric properties of the scales were assessed by conducting a confirmatory factor analysis (CFA) using AMOS (version 6.0). CFA allows researchers to determine how well the model fits the data. All constructs were modeled reflectively, with the exception of project size and target volatility, which were modeled formatively. In judging whether the constructs measured should be modeled formatively or reflectively we applied the guidelines suggested in prior research (Jarvis et al. 2003, Petter et al. 2007). Formative constructs can be distinguished from reflective constructs by the following characteristics: (1) the direction of causality is from the items to the construct; (2) the items for the construct are not interchangeable; (3) the covariance between measures is not necessary; and (4) formative measures need not share common antecedents and consequences (Jarvis et al. 2003, Petter et al. 2007). Measures for project size and target volatility meet these conditions.

In considering the measurement model for the empowering leadership construct, we determined the appropriateness of a reflective versus formative specification (Petter et al. 2007). We used theory as our guide in making this choice. Specifically, theory of self-managing teams identifies a style of leadership that involves a system of complementary leader behaviors that facilitate teams' self-direction and control over their assigned tasks (Druskat and Wheeler 2003, Manz and Sims 1987). Leaders who adopt an empowering style of leadership have an incentive to enact all five behaviors given their complementarities (Druskat and Wheeler 2003). For instance, leaders who show concern for their team's well-being are also likely to engage in coaching to satisfy identified needs. Similarly, leaders who engage their team in participative decision making also tend to inform their teams of project-related developments so that develops can form better judgments and make good decisions. Arnold et al. (2000) describe these behaviors as co-occurring among leaders who adopt this style of leadership and Faraj and Sambamurthy (2006) conceptualize the behaviors reflected in empowering leadership as representing a theoretical leadership archetype. As such, the underlying first-order dimensions are expected to covary. Based on this theoretical logic, and consistent with prior empowering leadership research (Arnold et al. 2000, Srivastava et al. 2006, Zhang and Bartol 2010), we specify empowering leadership as a second-order reflective construct whereby the second-order factor causes the co-occurrence of the five behaviors, "coordinates their mutual dependencies, and accounts for their observed covariance" (Tanriverdi and Uysal 2011, p. 713). The first-order factors are also modeled reflectively because the direction of causality is from the construct to the items, the items have similar content themes, and they covary with one another (Petter et al. 2007). From an empirical standpoint, we note that the correlations among the five first-order dimensions are substantial, ranging from .50 to .65 (Petter et al. 2007). The second-order factor loadings are statistically significant and range from .73 to .84, suggesting that the second-order factor causes the five first-order factors and accounts for their variance (Tippins and Sohi 2003). Finally, the target coefficient value indicates that the second-order factor accounts for 62% of the covariance among the first-order factors (Marsh and Hocevar 1985). Thus, we conclude that this factor structure is appropriate.

It is important to note that regression-based approaches to analysis, such as the random coefficient modeling we use to test our hypotheses, do not involve the use of latent constructs. Consequently, it is common to convert the measurement models of a second-order construct into a linear composite score by averaging the unit weights (Rai and Tang 2010, Tanriverdi and Uysal 2011). Rozeboom (1979) notes that when the underlying first-order constructs are highly correlated the linear composite scores based on different weighting schemes will be highly correlated. In such circumstances, a reflective or formative specification will not impact the estimated coefficients (Rai et al. 2006). In the interest of robustness, we estimated the random coefficient models using linear composites for empowering leadership based on its specification as a second-order formative construct. As expected, because the first-order dimensions are highly correlated, the results of the random coefficient model estimation using the second-order formative specification were the same as those involving the second-order reflective specification.

Metrics consistently used in prior literature and accepted as measures of good fit include the: goodness of fit index (GFI), adjusted goodness of fit index (AGFI), comparative fit index (CFI), and standardized root-mean square residual (SRMR) (Bentler 1990, Hu and Bentler 1999). GFI and CFI values larger than .95 are considered indicators of good fit, whereas values larger than .80 are considered acceptable for AGFI. Values smaller than .08 are considered indicators of good fit for SRMR (Hu and Bentler 1999)[3]. The fit statistics for the model fell within these ranges: GFI = .93; AGFI = .92; CFI = .92; SRMR = .07, demonstrating acceptable fit. Convergent validity was assessed by examining the lambda values for the indicators and the average variance extracted (AVE). It is recommended that lambda values be larger than .70 and AVEs be larger than .50 to support convergent validity (Kline 2005). The loading matrix is shown in Table 2. All items load higher than .70 on their respective factor. The AVEs were all larger than .50, providing support for convergent validity. Discriminant validity was assessed by comparing the square root of the AVE to the correlations among constructs. AVEs are shown along the diagonal in Table 3. Discriminant validity is established if the constructs have more common variance with their corresponding items than with other constructs. This is demonstrated when the square root of the AVE for each construct is greater than the inter-construct correlations (Fornell and Larcker 1981). This was the case with our model, providing support for discriminant validity. Finally, the composite reliabilities of the measures were all greater than .70, meeting threshold requirements (Fornell and Larcker 1981).

Formative measures are not required to exhibit reliability (Petter et al. 2007). However, they can be checked for stability by assessing multicollinearity. Multicollinearity can suggest that items are tapping into the same aspect of the construct and lead to model instability (Diamantopoulos and Winklhofer 2001). We examined the variance inflation factor

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[3] While finding consensus on benchmarks can be difficult, in the information systems literature an SRMR < .05 has been suggested as an appropriate rule of thumb (Gefen et al. 2000). Our SRMR value of .07 did not reach this more conservative threshold. Larger SRMR values reflect higher residual variance and are indicative of poorer model fit, which is a potential limitation. However, other fit statistics for the model fall with accepted ranges, suggesting that the measurement model is generally a good reflection of the data.

Table 2. Loadings and Crossloadings

| Construct | Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Project complexity | Complexity1 | 0.78 | 0.24 | 0.25 | 0.27 | 0.25 | 0.26 | 0.38 | 0.17 | 0.25 |
| | Complexity2 | 0.75 | 0.27 | 0.19 | 0.21 | 0.22 | 0.28 | 0.26 | 0.32 | 0.23 |
| Role ambiguity | R.Ambiguity1 | 0.17 | 0.79 | 0.25 | 0.13 | 0.20 | 0.31 | 0.24 | 0.15 | 0.29 |
| | R.Ambiguity2 | 0.32 | 0.73 | 0.29 | 0.28 | 0.29 | 0.23 | 0.22 | 0.31 | 0.23 |
| | R.Ambiguity3 | 0.37 | 0.75 | 0.21 | 0.31 | 0.23 | 0.33 | 0.22 | 0.22 | 0.36 |
| | R.Ambiguity4 | 0.31 | 0.76 | 0.37 | 0.24 | 0.28 | 0.38 | 0.32 | 0.26 | 0.19 |
| | R.Ambiguity5 | 0.14 | 0.75 | 0.13 | 0.22 | 0.14 | 0.36 | 0.15 | 0.27 | 0.14 |
| | R.Ambiguity6 | 0.27 | 0.74 | 0.27 | 0.27 | 0.13 | 0.34 | 0.21 | 0.25 | 0.20 |
| | R.Ambiguity7 | 0.35 | 0.77 | 0.21 | 0.35 | 0.24 | 0.17 | 0.18 | 0.26 | 0.16 |
| | R.Ambiguity8 | 0.33 | 0.73 | 0.31 | 0.31 | 0.20 | 0.29 | 0.17 | 0.14 | 0.30 |
| | R.Ambiguity9 | 0.29 | 0.76 | 0.19 | 0.20 | 0.37 | 0.21 | 0.14 | 0.14 | 0.13 |
| | R.Ambiguity10 | 0.19 | 0.82 | 0.17 | 0.36 | 0.13 | 0.28 | 0.15 | 0.19 | 0.32 |
| | R.Ambiguity11 | 0.21 | 0.77 | 0.26 | 0.15 | 0.17 | 0.16 | 0.19 | 0.36 | 0.16 |
| Role conflict | R.Conflict1 | 0.18 | 0.33 | 0.73 | 0.15 | 0.29 | 0.15 | 0.35 | 0.20 | 0.34 |
| | R.Conflict2 | 0.34 | 0.16 | 0.78 | 0.25 | 0.17 | 0.27 | 0.32 | 0.13 | 0.24 |
| | R.Conflict3 | 0.29 | 0.26 | 0.79 | 0.37 | 0.33 | 0.26 | 0.13 | 0.35 | 0.31 |
| | R.Conflict4 | 0.32 | 0.24 | 0.81 | 0.16 | 0.35 | 0.20 | 0.19 | 0.22 | 0.31 |
| | R.Conflict5 | 0.25 | 0.31 | 0.81 | 0.16 | 0.35 | 0.19 | 0.20 | 0.29 | 0.21 |
| | R.Conflict6 | 0.37 | 0.29 | 0.80 | 0.36 | 0.29 | 0.30 | 0.35 | 0.16 | 0.34 |
| | R.Conflict7 | 0.19 | 0.14 | 0.80 | 0.34 | 0.16 | 0.19 | 0.16 | 0.13 | 0.18 |
| E.Leadership: Leading by example | E.Leadership1 | 0.27 | 0.20 | 0.15 | 0.81 | 0.22 | 0.37 | 0.30 | 0.24 | 0.25 |
| | E.Leadership2 | 0.25 | 0.37 | 0.23 | 0.76 | 0.14 | 0.22 | 0.21 | 0.22 | 0.24 |
| | E.Leadership3 | 0.22 | 0.38 | 0.17 | 0.75 | 0.36 | 0.16 | 0.36 | 0.19 | 0.22 |
| E.Leadership: Participative decision making | E.Leadership4 | 0.17 | 0.25 | 0.32 | 0.36 | 0.75 | 0.13 | 0.33 | 0.13 | 0.21 |
| | E.Leadership5 | 0.28 | 0.18 | 0.17 | 0.19 | 0.76 | 0.30 | 0.18 | 0.13 | 0.17 |
| | E.Leadership6 | 0.37 | 0.33 | 0.15 | 0.16 | 0.77 | 0.21 | 0.23 | 0.21 | 0.29 |
| E.Leadership: Coaching | E.Leadership7 | 0.24 | 0.21 | 0.37 | 0.21 | 0.29 | 0.82 | 0.37 | 0.14 | 0.30 |
| | E.Leadership8 | 0.15 | 0.23 | 0.17 | 0.14 | 0.15 | 0.75 | 0.35 | 0.32 | 0.33 |
| | E.Leadership9 | 0.38 | 0.20 | 0.24 | 0.26 | 0.33 | 0.74 | 0.22 | 0.28 | 0.38 |
| E.Leadership: Informing | E.Leadership10 | 0.38 | 0.34 | 0.24 | 0.25 | 0.32 | 0.28 | 0.79 | 0.37 | 0.35 |
| | E.Leadership11 | 0.15 | 0.36 | 0.21 | 0.37 | 0.35 | 0.20 | 0.86 | 0.34 | 0.33 |
| | E.Leadership12 | 0.36 | 0.15 | 0.14 | 0.29 | 0.25 | 0.36 | 0.78 | 0.20 | 0.28 |
| E.Leadership: Showing concern | E.Leadership13 | 0.30 | 0.15 | 0.20 | 0.31 | 0.28 | 0.27 | 0.15 | 0.76 | 0.35 |
| | E.Leadership14 | 0.29 | 0.15 | 0.26 | 0.18 | 0.24 | 0.24 | 0.23 | 0.77 | 0.21 |
| | E.Leadership15 | 0.27 | 0.30 | 0.17 | 0.26 | 0.30 | 0.18 | 0.34 | 0.82 | 0.33 |
| Stress | Stress1 | 0.30 | 0.22 | 0.37 | 0.19 | 0.13 | 0.28 | 0.24 | 0.22 | 0.78 |
| | Stress2 | 0.37 | 0.37 | 0.18 | 0.20 | 0.16 | 0.21 | 0.38 | 0.28 | 0.76 |
| | Stress3 | 0.24 | 0.19 | 0.19 | 0.30 | 0.31 | 0.32 | 0.15 | 0.18 | 0.73 |
| | Stress4 | 0.31 | 0.28 | 0.35 | 0.33 | 0.29 | 0.30 | 0.34 | 0.29 | 0.78 |
| | Stress5 | 0.25 | 0.26 | 0.17 | 0.33 | 0.31 | 0.32 | 0.20 | 0.19 | 0.79 |
| | Stress6 | 0.18 | 0.38 | 0.17 | 0.36 | 0.20 | 0.27 | 0.22 | 0.17 | 0.85 |
| | Stress7 | 0.35 | 0.16 | 0.37 | 0.29 | 0.20 | 0.19 | 0.30 | 0.27 | 0.76 |

(VIF) to determine if multicollinearity was an issue. The VIFs were less than 3.0, indicating that multicollinearity was not a concern (Diamantopoulos and Winklhofer 2001). The validity of formative measures involves examination of the item weights (Petter et al. 2007). Although there is no recommended cut-off value, significant weights provide insight into the importance of each indicator. When formative indicators explain all of the variance in a construct, the average of their weights is $\sqrt{(1/n)}$, where n is the number of indicators (Klein and Rai 2009). Thus, the maximum average weight is .50 for project size (4 indicators) and .58 for target volatility (3 indicators). The weights of the indicators for project size—duration, cost, relative size, and effort—were .40, .55, .41, and .43, respectively. The weights of the indicators for target volatility—changes in budget, schedule, and scope—were .33, .67, and .69, respectively.[4] Finally, to assess discriminant validity, we examined item-to-item and item-to-construct correlations (Petter et al. 2007). This analysis revealed that item-to-item correlations were higher than item-to construct correlations and that the items had higher correlations with the composite scores of their proposed construct than with the scores of other constructs, supporting discriminant validity. Thus, we conclude that the model demonstrates acceptable validity and reliability.

### 3.5 Construct Aggregation

Given the multilevel nature of the data as well as the cross-level relationships being examined, we used random coefficient modeling (RCM) to test the research model. Like other regression-based approaches, RCM does not use latent constructs in estimating the coefficients. Consequently, for each reflective construct, we averaged the item-level scores to compute a single variable score. This approach is also appropriate for first- and second-order reflective constructs such as empowering leadership (Tanriverdi and Uysal 2011). Formative measures were aggregated to single variable scores by averaging unit weights, consistent with prior research (Rai and Tang 2010). Empowering leadership is a team-level construct that was measured by eliciting responses from multiple developers in each team, thus requiring aggregation of the individual responses to compute team-level scores. To justify this aggregation, we examined three statistics. The intraclass correlation coefficients, ICC[1] and ICC[2], reflect the variability in individual-level responses that can be attributed to team membership and the reliability of group-level means, respectively (Bliese 2000). The within-group agreement index, $rwg_{(j)}$, reflects the extent to which responses from developers on the same team converge greater than would be expected by chance (James et al. 1984). For the empowering leadership scales, the ICC[1] and ICC[2] values were .29 and .71, respectively. The average $rwg_{(j)}$ for the sample was .70. Collectively, these values meet suggested thresholds (average

[4] Given the relatively high weights for the indicators of target volatility, we also estimated models using a reflective specification. As would be expected when using linear composites, the results of the analysis using a reflective specification for target volatility were highly similar to those involving a formative specification (Rozeboom 1979).

$r_{wg(j)}$ threshold = .70; ICC[2] threshold = .70 ) , justifying aggregation of individual scores to the team level (Bliese 2000). We averaged the scores of developers within each team to compute a single team-level score for each team.

## 4. Results

### 4.1. Model Testing

Table 3 presents the descriptive statistics and correlations. Consistent with prior research (e.g., Rai et al. 2009), project size, target volatility, and complexity were positively and significantly correlated. Project size, complexity, and target volatility were positively correlated with role ambiguity, and project size and complexity were positively correlated with role ambiguity and role conflict. Empowering leadership was positively correlated with project size, target volatility, and complexity and negatively correlated with role ambiguity, role conflict, and stress. Project size, complexity, target volatility, role ambiguity, and role conflict were all positively correlated with stress. These relationships were in the expected directions and lend preliminary support for the model.

Given the hierarchically nested nature of the model and data, traditional ordinary least square (OLS) approaches are inappropriate. These traditional approaches do not allow for a simultaneous examination of relationships at different levels of analysis. Thus, the multilevel relationships were tested with RCM using the software R (version 2.6.2). RCM allows for an examination of relationships that cross levels of analysis and partitions the variance in the dependent variable into lower-level and unit-level components (Hofmann 1997). RCM also accounts for the nested structure of the data and accounts for non-independence of the observations (Bliese and Hanges 2004), which is particularly important in the current model in which developers were nested within projects and observations at the project level were not independent for developers on the same team. This is crucial, as failure to account for non-independence can result in inflated variance in the standard errors, which increases the likelihood of Type II error. Further, the assumption of no between-unit variance can lead to poorly estimated standard errors, thus increasing the likelihood of Type I error. RCM accounts for both between-unit variance in the dependent variable and non-independence of observations, which made this approach particularly well suited for model testing. Before estimating the model, empowering leadership, project size, complexity, and target volatility were grand mean-centered, while role ambiguity and role conflict were group mean-centered. This approach is recommended for cross-level moderation models to reduce collinearity (Chen et al. 2004, Hofmann and Gavin 1998). Group mean-centering eliminates the confounding effects of the between-group interaction between empowering

Table 3. Descriptive Statistics and Correlations

| | M | S.D. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Developer location | 1.09 | 0.80 | NA | | | | | | | | | | | | | |
| 2. Developer experience | 4.01 | 1.71 | -.05 | NA | | | | | | | | | | | | |
| 3. Team size | 10.00 | 1.53 | -.08 | .05 | NA | | | | | | | | | | | |
| 4. Team distribution | 4.98 | 1.37 | .10 | .15* | .17** | NA | | | | | | | | | | |
| 5. Leader experience | 4.84 | 1.39 | .14* | .19** | .26*** | .16** | NA | | | | | | | | | |
| 6. Managerial proj. control | 4.17 | 1.28 | .17** | -.14* | .19** | .17** | .16** | NA | | | | | | | | |
| 7. Empowering leadership | 4.10 | 1.47 | .13* | -.17** | .24*** | .19** | .25*** | .19** | NA | | | | | | | |
| 8. Project size | 73211.00 | 10220.00 | .14* | .15* | .29*** | .20** | .13* | .10 | .24*** | NA | | | | | | |
| 9. Project complexity | 4.27 | 1.51 | .10 | -.05 | .16** | .15* | .14* | .07 | .28*** | .38*** | .71 | | | | | |
| 10. Target volatility | 3.95 | 1.70 | .13* | .20** | .20** | .19** | .22*** | .14* | .29*** | .34*** | .32*** | NA | | | | |
| 11. Role ambiguity | 4.21 | 1.70 | -.04 | .01 | .09 | .14* | -.19** | -.20** | -.37*** | .29*** | .11* | .20** | .79 | | | |
| 12. Role conflict | 4.32 | 1.55 | .03 | -.04 | .06 | .20** | -.25*** | -.17** | -.31*** | .28*** | .23*** | .17** | .14** | .80 | | |
| 13. Pre-project job stress | 3.77 | 1.23 | -.08 | .04 | .05 | .15* | -.17** | -.19** | -.19** | .15* | .07 | .10 | .05 | .04 | .75 | |
| 14. Stress | 4.42 | 1.50 | -.01 | .05 | .02 | .20** | -.24*** | -.24*** | -.39*** | .24*** | .14** | .20** | .24*** | .19** | .32*** | .77 |

*Notes: 1. Developer location is a dummy variable representing where developers work. 0 = China, 1 = U.S. and 2 = India; 2. Level-1 n = 350; Level-2 n = 73; 3. p < .001; **p < .01; *p < .05; Average variance extracted is shown on the diagonal.*

leadership and role perceptions (Hofmann and Gavin 1998). Consistent with prior research, OLS was used to estimate effect sizes (Hofmann et al. 2003). Although nested models violate the assumption of independence required for OLS, the overall $R^2$ values provide unbiased estimates of the variance accounted for by the models (Hofmann et al. 2003).We next present the results according to the type of relationship tested. First, we discuss H1, H2, H5, and H6 that hypothesize cross-level direct effects. Next, we discuss H3 and H7 that hypothesize cross-level moderation effects. Finally, we discuss H4 and H8 that hypothesize within-level direct effects.

### 4.2. Cross-level Direct Effects

H1 predicted that technical ISD risk factors would have a positive, cross-level effect on role ambiguity and role conflict, respectively. Models 2 and 5 of Table 4 show the direct effects of technical ISD risk factors on role perceptions. Project size, complexity, and target volatility had a positive effect on role ambiguity ($\gamma = .21$, $p < .001$, $\gamma = .12$, $p < .05$, and $\gamma = .14$, $p < .05$, respectively), whereas project size and complexity had a positive effect on role conflict ($\gamma = .17$, $p < .01$ and $\gamma = .23$, $p < .001$, respectively). Thus, H1 was partially supported. These models explained 22% of the variance in role ambiguity and 26% of the variance in role conflict. H2 predicted that empowering leadership would have a negative, cross-level effect on role ambiguity and role conflict. Models 1 and 4 of Table 4 show that empowering leadership had a significant, negative effect on role ambiguity ($\gamma = -.26$, $p < .001$) and role conflict ($\gamma = -.23$, $p < .001$), providing support for H2. H5 predicted that empowering leadership would have a negative, cross-level effect on stress. Model 7 of Table 4 shows that empowering leadership had a significant, negative effect on stress ($\gamma = -.21$, $p < .001$). Thus, H5 was supported. H6 predicted that technical ISD risk factors would have a positive, cross-level effect on stress. Model 8 of Table 4 shows that project size and target volatility had a significant, positive effect on stress ($\gamma = .15$, $p < .05$, $\gamma = .13$, $p < .05$, respectively). Thus, H6 was partially supported. This model explained 31% of the variance in stress.

In terms of cross-level direct effects of the control variables, leader experience, managerial project control, and pre-project job stress has the most consistent impacts on role ambiguity, role conflict, and stress. Leader experience and project control consistently reduced role ambiguity, role conflict, and stress. Pre-project job stress significantly increased stress related to the project.

Table 4. Results of RCM Analysis

| Dependent Variable: | Role Ambiguity | | | Role Conflict | | | Stress | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | Model 9 | Model 10 |
| $R^2$ | .14 | .22 | .39 | .14 | .26 | .40 | .24 | .31 | .39 | .42 |
| Adj. $R^2$ | .13 | .21 | .38 | .13 | .25 | .39 | .23 | .30 | .38 | .41 |
| AIC | 1212.30 | 1190.40 | 1125.28 | 1321.30 | 1232.17 | 1124.08 | 1333.10 | 1280.50 | 1210.44 | 1108.12 |
| BIC | 1330.20 | 1149.58 | 1101.07 | 1391.44 | 1320.10 | 1207.41 | 1380.14 | 1329.13 | 1255.62 | 1150.13 |
| *Developer location* | .05 (.05) | .05 (.11) | .06 (.10) | .08 (.10) | .08 (.11) | .07 (.11) | .06 (.11) | .05 (.10) | .04 (.11) | .02 (.11) |
| *Developer experience* | -.03 (.05) | -.07 (.04) | -.06 (.05) | .07 (.05) | .04 (.04) | .03 (.05) | .02 (.05) | .03 (.05) | .03 (.06) | .02 (.07) |
| *Team size* | -.07 (.06) | -.02 (.06) | -.05 (.06) | -.06 (.06) | -.04 (.06) | -.04 (.06) | -.03 (.07) | -.02 (.07) | -.01 (.07) | -.01 (.07) |
| *Team distribution* | .08 (.04) | .07 (.04) | .07 (.04) | .13* (.02) | .12* (.02) | .10 (.03) | .14* (.02) | .13* (.02) | .10 (.03) | .08 (.04) |
| *Leader experience* | -.13* (.01) | -.12* (.01) | -.12* (.01) | -.17** (.02) | -.15* (.03) | -.13* (.03) | -.13* (.02) | -.12* (.02) | -.10 (.03) | -.07 (.05) |
| *Managerial proj. control* | -.14* (.01) | -.13* (.01) | -.12* (.01) | -.12* (.02) | -.10 (.03) | -.09 (.03) | -.16** (.02) | -.15* (.02) | -.13* (.02) | -.12* (.02) |
| *Pre-project job stress* | | | | | | | .25*** (.02) | .18** (.02) | .17** (.02) | .16** (.02) |
| E.Leadership | -.26*** (.04) | -.24*** (.03) | -.17** (.02) | -.23*** (.03) | -.22*** (.03) | -.20** (.03) | -.21*** (.02) | -.20** (.02) | -.17** ( .03) | -.16** (.02) |
| P.Size | | .21*** (.02) | .15* (.02) | | .17** (.03) | .16** (.03) | | .15* (.03) | .14* (.03) | .12* (.03) |
| P.Complexity | | .12* (.04) | .10 (.05) | | .23*** (.02) | .21*** (.02) | | .10 (.04) | .07 (.05) | .06 (.06) |
| T.Volatility | | .14* (.03) | .12* (.03) | | .10 (.04) | .07 (.05) | | .13* (.02) | .10 (.04) | .08 (.05) |
| E.Leadership*Size | | | -.20** (.02) | | | -.17** (.02) | | | -.13* (.03) | |
| E.Leadership*Complexity | | | .08 (.04) | | | -.19** (.02) | | | -.12* (.03) | |
| E.Leadership *Volatility | | | -.21*** (.02) | | | -.21*** (.02) | | | -.17** (.02) | |
| Role ambiguity | | | | | | | | | | .22*** (.03) |
| Role conflict | | | | | | | | | | .16** (.02) |

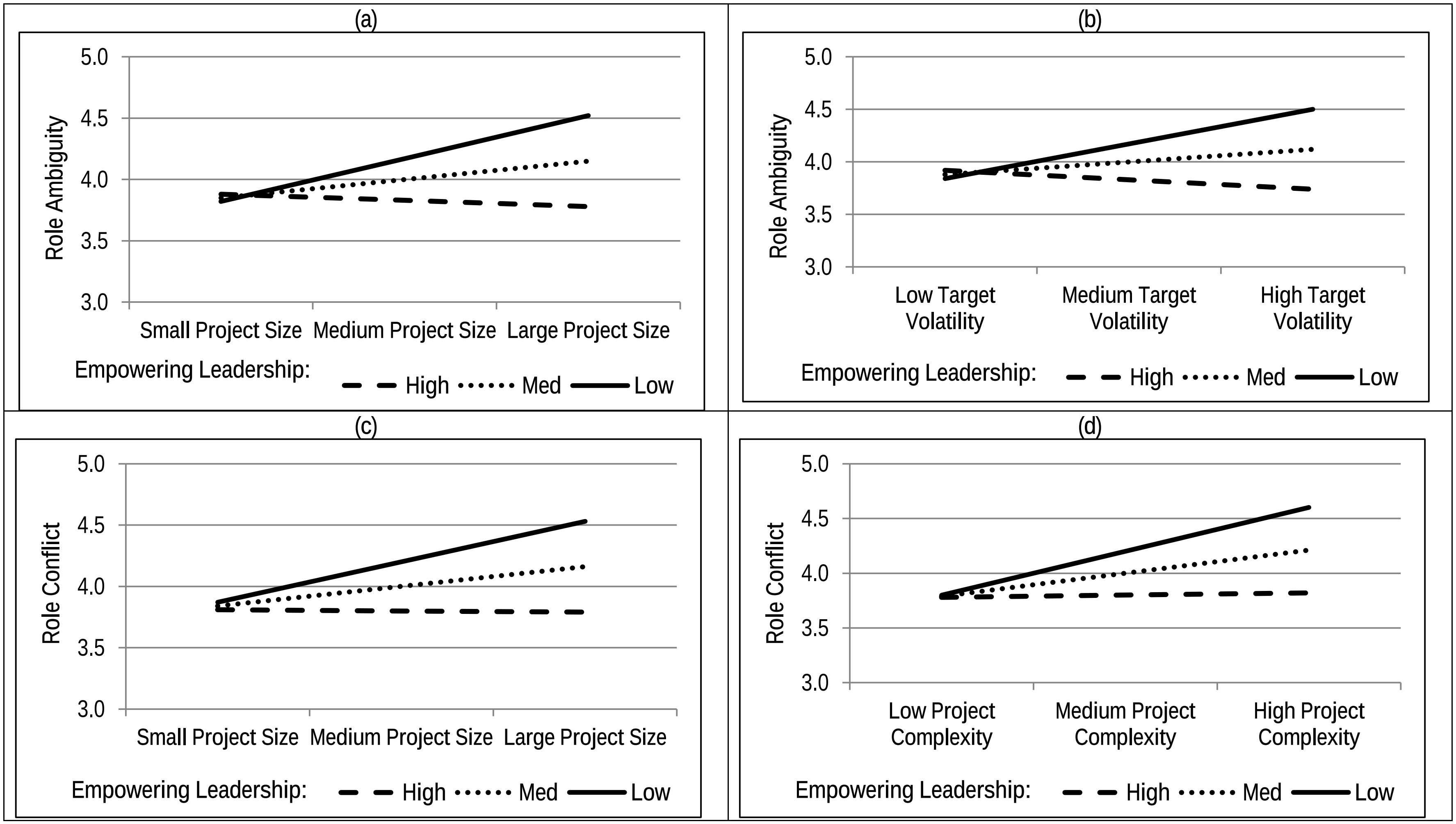
*Notes: 1. Italicized variables are controls; E.Leadership = Empowering leadership, P.Size = Project size, P.Complexity = Project complexity; T.Volatility = Target volatility; 2. Level-1 n = 350; Level-2 n = 73; Level-1 variables include developer location, developer experience, pre-project job stress, role ambiguity, role conflict, and stress. Level-2 variables include team size, team distribution, leader experience, managerial project control, empowering leadership, project size, project complexity, and target volatility; 3. Standard errors are in parentheses; 4. *** p < .001, **p < .01, *p < .05*

### 4.3. Cross-level Moderation Effects

H3 predicted that empowering leadership would reduce the negative impact of technical ISD risk factors on developers' role perceptions. Model 3 of Table 4 shows that empowering leadership interacted with project size ($\gamma = -.20$, $p < .01$) and target volatility ($\gamma = -.21$, $p < .001$) in influencing role ambiguity, explaining 39% of the variance ($\Delta R^2 = .17$). Model 6 of Table 4 shows that empowering leadership interacted with project size ($\gamma = -.17$, $p < .01$), complexity ($\gamma = -.19$, $p < .01$), and target volatility ($\gamma = -.21$, $p < .001$) to influence role conflict. This interaction model explained 40% of the variance in role conflict ($\Delta R^2 = .14$). H7 predicted that empowering leadership would reduce the negative impact of technical ISD risk factors on developers' stress. Model 9 of Table 4 shows that empowering leadership interacted with project size ($\gamma = -.13$, $p < .05$), complexity ($\gamma = -.12$, $p < .05$), and target volatility ($\gamma = -.17$, $p < .05$), explaining 39% of the variance in stress ($\Delta R^2 = .08$). Table 4 also reports two deviance statistics to help assess model fit: the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). These statistics allow for a comparison between the direct effects and interaction models by demonstrating the tradeoff between model accuracy (fit) and complexity (Akaike 1974, Schwarz 1978). Both measures penalize models with superfluous parameters by adding to their measure of deviance, though the BIC takes sample size into account and thus is a more conservative measure (Akaike 1974, Schwarz 1978). The lower the AIC and BIC values are, the better the model fits the data. As can be seen in Table 4, the interaction models (Models 3, 6, and 9) had lower AIC and BIC values than their direct-effects counterparts (Models 1, 2, 4, 5, 7, and 8) and thus better fit the data.

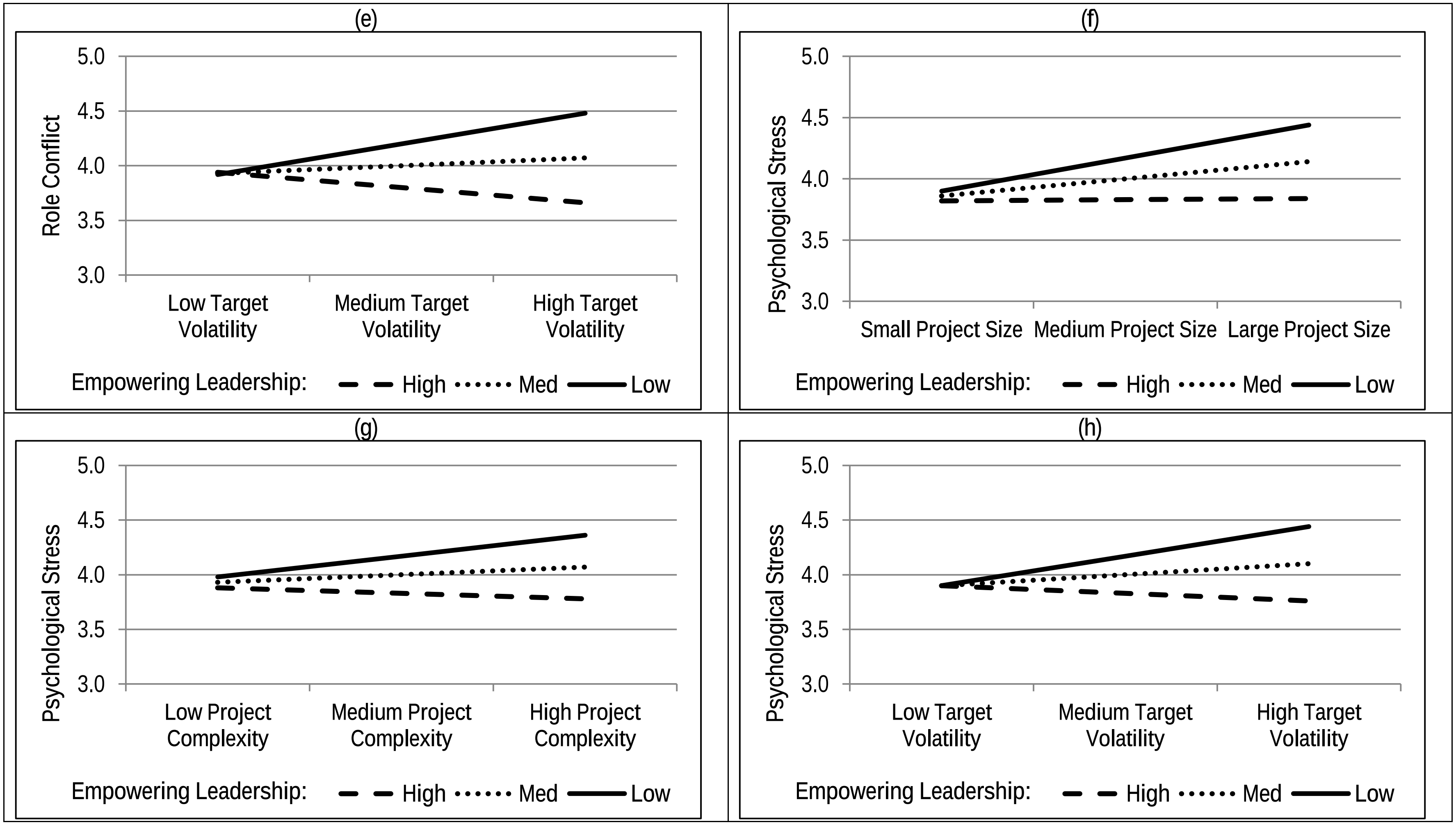
To further probe the interaction effects, the significant interactions were plotted following the guidelines of Aiken and West (1991). Figures 2a through 2h show the plots, which are highly consistent with one another. Each of the plots shows that, given the same level of technical ISD risk factors, when empowering leadership increased, role ambiguity and role conflict decreased. In every case, when project size, complexity, or target volatility were at their highest, role ambiguity, role conflict, and stress were lowest under conditions of high empowering leadership. This suggests that empowering leadership was especially beneficial under conditions of high technical ISD risk. In addition, the slopes of the lines representing low empowering leadership are steeper than the slopes representing high empowering leadership, suggesting that the relationship between technical ISD risk factors, role perceptions, and stress were weaker when empowering leadership was high, compared to low.

Figure 2. Interaction Plots for Technical ISD Project Risk Factors and Empowering Leadership on Role Ambiguity, Role Conflict, and Stress




Note: For all interaction plots, low = 1 standard deviation below the mean, medium = mean, high = 1 standard deviation above the mean.

Figure 2 continued…




Note: For all interaction plots, low = 1 standard deviation below the mean, medium = mean, high = 1 standard deviation above the mean.

We also conducted simple slopes tests to determine whether the slope of the regression lines in the plots below were significantly different from zero. Only four of the slopes in Figures 2a-2h were not significantly different from zero. In Figure 2e, the slope representing medium empowering leadership was not significantly different from zero, suggesting that role conflict did not change across varying levels of target volatility when empowering leadership was at moderate levels. In Figure 2f, the slope representing low empowering leadership was not significantly different from zero, suggesting that psychological stress did not change across varying project sizes when empowering leadership was low. For the plots shown in Figures 2g and 2h, the slopes representing moderate empowering leadership were not significantly different from zero, suggesting that psychological stress did not change across varying levels of project complexity or target volatility when empowering leadership was at moderate levels. Figures 2a-2h provide support for H3 and H7.

### 4.4. Within-level Direct Effect

H4 predicted that role ambiguity and role conflict would have a positive effect on stress. Model 10 of Table 4 shows that role ambiguity and role conflict had a positive effect on stress ($\gamma = .22$, $p < .001$ and $\gamma = .16$, $p < .01$, respectively), providing support for H4. This model explained 42% of the variance in stress. H8 involved relationships at the team level of analysis and all variables resided at the team level. Therefore, the variance components for all variables were at a single level, making OLS an appropriate method of testing H8. Table 5 shows the result of this analysis. In terms of the control variables, team distribution, leader experience, and project control accounted for significant variance in empowering leadership. These variables had positive coefficients, indicating that empowering leadership increased when teams were highly distributed across locations, leaders were more experienced, and managerial project control mechanisms were used more extensively. H8 predicted that technical ISD risk factors—project size, complexity, and target volatility—would positively influence empowering leadership and this was supported ($\beta = .12$, $p < .05$, $\beta = .20$, $p < .01$, $\beta = .16$, $p < .01$, respectively). This model explained 24% of the variance in empowering leadership.

### 4.3. Common Method Bias

Because the data were collected via one method, common method bias (CMB) is a potential threat. This concern is alleviated to some degree by having followed recommended steps to reduce CMB (Podsakoff et al. 2003). The constructs were measured from different sources (developers and leaders). Steps were taken to communicate to respondents that their anonymity would be protected (the surveys were administered by an external market research firm)

Table 5. Regression Analysis Examining Impact of Technical ISD Risk Factors on Empowering Leadership

| | Model 1 | Model 2 |
|---|---|---|
| $R^2$ | .11 | .24 |
| Adj. $R^2$ | .10 | .23 |
| *F* | 3.18** | 11.44*** |
| $\Delta F$ | | |
| *Team size* | .10 (.08) | .08 (.08) |
| *Team distribution* | .13* (.02) | .12* (.02) |
| *Leader experience* | .16** (.02) | .13* (.02) |
| *Developer experience* | -.05 (.13) | .03 (.17) |
| *Managerial proj. control* | .13* (.02) | .12* (.03) |
| Project size | | .12* (.02) |
| Project complexity | | .20** (.04) |
| Target volatility | | .16** (.02) |

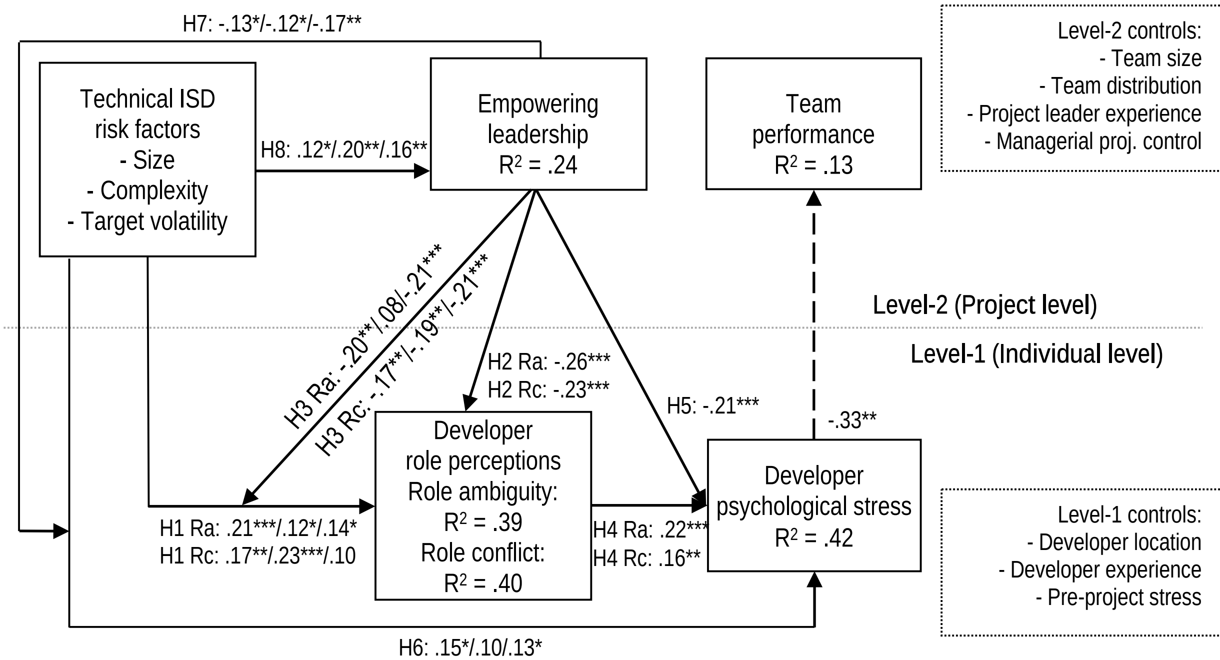
*Notes: 1. Italicized variables are controls. Team distribution is calculated using Blau's (1977) index of variability; 2. Standard errors are in parentheses; 3. n = 73; 4. *** p < .001, **p < .01, *p < .05*

to reduce evaluation apprehension and threats of social desirability bias. Moreover, CMB is less of a concern when a moderating effect is present, as is the case with our research. As Dong et al. (2009, p. 28) explain, "[t]he logic is that, if common method variance is substantial, it should be present regardless of the level of the moderator. Then, it is difficult to explain why the independent variables are more or less strongly related depending on the level of the moderator." Despite these assurances, we conducted statistical analyses using the marker-variable technique to further minimize concerns related to CMB (Lindell and Whitney 2001, Malhotra et al. 2006). We selected the second smallest positive correlation among constructs to represent potential CMB and used this to produce a CMB-adjusted correlation matrix. The matrix was then used to estimate CMB-adjusted path coefficients and variances explained. CMB is a threat if there are substantial differences between the CMB-adjusted estimates and the original estimates. The results from this analysis showed that the coefficients did not change by more than .03 and the variances explained changed by no more than 2%. Thus, we conclude that CMB is unlikely to be a threat to the validity of the results.

### 4.4 Supplemental Analysis

To enhance nomological validity and lend credibility to our results, we examined the downstream consequences of stress for team performance. A full description of this analysis is provided in online Appendix A. The results showed that team stress did have a significant effect on team performance. The model explained 13% of the variance in team performance. For ease of interpretation, a summary of the results from the RCM and OLS analyses is shown in Figure 3.

Figure 3. Summary of Model Testing Results




*Notes: These results are a summary of the coefficients from the random coefficient modeling and OLS regression in Tables 4 and 5. They are not results from a structural equation model. Ra = effect on Role ambiguity; Rc = effect on Role conflict; Coefficients separated by a "/" correspond to the path weights for project size, complexity, and target volatility, respectively; *** p < .001, **p < .01, *p < .05.*

## 5. Discussion

The objective of this research was to examine how technical ISD risk factors affect developer stress, the mechanisms by which this occurs, and what project leaders can do to mitigate the deleterious effects of technical ISD risk factors. Drawing on the JDCM, we hypothesized that project size, complexity, and target volatility represent demands that increase role ambiguity and role conflict. We also argued that empowering leadership, which reflects the sense of control afforded to developers regarding their work, would mitigate these effects as well as the effects of technical ISD risk factors on stress. Empowering leadership was also argued to directly reduce role ambiguity, role conflict, and stress. Technical ISD risk factors and role perceptions were hypothesized to contribute to developers' psychological stress. The multilevel model was tested among 73 ISD teams composed of 350 developers and their leaders. The results indicate that, when project size, complexity, and target volatility are high, empowering leadership reduces their impact on role ambiguity and when project size and complexity are high, empowering leadership reduces their impact on role conflict. When project size and target volatility are high, empowering leadership reduces their impact on stress. Technical ISD risk factors increase empowering leadership behaviors, while empowering leadership directly reduces role ambiguity, role conflict, and stress. Finally, project size, role ambiguity, and role conflict increase developer stress.

### 5.1. Theoretical Contributions and Future Research Directions

Our first research question was, "what are the implications of technical ISD risk factors for developer stress?" We contribute to the ISD project management literature by extending research on technical ISD risk factors and project-level outcomes by identifying the deleterious cross-level effects of technical ISD risk factors on developer stress. Overall, developer well-being is an important component of ISD project success and should be included in the nomological network of ISD. By leveraging the JDCM as the overarching theoretical lens (Karasek 1979, Van der Doef and Maes 1999), this research provides insight, not only on the effects of technical ISD risk factors, but also on the project leader interventions that ameliorate these effects. We extend the project risk framework advanced by Wallace et al. (2004) into the multilevel domain by examining how the demands created by technical ISD risk factors and the control provided through empowering leadership affect developer stress. In doing so, the multilevel nature of this research supports a shift toward a social actor approach in IS research (Lamb and Kling 2003, Xu and Zhang 2013). This shift contributes a deeper and more holistic understanding of the project-level effects of demands and control inherent in ISD projects on developers embedded in teams. By focusing on how developers and leaders respond to their project environment, we shed light on how and why technical ISD risk factors influence developer outcomes. Thus, we augment prior research on team-, project-, and organizational-level outcomes (e.g., Dong et al. 2009, Thamhain 2004, Wallace et al. 2004, Zhu et al. 2006a, Zhu et al. 2006b) with an understanding of how developers are affected by the joint effects of technical and managerial forces. Drawing on the JDCM, our findings show that the demands of technical ISD risk factors increase developer stress. This is particularly important given prior research showing that, under stress, developers tend to make more mistakes (Furuyama et al. 1994, Furuyama et al. 1997).

Second, in addition to understanding how technical ISD risk factors influence developer stress, it is important to understand how and why these effects occur. This drove our second research question, "what mechanisms explain how technical ISD risk factors affect developer stress?" Our research contributes to the project management literature by identifying cross-level mechanisms (i.e., role perceptions) by which technical ISD risk factors influence developer stress. By focusing on the project level only, prior work has overlooked developers' perceptions of role expectations. This is problematic because ISD success hinges on the ability of developers to coordinate multiple inputs to achieve objectives related to schedule, budget, and scope. We thus extend the literature on management of technical ISD risk factors by linking them to role ambiguity, role conflict, and stress. Specifically, project size, complexity, and target volatility exacerbate role ambiguity and role conflict, thereby shedding light on the technical ISD risk factors that drive developers' role perceptions. Technical ISD risk factors may be difficult to eliminate or control entirely but understanding the process by which they influence developers provides researchers with a point of departure for identifying how to manage them.

Third, understanding the process by which technical ISD risk factors influence developer stress helps to pinpoint possible points of intervention. We contribute to the project management literature by identifying a project management intervention for managing technical ISD risk factors, and thus addressing our third research question, "what role do leaders play in enabling developers to cope with the stress caused by technical ISD risk factors?" This augments existing ISD risk frameworks that account for the effects of technical ISD risk factors on project outcomes and highlight a need for interventions to mitigate such effects (Gemino et al. 2008, Wallace et al. 2004). Our research shows that project leaders can play an active role in reducing the negative effects of technical ISD risk factors on role perceptions, as well as help directly clarify developers' roles and reduce stress, by engaging in empowering leadership behaviors. To our knowledge, prior research has not explored project management interventions to reduce role ambiguity and role conflict. This gap in the literature is significant, given that stress has particularly negative consequences for software quality (Furuyama et al. 1994, Furuyama et al. 1997). The results of this research show that the empowering leadership approach is effective in reducing the impact of technical ISD risk factors on role ambiguity and role conflict and in reducing role ambiguity, role conflict, and stress directly. Thus, the current study unites the project management and leadership literatures to shed light on the theoretical mechanisms by which leadership behaviors can reduce stress among developers in large, complex, volatile project contexts.

### 5.2. Limitations and Future Research Directions

We note four limitations of this work and future research directions that emerge from the same. First, although we gathered multiple waves of data, the study may not capture different influences of technical ISD risk factors and empowering leadership as they fluctuate over the course of a project. Longitudinal research is needed to shed light on the effectiveness of empowering leadership in mitigating the influence of technical ISD risk factors and lowering role conflict and ambiguity throughout the team's life cycle.

Second, although the collection of multiwave, multisource, and multinational field data represents a strength of the study in terms of enhancing its external validity (e.g., Hsieh et al. 2011, Zhu et al. 2006a), data were collected from one organization. Although the sample spanned several different countries and nationalities, the work practices, culture, and climate of the participating organization may be somewhat unique. Future research with other samples will be needed to tease out any such effects. Such multi-organizational studies may be particularly suited to delve into social risks that could vary greatly across organizations.

Third, this research focused on technical ISD risk factors. This focus was driven by theoretical considerations regarding role stressors in ISD. Nevertheless, Wallace et al. (2004) identify social and environmental aspects of an ISD project, such as conflict with users and budget or schedule pressure as other sources of project risk. These are important potential risk factors that could have implications for role perceptions and stress. Other project characteristics have been identified as possible risk factors, such as team composition, availability of expertise, and top management support (Banker et al. 1998, Barki et al. 1993, Gopal et al. 2002, Griffin 1997, Jiang et al. 2000, Schmidt et al. 2001). By extension, mechanisms that complement empowering leadership may be of interest to future researchers. For example, while empowering leadership can enhance a developer's sense of control, it is possible that a developer's self-efficacy may play a role in the extent to which they act on their control. Developers with low levels of self-efficacy may not react well to an empowerment approach because they feel incapable of the responsibility associated with greater decision latitude. Investigating such possibilities will enhance our understanding of the conditions that are appropriate for an empowering leadership approach.

Fourth, due to the constructs on the survey and the multiple measurement points, we had to make trade-offs between comprehensiveness and length. The measure we used for project complexity (Gemino et al. 2008) was composed of just two items and focused on complexity due to integration and interface with other sub-systems. This may be one possible explanation for why empowering leadership did not moderate the impact of project complexity on role ambiguity. Other aspects of technical complexity, such as the newness of the technology (Barki et al. 1993), represent possible technical ISD risk factors that could have implications for role perceptions, particularly role ambiguity because role definition may be more fluid at the beginning of a project when multiple team members are grappling to understand a new technology. Future research is needed to explore such possibilities.

## 5.3. Practical Implications

The results of this work provide important implications for the management of ISD teams. First, we began our discussion by highlighting the increasing prevalence of stress among developers and the noting the consequences of such stress. The findings in this research represent an important first step in identifying the specific aspects of ISD projects that are likely to induce stress among individual developers. Our finding that project size, project complexity, and target volatility are positively associated with developer stress should sensitize managers and developers to the types of project conditions that make for a stressful experience. With this information, managers can be more deliberate about how they target interventions for managing stress. For instance, rather than targeting stress management interventions toward all developers, managers can identify those who are most at risk for developing stress by examining the ISD project conditions under which each developer is working. Managers can preemptively implement stress management interventions among developers working under such project conditions.

Second, in addition to identifying technical ISD risk factors as aspects of ISD projects that are stress-inducing, the findings in this research also highlight one main reason why these factors cause stress. Specifically, technical ISD project risk factors appear to induce stress by adversely affect developers' understanding of their roles and by creating conflicting role expectations. Understanding this link between technical ISD project risk factors and role perceptions represents another useful area for managerial intervention. Managers can be deliberate about establishing clear role boundaries so that developers know which tasks fall under their responsibilities which ones do not. Within each project, managers also need to be careful to evaluate the portfolio of tasks assigned to each developer in order to ensure that the tasks within the portfolio are not at odds with one another. Naturally, when technical ISD project risks are high, managers will need to monitor and revisit these role considerations periodically over the course of a project.

Third, our focus on empowering leadership provides a managerially actionable intervention. Once they are able to identify the ISD project conditions that are most likely to induce stress among developers, managers can play an important role in enabling developers to cope. Our research uncovered leading by example, participative decision making, coaching, informing, and showing concern as specific behaviors through which managers enable developers who are in stress-inducing ISD project conditions to cope. These leadership behaviors are helpful in not only enabling developers to resolve role ambiguity and role conflict, but also in reducing stress directly. Thus, managers would benefit from adding empowering leadership behaviors to their repertoire of leadership skills.

## 6. Conclusions

We presented a multilevel model of empowering leadership and technical ISD risk factors, with the objective of understanding how these forces influence stress among developers. Based on an empirical study of 350 developers embedded in 73 teams, our results showed that empowering leadership is effective in directly reducing role ambiguity and role conflict and in reducing the influence of technical ISD risk factors (size, complexity, and target volatility) on role ambiguity and role conflict. The findings have implications for leadership interventions in the ISD context and shed light on the factors that shape the efficacy of empowering leadership. In doing so, we contribute to ISD project management theories by incorporating the role of the developer. Moreover, we encourage organizations to think critically about the type of support they offer to developers as well as the training they provide to team leaders.

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