INFORMATION SYSTEMS PROJECTS AND INDIVIDUAL DEVELOPER OUTCOMES: ROLE OF PROJECT MANAGERS AND PROCESS CONTROL

ABSTRACT

We integrate control theory and the information systems (IS) project management literature using a multilevel lens to theorize the cross-level effects of technical IS project risk on individual developer outcomes—performance and psychological stress—and the mechanisms by which IS project managers' project-related knowledge attenuates this relationship. We argue that IS project managers with project-related knowledge mitigate technical IS project risk by facilitating the enactment of internal and external process controls in their IS projects. Our empirical study involves data collected from 1,230 individual developers embedded in 130 IS project teams that are managed by 20 IS project managers. Our results provide strong support for the three-level model and its set of (a) cross-level main effects of technical IS project risk on individual developer outcomes, (b) cross-level main effects of IS project manager project-related knowledge on enacted internal and external process controls, and (c) cross-level moderation of the relationship between technical IS project risk and individual developer outcomes *by* IS project manager project-related knowledge *through* internal and external process controls. Our study provides insights on how IS project management, IS project process controls, and technical IS project risk must be managed as a system of multilevel dependencies to achieve the desired developer outcomes.

INTRODUCTION

Information systems (IS) spending continues to constitute a sizable proportion of firm investment budgets, with total worldwide spending on pace to reach US$3.8 trillion in 2015 (Gartner 2015). Naturally, given the importance of these investments, providers of IS development services require process interventions that produce high quality outputs on time and within budget (e.g., Slaughter and Kirsch 2006). Failure to execute process interventions can result in significant costs. Product marketing company Avon Products recently abandoned its US$125 million project to integrate a tablet-based m-commerce front-end with a back-end enterprise system, citing problems with getting the software to work on a mobile platform among other challenges (InformationWeek 2013). And, the much-publicized problems with the rollout of the healthcare.gov site frustrated citizens keen to explore health insurance options available through the Affordable Care Act and created a backlash against the Obama Administration (CIO 2013). Such concerns have prompted IS project managers to focus on project-level interventions that promote project success. Many of these interventions are aimed at influencing the practices in IS project teams that are responsible for IS development (Keil et al. 2003). These interventions have been directed at managing the complex and non-routine nature of the development work, effectively eliciting the inputs of multiple developers and the client, and effectively integrating the complementary technological and business expertise distributed across members in the development team and personnel in the client organization (Patnayakuni et al. 2007).

Demanding IS project conditions, such as those described in the examples above, can adversely affect individual developers. This is significant because such difficult work conditions induce psychological stress, impairing cognitive functioning and resulting in software errors (Zhang and Pham 2000). The success of IS projects in meeting client needs hinges on the ability of individual developers to complete their software development task assignments and produce high quality outputs (Maruping et al. 2009b). Failure of individual developers to produce high quality outputs can result in exorbitant long-term costs (Harter et al. 2012). However, given the non-routine, unstructured nature of software development, individual developers are susceptible to IS project risk that encompasses the myriad factors that can derail an IS project. Studies have sought to identify this IS project risk (e.g., Schmidt et al. 2001; Wallace et al. 2004a, 2004b). In one of the few theoretically based comprehensive frameworks for organizing different types of IS project risk, Wallace et al. (2004a) found that technical IS project risk has the most proximal influence on the ability to execute IS project work. Technical IS project risk represents the extent to which IS projects have volatile or unclear requirements or must be deployed on multiple technology platforms (Wallace et al. 2004b).

Despite the disruptive influence of technical IS project risk, the extant literature provides little insight into how such risk affects individual developer well-being and task performance. This is a theoretically and practically significant issue that requires investigation, because as Boh et al. point out, “the largest component of software costs is for labor, i.e., developers” (2007: 1316). As already stated, the output of each individual developer is an important input into the IS project as a whole and, if deficient in quality, can derail the project or result in high maintenance costs. Additionally, the work involved in developing complex systems with uncertain requirements can create psychological stress among individual developers. Theories of psychological stress indicate that individuals experience stress from their interactions with the environment (Lazarus 1999). Such stress in a work context has been linked to decreases in performance (Chong et al. 2011; Ellis 2006). Additionally, exposure to such stressful IS project conditions could make it challenging to retain software developer talent (Ply et al. 2012). Consequently, failure to consider how individual developers are affected by technical IS project risk limits our ability to develop a more complete understanding of how to effectively manage IS projects.

Responsibility for managing IS project risk is the purview of IS project managers and failure of IS project managers to manage such risks has been identified as being among the top-three most common mistakes that lead to IS project failure (Nelson 2007). Clearly, IS project managers have a critical role to play in creating conditions that mitigate the adverse effects of technical IS project risk on individual developer outcomes. This puts IS project managers in a position to intervene in shaping how individual developers are affected by technical IS project risk. Prior research has developed some understanding of how IS project managers mitigate the detrimental effects of technical IS project risk on project-level outcomes through control (e.g., Keil et al. 2013, Maruping et al. 2009a. Although such studies provide guidance on how IS project managers mitigate the project-level effects of technical IS project risk, there is still little or no guidance about how IS project managers can mitigate the effects of such risk on individual developer outcomes. Consequently, two overarching research questions motivate this work:

RQ 1: *What is the impact of technical IS project risk on individual developer outcomes?*

RQ 2: *How does project-related knowledge enable IS project managers to mitigate the effects of technical IS project risk on individual developer outcomes?*

In order to address these research questions, we draw on two theoretical perspectives. First, we draw on Wallace et al.'s (2004a) framework of IS project risk to understand the adverse impacts of technical IS project risk on individual developer outcomes. Second, we draw on control theory to understand how and why IS project managers are able to intervene to mitigate the adverse effects of technical IS project risk on individual developer outcomes. Specifically, we focus on (1) the project-related knowledge of the IS project manager to theorize why they are able to intervene to mitigate the effects of technical IS project risk (Kirsch 1997; Kirsch et al. 2002) and (2) process control to theorize how they intervene by influencing the enactment of process controls. Finally, as we are examining these relationships across different levels of analysis, including individual, IS project and IS project manager, we adopt a multilevel theoretic lens. Multilevel research argues that organizations are open systems and as such, entities at various levels of analysis are interconnected (Klein et al. 1994; Markus and Robey 1988; Rousseau 1985). This implies that phenomena that unfold at one level of analysis can be expected to have effects on entities at other, proximal, levels of analysis (Kozlowski and Klein 2000; Orlikowski and Robey 1991). Consequently, in order to gain a more complete understanding of the phenomenon, i.e., the effects of technical IS project risk and the interventions of

IS project managers on individual developer outcomes, we need to incorporate entities at these different levels of analysis into a single model.

THEORETICAL DEVELOPMENT

In this section, we provide an overview of the IS project risk framework followed by a brief overview of control theory in IS projects. These two theoretical perspectives form the backdrop for our research model. We then describe and elaborate on the research model.

Technical IS Project Risk

The IS literature has broadly recognized that there are myriad risks that threaten to derail IS projects (Schmidt et al. 2001; Wallace et al. 2004a, 2004b). Wallace et al. (2004a) provide a useful framework for understanding IS project risk and elaborating its dimensions. Drawing from the sociotechnical system theory (Trist 1981), the IS project risk framework distinguishes between technical project risk and social project risk (Wallace et al. 2004a). *Technical IS project risk* represents the extent to which IS projects have volatile or unclear requirements and/or must be deployed on multiple, unfamiliar/new technology platforms (Schmidt et al. 2001). In contrast, social IS project risk represents the extent to which the IS project is embedded in a social context that can be unstable in terms of politics or availability of resources (Wallace et al. 2004a). Within this framework, both technical and social IS project risk are argued to increase project management risk by hampering IS project team functioning and by increasing the likelihood of poor planning and unrealistic targets. Interestingly, an empirical test of the framework showed that only technical IS project risk increases project management risk (Wallace et al. 2004a). This highlights the need for project managers to intervene in order to avert the negative effects of technical IS project risk.

In developing the IS project risk framework, Wallace et al. (2004a) identified project complexity risk and requirement risk as the underlying dimensions of technical IS project risk. *Project complexity risk* emerges when an IS project is built on an unfamiliar or new technology platform or needs to interface with multiple existing systems (Wallace et al. 2004a). *Requirement risk* represents the odds of project failure that emerges when IS project requirements are unclear or highly volatile (Nidumolu 1995). Numerous IS studies have found that project complexity risk (e.g., Espinosa et al. 2007) and requirement risk (e.g., Maruping et al. 2009a; Nidumolu 1995) reduce IS project performance. However, a majority of these studies have focused on either project complexity risk or requirement risk, but rarely both. Consequently, the technical IS project risk construct remains inadequately treated in the extant IS literature. Additionally, studies of technical IS project risk have focused exclusively at the IS project level, leaving the impacts at the individual level unexplored. As we will argue later, this technical IS project risk presents a threat to individual outcomes by changing specifications and increasing uncertainty about how task input efforts will affect outcomes (e.g., when working on unfamiliar technology platforms). Prior research (e.g., Maruping et al. 2009a; Tiwana and Keil 2010) has considered the moderating role of IS project risk—specifically, requirement risk—on the control-performance link at the IS project level. Given our interest in understanding the micro-level impacts of controls, we examine the role of IS project managers and controls in moderating the impact of technical IS project risk on individual developer outcomes.

Control in IS Projects

From a behavioral perspective, control is defined as the efforts by a controller to align the actions and behaviors of controlees with the achievement of specific objectives (Kirsch 1997). Control theory identifies several mechanisms that controllers can employ to achieve such alignment. In the context of IS projects, control has been defined as management's attempts to ensure that individuals working on IS projects are following a specified strategy to achieve desired objectives (Kirsch 1997). The extent to which specific entities occupy the role of controller and controlee in IS projects depends on the context. In some cases, the client liaison plays the role of controller and the IS project team plays the role of controlee (e.g., Kirsch et al. 2002; Rustagi et al. 2008). In other cases, the IS project manager plays the role of controller and the IS project team plays the role of controlee (e.g., Kirsch 1997; Maruping et al. 2009a). Given our interest in how IS project managers control IS projects, we follow research that views the IS project manager as the controller and the IS project team as the controlee (Kirsch 1997). Control in IS projects is exercised by monitoring and evaluating IS project team behaviors or outcomes (Kirsch 1997). Exercise of controls aligns the actions of IS project teams and results in higher IS project performance (Tiwana and Keil 2010). Empirical IS research on in-house and outsourced IS projects has largely found support for this relationship (e.g., Gopal and Gosain 2010; Maruping et al. 2009a; Tiwana and Keil 2010).

Process controls—also referred to as behavior controls—emphasize the specific processes or behaviors that IS project teams must follow (Gopal and Gosain 2010). We focus on the enactment of process controls in the work of the development team as processes can be espoused but not enacted (e.g., Rerup and Feldman 2011). Our focus on the enactment of process controls also aligns with our objective to examine how project managers influence the *practice* of process controls in the work of the development team and the resulting outcomes on individual developers. Additionally, research suggests that organizational efforts to implement software process interventions, such as the capability maturity model (CMMI) and software process improvement (SPI), play a significant role in influencing the work ambiguity experienced by individual IS workers (Ply et al. 2012) and their task performance (Slaughter and Kirsch 2006).The expectation is that, under the right circumstances, enacting process controls will yield desired performance outcomes (Nidumolu and Subramani 2003). In the absence of practiced process controls, developers may lack the requisite understanding of, or compliance with, the behaviors that lead to desired performance outcomes. This is especially true for strategic, non-routine IS projects, where means-end relations are not readily apparent (Rai et al. 2009). According to IS project control research, the enactment of process control is contingent on IS project managers' ability to observe IS project team activities—behavior observability (Kirsch et al. 2002). Firms that achieve CMMI level-4 or level-5 certification have direct reporting relationships between IS project managers and IS project teams, facilitating behavior observability (Ply et al. 2012).[1]

The appropriate design and enactment of process controls requires IS domain knowledge because IS projects involve multiple tasks and subtasks that are of varying degrees of interdependence and individual developers must be appropriately matched to the technical domain requirements of the tasks (Keil et al. 2003). Thus, individual developers often work on a variety of tasks and sub-tasks that may change over the course of the IS project. Because of the idiosyncrasies and scope of each IS project, each IS project manager must determine whether and to what extent to promote the enactment of process controls. This requires the IS project manager to have the understanding of the technical activities by which inputs are transformed into outputs (Kirsch 1997). In addition, it requires IS project managers to understand how to plan, set milestones, monitor progress and coordinate interdependent actions (Napier et al. 2009). Therefore, in considering how IS project managers mitigate the effects of

[1] The Software Engineering Institute developed the capability maturity model integration (CMMI) as a successor to CMM. As with CMM, higher levels of CMMi indicate greater levels of process maturity, reflecting many of the same reporting relationships.

technical IS project risk on individual developer outcomes, it is important to incorporate their IS project-related knowledge and the influence on the enactment of process control.

IS Project Managers and the Enactment of Process Control

IS project management is particularly important to IS project performance (Keil et al. 2003; Schmidt et al. 2001). Schmidt et al. (2001) identified a lack of IS project management knowledge as among the top factors affecting IS project success. Similarly, Nelson (2007) noted that IS project managers play a major role in the success or failure of IS projects through estimation of project cost and schedule, stakeholder management, risk management, planning and personnel management. Napier et al. (2009) have identified a similar set of factors in distinguishing effective versus ineffective IS project managers. Kirsch (1997) noted that the project-related knowledge of IS project managers is an important precursor to the enactment of such activities. Control theory in the IS literature supports this idea, noting that the project managers' knowledge of the IS development process is a key determinant of the exercise of process control (Kirsch 1997; Kirsch et al. 2002). When IS project managers have extensive knowledge of the development process, they understand the necessary actions that need to be taken to successfully implement IS project requirements. Consequently, they can meaningfully enact controls to monitor activities and outputs of individual developers and the IS project team to ensure the necessary behaviors and procedures are followed and outputs of requisite quality are developed through the development process (Kirsch 1997). Supporting this perspective, Verner and Evanco (2005) found a positive association between IS project manager knowledge and IS project performance. As such, IS project managers with knowledge of the development process play an active role in influencing the specific processes that IS project teams enact during project development (Kirsch et al. 2002).

IS project managers' project-related knowledge incorporate an understanding of the technical aspects of IS development as well as the managerial aspects. Per Kirsch (1997), there is *project-related technical knowledge* about the development of software, which involves understanding of detailed technical design, code testing, development tools and platforms, and development methodologies. It reflects how well the IS project manager understands the technical activities necessary to construct the software product itself. IS project managers also require *project management knowledge*, which involves an understanding of the managerial details (e.g., managing client relationships, incentivizing developers, mobilizing resources) involved in facilitating IS project success (Keil et al. 2003; Verner and Evanco 2005). Both aspects of IS project-related knowledge are important because technical understanding can inform the IS project manager's appreciation for the technical activities and steps necessary to achieve project goals and project management understanding can inform the conditions that enable such technical steps to translate into a completed software product. In essence, project-related knowledge provides IS project managers with the cause-and-effect knowledge necessary to implement effective process controls.

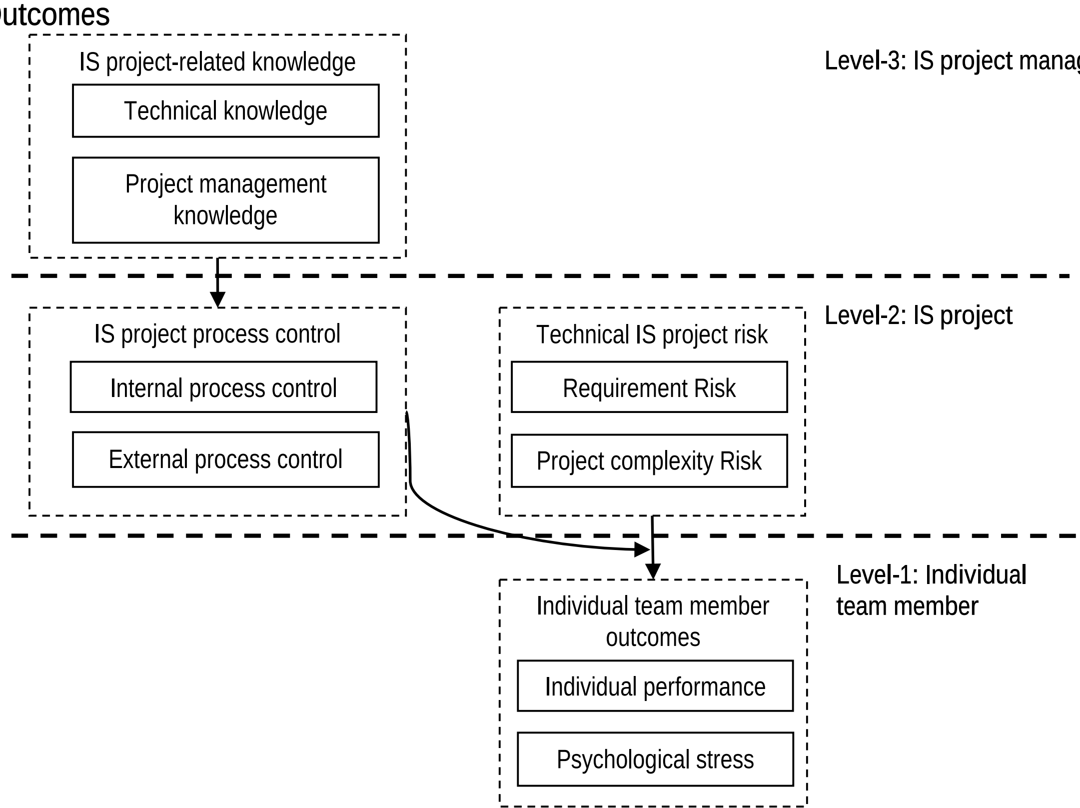
Although control theory underscores IS project managers' project-related knowledge as a major determinant of process control, three important gaps in understanding exist. First, prior IS project management research based on control theory has focused exclusively on the project-level impacts of IS project managers' project-related knowledge, thereby resulting in limited understanding on how individual developers are affected. Second, the IS project manager knowledge → IS project process control → IS project outcomes causal chain has not been empirically examined as a mediated relationship. As such, the role of process control as a mediating mechanism between IS project managers' project-related knowledge and IS project success has not been empirically established. Third, prior work has not addressed whether IS project manager project-related knowledge should be directed toward the internal activities of the IS project team or directed toward how the project team interfaces with the external task environment or both, and what implications such efforts have for individual developers. Yet, theory on team effectiveness suggests that effective managers manage from the boundary, engaging in behaviors that are directed toward their assigned project team as well as behaviors that are directed toward the environment external to the project team (Druskat and Wheeler 2003). Delineating between internally versus externally directed process controls can help uncover the mechanisms through which knowledgeable IS project managers influence individual developer well-being and performance through the enactment of process controls.

The constructs in our research model are summarized in Table 1. Our research model, which integrates internally and externally directed IS project-level process controls and individual developer outcomes, is shown in Figure 1.

Table 1. Construct Definitions

Construct	Level of Analysis	Definition	Sources
Performance	Individual	The extent to which delivered task output adheres to quality, accuracy, quantity and timelines expectations.	Hoegl and Gemuenden (2001)
Psychological stress		The anxiety and worry associated with work tasks.	Lazarus (1999)
Internal process control	IS project team	Procedures enacted for planning and coordinating software development tasks.	Kirsch et al. (2002), Napier et al. (2009)
External process control		Procedures enacted to interface with an external client.	Ancona and Caldwell (1992), Gopal and Gosain (2010),
Requirement risk		The threat that emerges from unclear or volatile project requirements.	Nidumolu (1995), Schmidt et al. (2001), Wallace et al. (2004a)
Project complexity risk		The threat that emerges from developing software that needs to integrate with multiple existing systems or is developed on an unfamiliar/new platform.	
Technical knowledge	IS project manager	Understanding of detailed technical design, code testing, development tools and platforms.	Andersen and Matthiasen (1990), Iivari et al. (2004), Tiwana and Keil (2010), Verner and Evanco (2005)
Project management knowledge		Understanding of the details involved in managing a project from launch to completion.	

Figure 1. Multilevel Research Model of IS Project Management Process Control and Individual Outcomes



Cross-level Influence of Technical IS Project Risk on Individual Developer Outcomes

As much of the IS literature has acknowledged, IS project work is inherently challenging for a variety of reasons. First, technical, knowledge-intensive undertakings, such as IS projects, are highly interdependent, requiring effective coordination of task inputs and outputs across members, including developers and clients, involved in an IS project (Maruping et al. 2009b). Various software modules are often inextricably linked such that the structure and design of one influences the functioning of another. Second, because each client organizational context is likely to differ in its strategies, technologies and business processes, there are often no predetermined solutions to IS project requirements especially for strategic systems (Rai et al. 2009; Wallace et al. 2004a). IS project teams must integrate the knowledge resources in their possession to identify and implement solutions in a way that satisfies client needs (Patnayakuni et al. 2007). Third, the interdependence of developer inputs and outputs requires individual developers to balance team versus individual performance interests (Maruping et al. 2009a). These conditions, which tend to be pervasive across strategic IS projects, can make for a challenging environment for achieving high individual performance. They can also put a psychological strain on individual developers. In fact, a central proposition in theories of work-related stress is that psychological stress emerges as a result of those interactions of a person with the environment that threaten or challenge an individual's well-being or goals (Lazarus 1999).

From the standpoint of the challenges that individual developers face in developing a project solution, technical IS project risk represents a common threat that can derail IS projects (Schmidt et al. 2001; Wallace et al. 2004a). Requirement risk emerges when IS project specifications are unclear, ambiguous or change frequently over time (Nidumolu 1995; Wallace et al. 2004a). A lack of clarity regarding system specifications results in a lack of task clarity for individual developers as they do not have a clear understanding of what the system needs to accomplish. This can lead to individual developers implementing requirements incorrectly or implementing the wrong functionality (Schmidt et al. 2001). Changing requirements also cause individual developers to shift task goals and engage in rework effort. This forces individual developers to delay action on current tasks as they divert attention to implementing necessary changes. Developers who are dependent on this code output to complete their own coding tasks are also affected. Ongoing rework in response to changing requirements can result in software errors (Maruping et al. 2009a). Incomplete or unclear requirement specifications also increase the psychological stress experienced by individual developers. The psychological stress associated with work tasks has generally been argued to increase as objectives become more ambiguous (LePine et al. 2005). A lack of clarity about what the system is meant to accomplish makes it difficult for individual developers to devise a plan for task execution, increasing psychological stress (Andres and Zmud 2002). Changing requirements increase individual developers' psychological stress in several ways. The amount of effort required for rework on existing pieces of code places a cognitive strain as individual developers need to understand and address the implications for other aspects of the code that is their responsibility (Banker and Slaughter 2000). Moreover, the constant task switching from implementing requirements to reworking existing requirements or accommodating new ones can lead to an increased feeling of work overload that underlies psychological stress.

H1: *Requirement risk will have (a) a negative cross-level effect on individual developer performance and (b) a positive cross-level effect on individual psychological stress*.

Project complexity risk, which emerges when system functionality involves significant code interdependencies and is built on a new technology platform, also presents a challenge to individual developers. New or unfamiliar platforms increase the chance of making errors, as the means for implementing functional requirements are less clear (Espinosa et al. 2007). When systems are developed for new or unfamiliar platforms, the code structures necessary to achieve desired outcomes are ambiguous. Individual developers' task performance is, therefore, hampered as increasing complexity makes it more difficult to identify solutions for implementing IS project requirements. The level of psychological stress experienced by individual developers should also be affected by complexity risk. The lack of clarity regarding the connection between coding structures and the achievement of desirable outcomes means that individuals must expend greater cognitive effort in attempting to identify ways to implement requirements on a new or unfamiliar platform. This often requires individual developers to experiment with a variety of potential solutions, which adds to their workload and the pressure to produce an acceptable output (Gardner 2012). Given that a lack of control over tasks characterizes code interdependencies (Andres and Zmud 2002) and increases psychological stress (LePine et al. 2005), coding interdependencies should contribute to psychological stress as individual developers have a lack of control over their task assignments.

H2: *Project complexity risk will have (a) a negative cross-level effect on individual developer performance and (b) a positive cross-level effect on individual psychological stress*.

The hypothesis above suggests that technical IS project risk has negative implications for the individual developers involved in developing the system. Consistent with prior research, technical IS project risk is viewed as an exogenous factor over which IS project teams have little, if any, control in mitigating its occurrence (Keil et al. 2013; Schmidt et al. 2001; Tiwana and Keil 2010; Wallace et al. 2004a). As we argue next, with the relevant knowledge, IS project managers are in a position to facilitate actions that mitigate the deleterious effects of IS project technical risks on individual developer outcomes.

Enactment of Internally Directed IS Project Management Process Controls

As risk mitigation is a major aspect of IS project management and control clearly represents an important mechanism for achieving this objective (Maruping et al. 2009a; Tiwana and Keil 2010), IS project managers who possess greater IS project-related knowledge are expected to attenuate the negative cross-level effect of technical IS project risk on individual developer outcomes by facilitating the enactment of internal process controls. As IS project managers with project-related knowledge are aware of the circumstances in which process controls are needed, they will be the ones who should be effective in facilitating their deployment in an IS project. Internally directed process controls represent efforts by IS project managers to implement controls on the activities that IS project teams use to transform IS project inputs into a working software product that meets client needs. Marks et al. (2001) have classified such processes into three broad categories: transition, action, and interpersonal. These categories of processes map onto the practices that knowledgeable IS project managers exercise to mitigate IS project risk (Napier et al. 2009; Wallace et al. 2004a). *Transition processes* are executed during periods of time when teams are focused on evaluation and planning activities that will guide goal accomplishment (Marks et al. 2001). They include various activities including mission analysis, formulation and planning, goal specification, and strategy formulation (Marks et al. 2001). Transition processes used to manage IS project risk are reflected in IS project manager process controls including creating realistic schedules and estimates, matching people and tasks, delegating responsibility, project planning and providing detailed work breakdowns (Keil et al. 2003; Napier et al. 2009; Verner and Evanco 2005). *Action processes* are carried out during periods of time when teams are engaged in acts that are contributing directly to goal accomplishment. They involve various activities including monitoring progress toward goals, systems monitoring, team monitoring, and backup behavior and coordination (Marks et al. 2001). The action process controls used by IS project managers include monitoring project progress, prioritizing tasks, managing complexity, and identifying and proactively addressing problems (Napier et al. 2009). *Interpersonal processes* are aimed at managing developer well-being, and the activities include conflict management, motivation and confidence building and affect management (Marks et al. 2001). IS project managers promote the enactment of interpersonal process controls through motivating developers, developing them, caring for them, fostering communication between members, and responding to members' concerns (Napier et al. 2009; Verner and Evanco 2005).

IS project managers with IS project management knowledge promote the enactment of internal process controls to weaken the negative influence of IS project technical risks on individual developer outcomes by encouraging IS project teams to put mechanisms in place to monitor and evaluate task outcomes on the changing project requirements and/or new/unfamiliar platform. Research on control theory finds that IS project managers with knowledge of the IS development process were able to clearly outline and delegate the main tasks necessary for achieving project objectives (Kirsch 1997). The comparison of actual task outcomes against established task performance targets is an important monitoring mechanism in process controls (Ply et al. 2012). The feedback cycle that such controls establish enable individual developers to identify problem areas early and make corrections. Individual developers are able to recalibrate their task execution as they discover more about the new platform, thus enhancing task performance (Espinosa et al. 2007). By facilitating the exercise of internal process controls, IS project managers with greater IS project-related knowledge are able to attenuate the effect of technical IS project risk on individual developer psychological stress. IS project managers' project management knowledge enables them to implement interpersonal process controls to avoid having IS project-induced personnel issues derail the project. Project complexity risk and requirement risk can lead to confusion about who should do what and frustration can quickly build, leading to increased psychological stress. Nelson (2007) noted that failure to deal with personnel issues was among the leading factors that affected productivity on IS projects. Consistent with conflict management, IS project managers with project management knowledge take steps to listen and encourage IS project developers to resolve their differences (Napier et al. 2009). With such coping mechanisms in place, individual developers' appraisal of the technical IS project risk is less likely to evoke feelings of stress (Edwards 1996; Lazarus 1999). This should weaken the effect of technical IS project risk on individual developer psychological stress.

H3: *IS project managers' IS project management knowledge will moderate the cross-level effect of requirement risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of internal process control such that the effect of requirement risk will be weaker with increasing enactment of internal process control*.

H4: *IS project managers' IS project management knowledge will moderate the cross-level effect of project complexity risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of internal process control such that the effect of project complexity risk will be weaker with increasing enactment of internal process control*.

The IS project manager's technical knowledge makes it possible to delegate the right task to the developer with the right skills so that changing requirements and increasing complexity do not compromise individual developers' task performance (Napier et al. 2009). In contrast, IS project managers with little technical and project management knowledge may be less aware of the internal process controls necessary to enhance individual developer outcomes. For example, with little technical knowledge, IS project managers may not understand the interdependencies associated with developing key software components and, hence, are unable to facilitate the required task sequencing when planning for project execution (Keil et al. 2003). Greater technical knowledge enables IS project managers to more accurately delegate tasks to individual developers with the relevant skills. This ensures that developers are not subjected to increased stress due to a complex task environment for which their skills are ill-suited. Indeed, prior research suggests that increased experience for a portfolio of responsibilities can reduce amount of stress felt in the work environment (Hunter and Thatcher 2007). IS project managers' technical knowledge also enables them to facilitate the necessary monitoring and feedback mechanisms for gauging how their changes in response to volatile IS project requirements are working. Such feedback helps to reduce the task uncertainty that fuels psychological stress. When individual developers have no formal mechanism for establishing how effectively their input efforts translate to task accomplishments in the unfamiliar or volatile technological domain, the effect of such an environment on their level of psychological stress goes unabated.

H5: *IS project managers' IS technical knowledge will moderate the cross-level effect of requirement risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of internal process control such that the effect of requirement risk will be weaker with increasing enactment of internal process control*.

H6: *IS project managers' IS technical knowledge will moderate the cross-level effect of project complexity risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of internal process control such that the effect of project complexity risk will be weaker with increasing enactment of internal process control*.

Enactment of Externally Directed IS Project Management Process Controls

We expect IS project managers with IS project-related knowledge to attenuate the negative effect of technical IS project risk on individual developer outcomes by facilitating the exercise of external process controls. IS project managers with IS project-related knowledge are well aware of the role the client can play in managing technical IS project risk (Napier et al. 2009; Rai et al. 2009). Members of the client organization have more complete information about their existing technology platforms and infrastructure on which the developed solutions will need to be implemented. They also have better insight into the business forces that may be shaping their requirements. Such IS project managers are well aware that even once requirements have been documented, ongoing knowledge sharing with members of the client organization is necessary to instantiate effective context-specific process controls (Patnayakuni et al. 2007). Ongoing interaction of developers with the client also provides important insights to the IS project manager about the client's perspective on critical aspects of the IS project (Gopal and Gosain 2010; Rai et al. 2009). Consequently, development teams engaging with the client through external processes represents an important mechanism for reducing the negative impact of IS project technical risk on individual developer outcomes.

We suggest that enactment of externally directed process controls arise from IS project managers' efforts to control knowledge exchange and integration, resource acquisition, and support from the client. Ancona and Caldwell (1992) developed a taxonomy of team boundary-spanning activities that elucidates the behaviors through which project teams interact with their external environment. They identified three main boundary-spanning activities: ambassador, task coordinator, and scout. *Ambassador* activities represent efforts to defend the team from external pressure, persuade external constituents to support the team and its objectives, and gather resources for the team (Ancona and Caldwell 1992). Such activities often involve communications with departmental management and sometimes top management as well as clients. *Task coordinator* activities involve interactions with external constituents to coordinate design and technical issues. Such activities include obtaining feedback on system design, negotiating project milestones, and seeking clarification on system requirements. *Scouting* activities reflect efforts to scan the environment outside of the team for ideas and expertise on how to approach task execution. Such activities include interacting with other teams to get alternative ideas/expertise, scanning the environment inside or outside the organization for information, and collecting technical information from external constituents (Ancona and Caldwell

1992). These boundary spanning activities embody the processes by which teams interact with their external environment (Ancona and Caldwell 1992). Several scholars (e.g., Ancona 1990; Choi 2002) have referred to such activities as external processes and note that project managers are heavily involved in their enactment. The term "boundary spanning" and "external process" have been used interchangeably in the literature. However, in contrasting such processes with internal processes, Ancona (1990) and Choi (2002) have used the term external processes. Thus, consistent with previous literature, we use the term external process.

Technical IS project risk hampers individual developer performance and fuels psychological stress through a lack of certainty induced by developing software for new/unfamiliar technology platforms or by having incomplete requirement information, as suggested earlier. IS project managers with project management knowledge understand the need for individual developers to clarify ambiguous requirements and gain a better understanding of the technological platform and infrastructure on which the software will operate (Gopal and Gosain 2010). IS project managers with such knowledge are, therefore, positioned to facilitate the enactment of external processes. They understand that interactions with the client enable individual developers to receive useful feedback about their work (MacCormack et al. 2001). Using this client input, developers can then devote effort to improving the aspects of the IS project for which they are responsible. IS project managers with project management knowledge reduce the impact of technical IS project risk on psychological stress by enabling individual developers to cope through better information about the client environment (Lazarus 1994, 1999).

H7: *IS project managers' IS project management knowledge will moderate the cross-level effect of requirement risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of external process controls such that the effect of requirement risk will be weaker with increasing enactment of external process control*.

H8: *IS project managers' IS project management knowledge will moderate the cross-level effect of project complexity risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of external process controls such that the effect of project complexity risk will be weaker with increasing enactment of external process control*.

IS project managers with technical knowledge understand the importance of complete and accurate information in enabling effective execution of software tasks. As noted earlier, project complexity risk and requirement risk affect individual developer task performance by rendering the necessary input information incomplete. Developers often lack an understanding of the business context (including business needs and existing technology platforms and infrastructure) and, therefore, benefit significantly from information that provides greater insight into how the client organization operates (Patnayakuni et al. 2007). Knowledgeable IS project managers realize that information gathering enhances individual developers' understanding of the client business context (Gopal and Gosain 2010; Rai et al. 2009). Such information enables individual developers to execute their tasks more effectively when faced with greater technical IS project risk. Nidumolu (1995) found that interaction between IS project teams and members of the client organization (via horizontal coordination) reduced IS project uncertainty, enabling IS project teams to achieve their objectives. A reduction in IS project uncertainty will also reduce the effects of technical IS project risk on psychological stress (Lazarus 1999).

H9: *IS project managers' IS technical knowledge will moderate the cross-level effect of requirement risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of external process controls such that the effect of requirement risk will be weaker with increasing enactment of external process control*.

H10: *IS project managers' IS technical knowledge will moderate the cross-level effect of project complexity risk on—(a) individual developer performance and (b) individual psychological stress—through the enactment of external process controls such that the effect of project complexity risk will be weaker with increasing enactment of external process control*.

METHOD

Sample and Participants

We conducted a field study of offshore IS projects managed by a leading software vendor in India and several of its U.S. based clients. Our sampling frame was 500 strategic IS projects completed over a four-year period, beginning July 2004. All of the IS projects were custom-developed by the vendor to the specific requirements of each U.S. client on respective projects. Examples of IS projects included a complete human resource management system and a customer relationship management system. There were a total of 1,230 individual developers who were nested within 130 IS project teams, which were nested within 20 IS project managers. In evaluating the sample of strategic IS projects, we were careful to ensure that there was no cross-nesting of individual IS project members across different IS projects. To address this issue, we examined and compared the rosters on all IS project teams, and found that 130 teams in our sample had no such cross-nesting. Additionally, we focused on IS projects that involved a single IS project team. Some large-scale projects in the sampling frame required multiple IS project teams such that IS project teams were nested within IS projects. This was not the case for the 130 IS projects in our sample.

Measurement

We provide the details related to the measurement in this section (see Appendix A for scales).

Dependent Variables

Individual performance ratings on the IS project were provided by the IS project manager at the end of the project for every individual developer and were based on a proprietary four-item scale used in the organization. The measure was designed to evaluate various aspects of a developer's work on a particular project and included items, such as quality of work output, quantity of work output and effort put forth on the project. The vendor firm used these ratings on this scale in its performance appraisals. *Psychological stress* was measured using a scale adapted from Keller (2001). The scale consists of four items that capture the extent to which an individual experiences an aversive psychological response to their work environment. We adapted the scale to measure psychological stress relating to the focal IS project. Developers provided responses to the psychological stress items at the end of the project. *Client satisfaction* with the delivered system was measured using a four-item scale from Nidumolu (1995). The scale captures the client's assessment of the quality of the system as well as the extent to which it meets their business needs. We use this measure in a supplemental analysis in Appendix B.

Independent Variables

Prior IS project management literature has identified technical and project management knowledge as important facets of project-related knowledge (e.g., Keil et al. 2003; Napier et al. 2009). Similarly, Andersen and Matthiasen (1990) and Iivari et al. (2004) distinguish between IS technical knowledge, which includes factors such as understanding of software design, database design and IS testing, and IS project management knowledge, which includes factors such as project organizing and quality assurance. Accordingly, based on IS control theory, we measured the *technical knowledge* of the IS project manager (Tiwana and Keil 2010). Our items captured the extent to which the IS project manager was knowledgeable about the technical activities necessary to develop systems. Based on the literature on effective IS project managers, we measured *project management knowledge* of the IS project manager (Napier et al. 2009; Verner and Evanco 2005). Our items captured the extent to which IS project managers were knowledgeable about project management activities, such as the importance of planning, resource estimation, monitoring and client interfacing, necessary to take an IS project from inception to completion (Keil et al. 2003; Napier et al. 2009). We measured *internal IS project process control* using a nine-item scale by Mathieu et al. (2006). The scale includes three dimensions—each consisting of three items—from Marks et al.'s (2001) super-ordinate categories of team processes: transition, action, and interpersonal processes. Collectively, the scale items capture the extent to which a team follows established procedures for outlining core objectives, monitoring progress toward those objectives, tracking of resources, and management of developer well-being. *External IS project process control* was measured by adapting an eighteen-item scale from Ancona and Caldwell (1992). The scale includes three dimensions identified by Ancona and Caldwell (1992) as boundary spanning behaviors: ambassador, task coordinator, and scouting. To measure *IS project requirement risk*, we used IS project documentation to identify the total number of formal written changes to project requirements. This is reflective of IS project risk due to volatility in requirements (Nidumolu 1995). Consistent with Rai et al. (2009), we measured IS project complexity risk using the number of adjusted function points, which uses 14 complexity characteristics that incorporate information about the different system requirements and technology platforms on which the system is built (see also Albrecth and Gaffney 1983). The adjusted function points are a weighted sum of the number of inputs, inquiries, and masterfiles that must be accessed from other systems/platforms and the number of outputs and queries generated for other systems (Albrecht and Gaffney 1983). These metrics were obtained from the IS project documentation of the vendor firm.

Control Variables

In light of our multilevel research model, we controlled for several factors at the level of the IS project manager, the IS project and the individual developers. At the level of the IS project manager, we controlled for age, gender, organizational tenure and IS project management experience. IS project managers with greater organizational tenure and IS project management experience are likely to have greater familiarity with the steps necessary to facilitate success (Rai et al. 2009). At the IS project level, we controlled for IS project size, IS project team size and IS project team experience as they have been found to affect IS project performance (see Espinosa et al. 2007; Maruping et al. 2009a; Ravichandran and Rai 2000). As part of its standard routine, the vendor firm maintained detailed records on various software project metrics for completed projects. Thus, we were able to obtain project size from the vendor firm's archival records. Consistent with prior research, IS project size was measured as total lines of code. In addition, we controlled for the following aspects of the IS project team: (a) size, to account for potential coordination problems this might cause for individual developers, (b) experience, to determine the number of previous projects on which the team had worked, (c) the level of technical knowledge on the team, (d) the level of project management knowledge on the team, and (e) the level of familiarity among developers on the team. We obtained these data from IS project team rosters and self-reports on surveys based on the same measurement scales used to rate project managers. At the level of individual developers, we controlled for several individual characteristics. First, we controlled for demographic characteristics including age, gender, organizational tenure and IS project experience. Second, we controlled for two personality traits that have been found to influence individual performance in team contexts: conscientiousness and extraversion (Barrick et al. 1998). Conscientiousness and extraversion were measured using scales from Costa and McCrae's (1992) NEO Five-Factor Inventory (FFI), which is among the most widely used instruments for measuring the five-factor personality model. Each scale consists of 12 items.

Procedure

Data were collected as the IS project activities were occurring over the entire life-cycle of the projects. We collected data at the beginning and end of each project. IS project manager project-related knowledge was measured from the supervisor of each IS project manager at the beginning of the project through a survey.[2] Data regarding internal and external IS project process controls were collected after the development phase of each project. Individual developer performance ratings were collected after the IS project was delivered to the client. Developer psychological stress was measured at the beginning and end of the project. End-of-project responses to the psychological stress scale were used in our analyses. Four months after the IS projects had been delivered and implemented, clients provided responses to questions about their satisfaction with the delivered system. Data related to IS project characteristics and IS project team characteristics were extracted from project documents at the end of the development phase of each project. At the beginning of the IS project, developers provided responses to

[2] We also obtained ratings of project manager technical and project manager knowledge from developers in each IS project team. These responses were highly correlated with the supervisor ratings.

questions about their own technical knowledge and project management knowledge. These responses were averaged to compute team-level technical knowledge and project management knowledge. We also measured team familiarity following Espinosa et al. (2007). Conscientiousness and extraversion were collected at the beginning and end of the project, and we found a high correlation between responses to these scales at both measurement points. Pre-project responses to the personality scales were used in the analyses. The combination of subjective and objective data collection is a major strength of our procedure and enhances the validity of our results.

RESULTS

Measurement Scale Validation

Results from confirmatory factor analyses (CFA) indicated that all scales displayed good psychometric properties including reliability, convergent validity, and discriminant validity. The results also supported treating internal and external process controls as second-order constructs that explain the covariation in their underlying dimensions (see Appendix C for CFA details). All factor loadings were greater than .70. All scale reliabilities were acceptable for the internal process control scales (transition: .77, action: .82, and interpersonal: .75), external process control scales (ambassador: .79, task coordinator: .77, and scouting: .83), IS project manager project-related knowledge scales (technical knowledge: .74 and project management knowledge: .77) and individual developer outcomes scales (individual performance: .75 and psychological stress: .71) and, for each factor, the average variance extracted (AVE) was greater than .50. The square root of the average variance extracted for each construct was greater than the inter-construct correlations, providing support for discriminant validity. All loadings of the first-order internal/external process controls constructs on their respective second-order constructs were significant, providing evidence in support of the second-order factor models (Tippins and Sohi 2003). Specifically, the loadings of the three first-order factors for internal processes (transition, action, and interpersonal processes) on the second-order factor for internal processes were greater than .79 and the loadings of the three first-order factors for external processes (ambassador, task coordinator, and scouting) on the second-order factor for external processes were greater than .76. The target coefficient (T) comparing a model with two second-order reflective constructs for internal and external processes that freely correlate to a first-order model of six freely correlating internal/external process controls constructs was .894, indicating that the two second-order constructs account for 89.4% of the variation among the first-order internal/external process controls constructs (Marsh and Hocevar 1985). The high covariaton among the respective first-order dimensions of internal and external processes and the high loadings of each of the first-order dimensions on their respective second-order factors is consistent with prior research (LePine et al. 2008) and supports our measurement of internal and external control processes as linear composites with unit weighting of their underlying dimensions.

Because multiple developers within each team responded to questions about external and internal team processes, it was necessary to determine the extent to which these responses converged within teams. The average $r_{wg(j)}$ for the internal process control items was .71 and for the external process control items was .74, exceeding the recommended cutoff of .70 (James et al. 1984). In addition, for internal process control, the ICC(1), which represents the proportion of variance attributable to between-team differences, was .24 and the ICC(2), which represents the stability of the team-level means, was .71 (Bliese 2000), suggesting that it was appropriate to aggregate developer responses to represent a team-level score. Further, for external process control, the ICC(1) was .28 and the ICC(2) was .76, indicating significant between-team variation in external processes and adequate stability of the team-level means. Hence, we averaged developers' responses within each project team to compute a team-level score for internal and external process controls.

Table 2. Descriptive Statistics and Correlations

Variable	Mean	SD	$\sqrt{AVE}$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Individual performance[a]	5.12	1.01	.79	(.75)																							
2. Psychological stress[a]	4.90	1.22	.75	-.19**	(.71)																						
3. Extraversion[a]	5.40	0.68	NA	.13*	.14*	(.75)																					
4. Conscientiousness[a]	3.22	1.20	NA	.14*	.12*	.12*	(.78)																				
5. Experience[a]	4.41	1.28	NA	.13*	-.07	.02	.08																				
6. Age[a]	29.28	13.20	NA	.07	-.08	.05	.05	.12*																			
7. Gender[a]	NA	NA	NA	.09	.02	.05	.00	.03	.02																		
8. Organizational tenure[a]	2.32	0.88	NA	.12*	.04	.03	.02	.12*	.12*	.02																	
9. Team size[b]	10.12	2.28	NA	.03	.07	.07	.10	.03	.04	.07	.03																
10. Team experience[b]	1.03	0.55	NA	.07	.08	.02	.07	.02	.04	.08	.03	.02															
11. Project size[b]	420,103	69,601	NA	-.23***	.21***	.04	.05	.04	.10	.02	.05	.01	.13*														
12. Team technical knowledge[b]	5.19	1.08	NA	.12*	-.13*	.08	.14*	.18**	.15*	.04	.17**	.05	.10	.13*													
13. Team project management knowledge[b]	4.30	0.80	NA	.08	-.05	.08	.07	.07	.10	.02	.14*	.03	.02	.03	.04												
14. Team familiarity[b]	4.91	2.28	1.33	.19**	-.20**	.07	.05	.10	.07	.08	.23***	.05	.07	.04	.05	.03											
15. Project complexity risk[b]	9,870	2,284	NA	-.19**	.23***	.04	.08	.04	.03	.06	.02	.07	.13*	.08	.14*	.01	.05										
16. Requirement risk[b]	17.80	6.26	NA	-.25***	.20**	.02	.04	.02	.02	.02	.01	.03	.03	.14*	.13*	.07	.10	.30***									
17. Internal process control[b]	3.80	1.22	.78	.25***	-.26***	.14*	13*	.03	.04	.04	.06	.05	.15*	.12*	.10	.03	.17**	.13*	.14*	(.77)							
18. External process control[b]	4.12	1.28	.77	.22***	-.19**	.07	.02	.05	.02	.02	.10	.10	.13*	.20**	.13*	.04	.20**	.19**	.14*	.21**	(.73)						
19. Age[c]	35.28	3.22	NA	.02	.07	.02	.07	.02	.07	.04	.02	.04	.03	.03	.13*	.05	.04	.02	.03	.04	.02						
20. Gender[c]	NA	NA	NA	.05	.02	.04	.04	.04	.04	.04	.04	.11*	.00	.07	.02	.03	.02	.08	.10	.08	.07	.03					
21. Organizational tenure[c]	4.22	1.98	NA	.02	.03	.04	.05	.03	.02	.03	.02	.03	.02	.02	.15*	.02	.10	.05	.03	.02	.05	.07	.10				
22. Experience[c]	8.05	2.23	NA	.20**	-.19**	.14*	.13*	.02	.07	.02	.05	.03	.05	.17**	.17**	.07	.07	.07	.13*	.15*	.13*	.10	.12*	.15*			
23. Technical knowledge[c]	5.13	1.07	NA	.20**	-.19**	.07	.15*	.20**	.19**	.05	.14*	.04	.15*	.04	.13*	.02	.08	.14*	.16**	.08	.05	.16**	.04	.12*	.14*	(.74)	
24. Project management knowledge[c]	5.19	0.85	NA	.21***	-.28***	.10	.16**	.21***	.24***	.07	.17**	.02	.19**	.03	.04	.10	.05	.17**	.17**	.13*	.14*	.15*	.03	.15*	.17**	.20**	(.77)
25. Client satisfaction[b]	5.57	1.07	NA	.21***	.20**	.13*	.15*	.17**	.14*	.13*	.12*	.08	.17**	.04	.10	.07	.13*	-.10	-.13*	.17**	.19**	.04	-.04	.10	.17**	.15*	.23***

Notes:

1. Level-1, n = 1,230; Level-2, n = 130; Level-3, n = 20.
2. [a] variable pertains to individual developers, [b] variable pertains to IS project, [c] variable pertains to IS project manager. Values in parentheses are reliabilities.
3. AVE = average variance extracted.
4. * p < .05; ** p < .01; *** p < .001.

Hypotheses Tests

Table 2 presents the means, standard deviations, and correlations. Given the multilevel nature of the hypotheses and data, particularly, three-levels of data, we used random coefficient modeling (RCM) for the analysis. We employed HLM 6.08, a RCM software package for data analysis (Bryk and Raudenbush 1992). RCM is well-suited for analyzing hierarchically nested data. In the current study, the 1,230 developers were nested within 130 IS projects that were in turn nested within 20 IS project managers. HLM and other RCM tools remedy many of the threats for Type I and Type II errors by explicitly accounting for and modeling the non-independence of observations in data (Bliese and Hanges 2004). We report Snijders and Bosker (1999) overall pseudo R^2 ($\sim R^2$), which is based on the proportional reduction of levels 1, 2 and 3 errors due to predictors in the models.

H1 and H2 predicted that requirement risk and project complexity risk would have a cross-level effect on individual developer outcomes. H3, H4, H5, and H6 predicted that IS project managers' project management knowledge and technical knowledge would moderate these cross-level relationships through enacted internal process controls. H7, H8, H9, and H10 predicted that IS project managers' project management knowledge and technical knowledge would moderate the effect of requirement risk and project complexity risk on individual developer outcomes through enacted external process controls. Before proceeding to test these hypotheses, it was necessary to determine (1) how much of the variance in individual developer outcomes was attributable to the individual developer, the IS project team to which he/she was assigned, and the IS project manager to whom the IS project was assigned and (2) the extent to which differences in internal and external process controls across IS projects were due to the specific IS project manager to whom the project was assigned.

We conducted an analysis of the variance components for individual developer performance by estimating a null model. The results of a χ^2 test indicate that there was sufficient variability at all three levels of analysis. Specifically, 52.1% of the variance in individual developer performance was attributable to individual-level differences, 28.5% ($\chi^2 = 3482.55$, $p < .001$) of the variance was due to differences between IS project teams and 19.4% ($\chi^2 = 686.08$, $p < .001$) was attributable to differences between IS project managers. Results of a null model predicting psychological stress show that 46.2% of the variance was between individuals, 29.3% ($\chi^2 = 3210.18$; $p < .001$) of the variance was due to between-IS project differences and 24.5% ($\chi^2 = 1044.55$; $p < .001$) of the variance could be attributed to differences between IS project managers. This further reinforced the need for a three-level multilevel approach to the analysis and model testing (Bryk and Raudenbush 1992).

We also examined the variability of IS project process controls across IS projects nested in IS project managers. This was accomplished by estimating a null model in which IS projects were nested within IS project managers. Results of a χ^2 test revealed that in the case of internal IS project process control, 54.4% of the variance was due to factors at the IS project level and 45.6% (χ^2 = 456.28, p < .001) was attributable to differences between IS project managers. For external IS project process control, 55.5% of the variance was due to IS project-level factors and 44.5% (χ^2 = 401.22, p < .001) of the variance was due to IS project manager differences. This suggests that the exercise of process controls on each IS project was influenced by IS project managers.

Table 3. Results of Three-level Model Predicting Individual Developer Outcomes

	Individual performance				Individual psychological stress		
Variable	1a	2a	3a	4a	1b	2b	3b
Level-1 (controls):							
Intercept	.06 (.008)	.05 (.008)	.02 (.007)	.02 (.007)	.10 (.004)	.08 (.005)	.06 (.008)
Experience	.07 (.012)	.06 (.013)	.03 (.013)	.03 (.013)	.07 (.005)	.04 (.006)	.05 (.008)
Age	.08 (.023)	.10 (.022)	.08 (.024)	.07 (.025)	.06 (.014)	.03 (.011)	.03 (.011)
Gender	-.08 (.014)	-.09 (.016)	-.06 (.018)	-.06 (.018)	.08 (.019)	.08 (.012)	.07 (.013)
Organizational tenure	.09 (.012)	.08 (.013)	.05 (.017)	.05 (.017)	-.10 (.012)	-.03 (.009)	-.02 (.010)
Conscientiousness	.12* (.006)	.12* (.006)	.09 (.008)	.08 (.008)	.08 (.007)	.04 (.006)	.03 (.011)
Extraversion	.07 (.013)	.06 (.012)	.03 (.010)	.01 (.010)	.07 (.010)	.05(.015)	.02 (.016)
Level-1 (main effects):							
Psychological stress				-.13* (.004)			
Level-2 (controls):							
Team size	-.07 (.013)	-.05 (.013)	-.04 (.015)	-.04 (.015)	.04 (.007)	.04 (.008)	.06 (.008)
Team experience	.13* (.010)	.10 (.012)	.09 (.014)	.08 (.014)	-.14* (.003)	-12* (.003)	-.08 (.004)
Project size	-.12* (.009)	-.12* (.010)	-.05 (.012)	-.05 (.012)	.17** (.005)	.14* (.007)	.10 (.014)
Team technical knowledge	.13* (.010)	.12* (.011)	.08 (.013)	.06 (.017)	-.07 (.011)	-.04 (.014)	-.03 (.019)
Team project management knowledge	.03 (.011)	.02 (.014)	.01 (.017)	.00 (.020)	-.03 (.021)	-.02 (.022)	.00 (.027)
Team familiarity	.02 (.021)	.01 (.022)	.01 (.023)	.00 (.027)	-.04 (.022)	-.03 (.023)	-.01 (.024)
Level-2 (main effects):							
Project complexity risk	-.07 (.012)	-.09 (.013)	-.05 (.019)	-.04 (.019)	.10 (.011)	.08 (.010)	.08 (.011)
Requirement risk	-.12* (.008)	-.10 (.011)	-.09 (.017)	-.08 (.017)	.14* (.008)	.13* (.011)	.10 (.022)
Internal process control		.16** (.003)	.15* (.005)	.14* (.005)		-.17** (.005)	-.13* (.006)
External process control		.17** (.003)	.13* (.005)	.12* (.005)		-16** (.003)	-.10 (.003)
Level-3 (controls):							
Age	.06 (.016)	.06 (.016)	.03 (.021)	.03 (.021)	.05 (.002)	.04 (.003)	.05 (.004)
Gender	-.04 (.013)	-.03 (.015)	-.02 (.017)	-.01 (.017)	.07 (.008)	.05 (.010)	.03 (.011)
Organizational tenure	.06 (.013)	.06 (.014)	.03 (.019)	.03 (.019)	-.08 (.010)	-.04 (.012)	-.03 (.011)
Level-3 (main effects):							
Project management knowledge	.19** (.003)	.16** (.004)	.13* (.006)	.12* (.006)	-.19** (.004)	-.13* (.006)	-.14* (.005)
Technical knowledge	.21*** (.002)	.19** (.003)	.14* (.004)	.11* (.005)	-.17** (.004)	-.14* (.007)	-.12* (.005)
Cross-level interactions (process controls):							

Project complexity risk x internal process control			.17** (.003)	.16* (.003)			-.15* (.007)
Requirement risk x internal process control			.18** (.002)	.18** (.002)			-.13* (.005)
Project complexity risk x external process control			.13* (.005)	.13* (.005)			-.16* (.002)
Requirement risk x external process control			.17** (.004)	.15* (.004)			-.15** (.008)
Cross-level interactions (PM project-related knowledge):							
Project complexity risk x project management knowledge		.06 (.010)	.05 (.011)	.03 (.012)		.03 (.010)	.02 (.011)
Requirement risk x project management knowledge		-.13* (.006)	-.12* (.007)	-.12* (.007)		.14* (.005)	.13* (.006)
Project complexity risk x technical knowledge		.04 (.007)	.03 (.010)	.02 (.011)		.05 (.009)	.03 (.011)
Requirement risk x technical knowledge		.17** (.003)	.15* (.005)	.14* (.005)		.17** (.007)	.15* (.008)
Random effects:							
Level-1 variance (e_{ijk})	.60***	.55***	.46***	.43***	.50***	.46***	.41***
Level-2 variance (r_{0jk})	.58***	.51***	.41***	.38***	.42***	.39***	.33***
Level-3 variance (U_{00k})	.44***	.40***	.30***	.26***	.32***	.30***	.26***
Deviance	7817.15	7324.30	7165.35	7000.20	7208.35	6931.40	6398.80
χ^2	812.30	765.16	590.30***	561.40***	841.33***	687.10***	512.38***
R^2	.11	.21	.35	.38	.12	.20	.34
ΔR^2		.10	.14	.03		.08	.14

Notes:
1. Level-1, n = 1,230; Level-2, n = 130; Level-3, n = 20.
2. Level-1 experience, age, gender, and organizational tenure are for individual developers, level-3 age, gender, and organizational tenure are for IS project managers.
3. Standard errors are shown in parentheses.
4. Shaded areas are not applicable for the specific column.
5. * p < .05; ** p < .01; *** p < .001.

We tested H1 and H2 using a three-level model in which individual developers were nested within IS project teams and IS project teams were nested within IS project managers. Although a two-level model would ordinarily suffice for testing the cross-level relationship between technical IS project risk and individual developer outcomes, in our case, these IS projects are nested within IS project managers. Consequently, it is likely that the relationship between technical IS project risk and individual developer outcomes could vary across IS project managers (e.g., stronger cross-level relationship under some IS project managers, weaker cross-level relationship under other IS project managers). Failure to account for this nesting would result in biased coefficient estimates (Bauer et al. 2006). The results of the three-level model testing, shown in Table 3, indicate that technical IS project risk has a negative cross-level effect on individual performance (model 1a: γ = -.12, p < .05) and a positive cross-level effect on psychological stress (model 1b: γ = .14, p < .05) in the case of requirement risk, thus supporting H1a and H1b.

Project complexity risk does not have a significant effect on individual developer performance and psychological stress (model 1a: γ = -.07, p > .10; model 1b: γ = .10, p > .10), thus supporting H2a and H2b.

H3 through H10 suggest that IS project manager project-related knowledge moderates the relationship between technical IS project risk and individual developer outcomes through its effect on internal and external process controls. This suggests that IS project managers' project-related knowledge has an indirect interaction effect with technical IS project risk through internal and external process controls in influencing individual developer outcomes. As such, they represent mediated moderation relationships because the moderating effect of project-related knowledge is mediated by internal and external process control. We followed the bootstrap approach advocated by Edwards and Lambert (2007) and Muller et al. (2005) for testing mediated moderation effects. This allows us to establish the indirect moderating effect of IS project manager project-related knowledge on the relationship between technical IS project risk and individual developer outcomes through internal/external process control (i.e., IS project manager project-related knowledge X technical IS project risk → internal/external process control → individual developer outcomes). Consistent with Hofmann and Gavin (1998), we group mean-centered the technical IS project risk (project complexity risk and requirement risk) and process control (internal and external) variables to remove potential confounds with the between-group interactions involving IS project manager project-related knowledge.

Table 4. Two-level Model Predicting Internal and External IS Project Process Control

	Internal process control		External process control	
Variable	1a	2a	1b	2b
Level-1 (controls):				
Intercept	.15 (.025)	.10 (.030)	.04 (.017)	.03 (.018)
Team size	.02 (.016)	.01 (017)	.03 (.020)	.02 (.021)
Team experience	.04 (.020)	.05 (.021)	.05 (.022)	.05 (.022)
Project size	.12* (.004)	.08 (.008)	.14** (.003)	.13* (.003)
Project complexity risk	.12* (.007)	.11* (.008)	.14* (.008)	.13* (.007)
Requirements risk	.02 (.022)	.02 (.024)	.01 (.022)	.01 (.023)
Team technical knowledge	.02 (.029)	.01 (.031)	.04 (.023)	.01 (.028)
Team project management knowledge	.01 (.030)	.00 (.032)	.03 (.022)	.02 (.029)
Team familiarity	.12* (.003)	.10 (.009)	.08 (.027)	.06 (.028)
Level-2 (controls):				
Age (project manager)	.07 (.022)	.06 (.023)	.03 (.024)	.02 (.025)
Gender (project manager)	.02 (.017)	.01 (.018)	.03 (.033)	.02 (.034)
Organizational tenure (project manager)	.02 (.014)	.01 (.015)	.02 (.030)	.02 (.031)
Level-2 (main effects):				

Project management knowledge		.15* (.005)		.17** (.004)
Technical knowledge		.19** (.004)		.15* (.003)
Random effects:				
Level-1 variance (r_{ij})	.48***	.41***	.55***	.47***
Level-2 variance (U_{0j})	.37***	.31***	.47***	.39***
Deviance	7204.40	6775.31	4430.20	4011.20
χ^2	581.15	508.30	610.14	528.31
R^2	.12	.19	.20	.28
ΔR^2		.07		.08

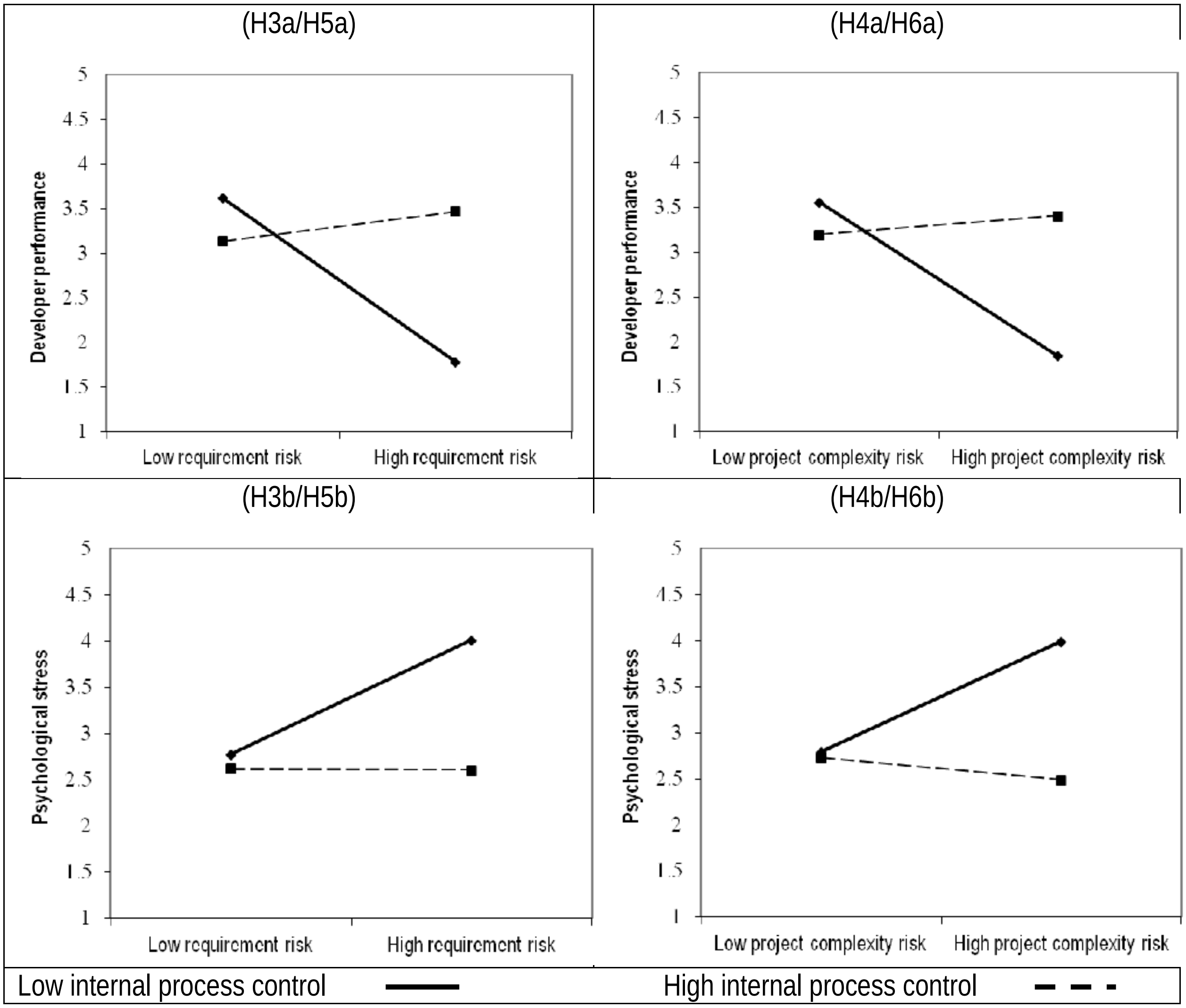
Notes:

1. Level-1, n = 1,230; Level-2, n = 130; Level-3, n = 20.
2. Standard errors are shown in parentheses.
3. Shaded areas are not applicable for the specific column.
4. * $p < .05$; ** $p < .01$; *** $p < .001$.

The results of the bootstrapping analysis of indirect effects for H3 through H6 are presented in Appendix D (Table D1). The indirect effect of the interaction between IS project manager project-related knowledge and technical IS project risk through internal process controls was positive in all cases predicting individual performance and negative in all cases predicting psychological stress. Further, in all cases the confidence interval around the indirect effect did not contain zero. This provides support for the indirect moderating effects of IS project manager project-related knowledge.

To gain a better understanding of the moderating effect of internal process controls on the relationship between technical IS project risk and individual outcomes, we followed the guidelines of Aiken and West (1991) in plotting the interactions. As the interaction plots in Figure 2 show, technical IS project risk has a negative relationship with individual performance when internal process control is low and the relationship is not significantly different from zero when internal process control is high, thus supporting H3a, H4a, H5a and H6a. Technical IS project risk has a positive relationship with psychological stress when internal process control is low and the slope is not significantly different from zero when internal process control is high, thus supporting H3b, H4b, H5b and H6b. Overall, these results support our prediction that internal process control attenuates the influence of technical IS project risk on individual outcomes.

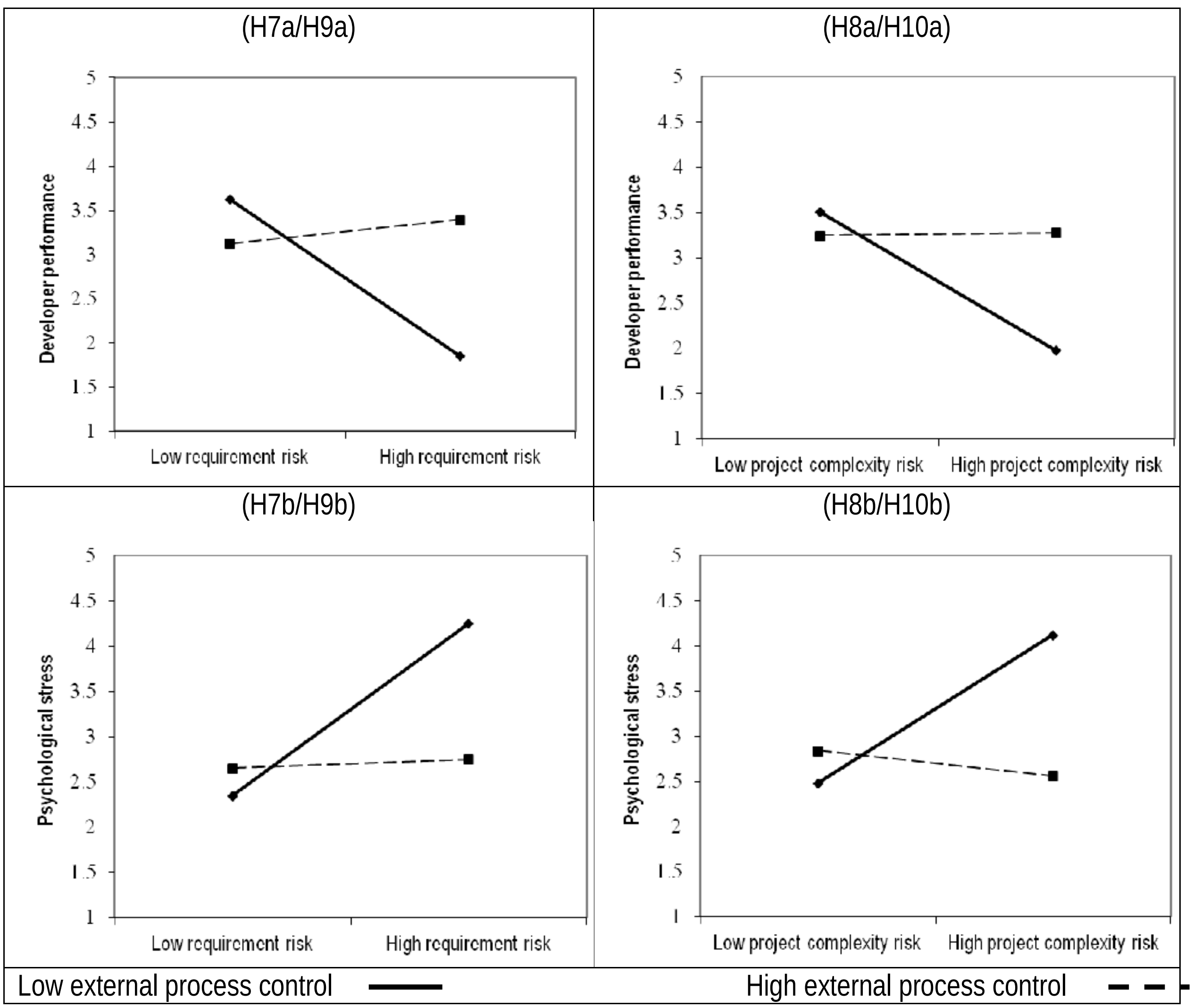
Figure 2. Plot of Interactions between Internal Process Controls and Technical IS Project Risk



H7 through H10 predicted that IS project manager project-related knowledge would have an indirect moderating effect on the relationship between technical IS project risk and individual developer outcomes through external processes. The results of the bootstrap analysis testing this indirect effect are shown in Appendix D (Table D2). IS project manager project-related knowledge has a positive indirect moderating effect on the relationship between technical IS project risk and individual performance and the confidence interval does not contain zero, thus supporting H7a, H8a, H9a and H10a. The results also show that IS project manager project-related knowledge has a negative indirect moderating effect on the relationship between technical IS project risk and psychological stress, with the confidence interval not containing zero. Thus H7b, H8b, H9b and H10b are supported.

We plotted the significant interactions to understand the form of the moderating effect of external process control on the relationship between technical IS project risk and individual developer outcomes. The interaction plots are shown in Figure 3. As shown in Figure 3, technical IS project risk has a negative relationship with individual performance when external process control is low and the relationship is not significantly different from zero when external process control is high. Technical IS project risk has a positive relationship with psychological stress when external process control is low and the slope is not significantly different from zero when external process control is high. This supports our prediction that external process control attenuates the influence of technical IS project risk on individual outcomes and lends further support for H7 through H10.

Figure 3. Plot of Interactions between External Process Controls and Technical IS Project Risk



In arguing for the cross-level effects of technical IS project risk on individual developer outcomes, we treated individual developer performance and psychological stress as separate outcomes. However, psychological stress has consistently been found to negatively influence task performance (see meta-analysis by LePine et al. 2005). When individual developers experience psychological stress, their judgment and ability to make decisions effectively becomes impaired (Driskell et al. 1999). The results in Table 2 (model 4a) show that psychological stress has a significant negative effect on individual performance ($\beta = -.13$, $p < .01$). To determine the extent to which psychological stress mediates the cross-level effects of technical IS project risk on individual developer performance, we conducted a 2-1-1 cross-level mediation test following Krull and MacKinnon (2001), where the independent variable resides at level-2 and the mediator and dependent variable reside at level-1. As we did not detect a significant main effect of project complexity risk on psychological stress, there was no significant indirect effect of project complexity risk on performance. In contrast, requirement risk has a negative cross-level indirect effect on individual performance through psychological stress (indirect effect = -.02). This demonstrates the role of psychological stress as a mediating link between technical IS project risk and performance.

DISCUSSION

Our findings support our model and the hypotheses related to the: (a) cross-level negative effects of technical IS project risk (level-2 determinant) on individual developer outcomes (level-1) and (b) cross-level moderating effects of IS project manager project-related knowledge (level-3 determinant) on the relationship between technical IS project risk (level-2 determinants) and individual developer outcomes (level-1 outcomes) through the enactment of internal and external IS project process controls (level-2 mediators). Cumulatively, our results provide compelling support that there are significant interdependencies across the three levels of analysis and that integrating these three levels provides a rich explanation of the key mechanisms through which knowledgeable IS project managers can enable individual developers to cope with the effects of technical IS project risk, both in terms of performance and psychological stress.

Contributions

Our results contribute to theory in several important ways. First, our research contributes to the IS project risk framework and the broader literature on IS project risk. Although prior research broadly understood that technical

IS project risk is an impediment to performance (Schmidt et al. 2001; Wallace et al. 2004a), there was little theory to (1) understand the micro-level impacts of such risk on individual developer outcomes of psychological stress and performance and (2) suggest why and how IS project managers can mitigate the micro-level impacts of such threats (Jiang et al. 1998; Napier et al. 2009). Our findings show that technical IS project risk is a threat because it increases the psychological stress and decreases the task performance of the individual developers who are responsible for developing the software system. Additionally, although Wallace et al. (2004a) and others have emphasized that technical IS project risk creates risk in terms of being able to execute the IS project, they have not articulated whether and how the threat posed for individual developer outcomes by technical IS project risk can be averted by IS project managers. Our findings show that IS project managers can have a robust impact in attenuating the deleterious effects of technical IS project risk on individual developers.

Second, although it is axiomatic that the purpose of IS project managers is to enable IS employees to perform better, there has hitherto been little theory in IS to explain why and how this is accomplished (Jiang et al. 1998; Napier et al. 2009; Nelson 2007). By drawing on control theory and elaborating the mechanisms in use, this research shows that both technical and managerial IS project-related knowledge are influential in prompting IS project managers to intervene with processes to counter the adverse impacts of technical IS project risk. Specifically, we identified the enactment of internal and external IS project process controls as the mediating process mechanisms by which knowledgeable IS project managers attenuate the negative effects of technical IS project risk on individual developers. This important intervening mechanism linking IS project managers to the attenuation of technical IS project risk represents a useful extension to our understanding of how and why effective IS project management is enacted and with beneficial performance and well-being consequences at the critical—but overlooked—level of the individual developer. Research has not previously considered the role of the activities reflected in process controls in affecting psychological stress. Our research shows that through the use of internal process controls knowledgeable IS project managers enable individual developers to cope with the stresses of technical IS project risk by providing mechanisms for reducing ambiguity (e.g., setting target milestones, monitoring progress, coordinating timing of inputs and outputs). Likewise, by enacting external process controls, knowledgeable

IS project managers enable individual developers to cope with the stresses of technical IS project risk by providing more information to reduce ambiguity.

Third, this research shows why there are differences between IS project managers in their ability to intervene through the enactment of process controls. Our findings show that it is clearly desirable to have an IS project manager with project-related knowledge in both domains—technical to understand how to support efforts to construct the system (e.g., coding, code testing, integration) and project management to understand how to facilitate the broader objective of delivering the working system to the client (e.g., scheduling, planning, monitoring, coordinating, cooperating). Firms that erroneously assume that project managers do not need to possess knowledge in the technical or project management domain are likely to end up with a less effective set of internal and external process controls that not only adversely impacts project-level outcomes, but also creates unfavorable conditions for individual developers to be able to perform their work effectively or psychologically cope with technical risk.

Fourth, this research contributes to control theory and the broader IS project management literature by providing a more holistic view of the multilevel mechanisms by which IS project managers influence individual developer outcomes. For an interdependent process that IS development is, where the input of individual developers is a critical determinant of IS project performance (e.g., Maruping et al. 2009b), ignoring how individual IS project developers are affected by technical IS project risk can be detrimental. This is a major reason that Markus and Robey (1988) and Orlikowski and Robey (1991) called for research to adopt a multilevel lens when examining various phenomena, such as IS project development. By adopting a multilevel lens, our research empirically demonstrates that IS project process controls can improve IS project performance by providing a structure that enhances the ability of individual developers to cope with technical IS project risk thus, increasing individual task performance and reducing psychological stress. Further, our supplemental analysis shows that individual performance influences IS project success in the form of client satisfaction with the system. As such, we elaborate the IS project manager → IS project process control → IS project outcomes relationship by theorizing the cross-level linkages that provide a more complete understanding of how IS project managers influence IS project outcomes. This helps to bring control theory in the IS literature to the micro level by explaining how the work structure created by process controls affects the ability of individual IS employees to perform their assigned tasks. The findings represent a key step in beginning to bridge the macro-micro gap in IS project management research.

Finally, this research contributes to IS control theory and to the IS project management literature through its identification of internal versus external IS project process controls. Although there has been reference to the importance of integrating the client into the team's processes (e.g., Rai et al. 2009), prior IS research has not made the distinction between IS project process controls that are oriented toward an IS project team's internal efforts to develop an IS versus those that are oriented toward the external client environment (e.g., Keil et al. 2003). By drawing on the taxonomy of team processes (Marks et al. 2001) and boundary spanning theory (Ancona and Caldwell 1992), we were able to elaborate how we theoretically conceptualize IS project management by identifying and contrasting the internally versus externally directed IS project process controls that are implemented when knowledgeable IS project managers are involved. By drawing this distinction and linking both types of IS project process controls to the mitigation of technical IS project risk on individual developer outcomes, we show that there are multiple mechanisms by which IS project managers can influence individual performance and psychological stress. This finding also suggests that in addition to maintaining an awareness of levels beyond the IS project level, IS project managers need to achieve a dual focus between process interventions directed internally toward the IS project team and externally toward how the IS project team interfaces with the client environment. Clearly, IS project managers with IS project-related knowledge understand the importance of establishing process controls to facilitate the integration of both the technical knowledge necessary to construct the software and the client business domain knowledge needed to structure the software to meet client expectations. Our study identifies the specific process controls that underlie internal and external process controls that should be focal interventions for project managers to implement and increase emphasis on with increasing technical risk.

Strengths, Limitations, and Future Research

There are several positive attributes of our study that enhance the validity of our findings. Our data were gathered from multiple sources including questionnaires and archives, thus alleviating the concerns regarding common method bias. Data were collected at different points in time, thus strengthening the validity of our findings. Our focus was on strategic IS projects that required fully customized solutions rather than minor reconfiguration of existing solutions. This enabled us to access the complete life-cycle of IS projects. Our focus on a three-level model structure also enabled us to take full advantage of the data and study design.

Although we took several precautions to make sure our study is methodologically and analytically rigorous, our study has a few limitations. Several of the variables in the model were collected from the developers using surveys. We conducted a marker variable test to determine whether common method variance was a threat to our results (Lindell and Whitney 2001). The results of the test revealed attenuation of no more than .03 in the correlations between the variables and the significance level of all correlations remained the same. This suggests that common method variance is not a concern in the results. Our study was limited to one vendor firm in India. We limited our analyses to IS projects offshore-outsourced only from U.S-based clients to avoid contamination by other factors. Future work should investigate if our findings generalize to offshoring IS projects from countries other than the US and vendors from countries other than India. Given our limited sample size at the level of IS project managers, we were constrained in the number of predictors we could include in our analyses. Consequently, we only included a limited number of IS project manager characteristics. Future research should go beyond project manager characteristics and investigate other factors at the IS project manager level, such as leadership style. Given our study design, we only measured process controls from developers. This made it difficult to ascertain the extent to which the use of such controls was driven by IS project managers versus the developers themselves. However, in CMMI level-5 vendors, such as the one in our study, IS project managers play an active role in directing what IS project teams do. Finally, as we noted in describing our sample, we only focused on IS projects that involved a single IS project team and no cross-nesting of individual developers. With increasing emphasis on multi-team systems, it will be important for future research to incorporate these considerations into theorizing the impact of controls as this would likely involve coordination within teams as well as between teams (Mathieu and Chen 2011).

These limitations notwithstanding, our research lays the ground work for future research to further understand the cross-level dependencies that exist in IS projects. Our focus in this research was on the top-down influences of IS project manager process interventions. However, the findings of Ply et al. (2012) on how IS employees are affected by different levels of process maturity—per CMM—suggest that it would be theoretically insightful to incorporate the influence of the organization's CMMI level. In the case of our research, we were unable to incorporate such considerations as the study involved a single CMMI level-5 vendor firm. Yet, the fact that we found variation in performance among IS projects developed in a CMMI level-5 organization is interesting and suggests that there may be some between-firm *and* within-firm differences that affect IS project success. Clearly, as our findings show, IS project managers account for some of the within-firm variation in IS project performance. It is possible that between-firm differences (e.g., centralization versus decentralization of decision making about process controls) might play a direct or moderating role. Future research can examine if the high covariation among the dimensions of internal/external process controls that we observed in a CMMI level-5 vendor context is attenuated in firms with lower process maturity. Such research would be helpful in, identifying whether a disaggregated assessment of the enablers/impacts of the internal/external process control dimensions is useful in lower process maturity contexts. As such, efforts to integrate firm level, IS project manager level and individual developer level considerations would go a long way toward bridging the macro-micro gap in this research domain.

This research provides a first step toward uncovering the micro-level mechanisms by which IS project managers affect individual developer outcomes. The supplemental analysis results showed that psychological stress is one such mechanism. However, there are interesting avenues to expand the set of micro-level factors that link IS project-level process controls to individual task performance. One useful next step would be to identify the impacts of process controls on the specific tasks assigned to each individual developer. Insights could be gained from work that can identify individual task characteristics (e.g., task analyzability, task significance) that might be influenced by process controls and might in turn affect individual task performance (Slaughter and Kirsch 2006).

We focused on the exercise of process controls in IS projects and the results indicate that IS project managers who possess IS project-related knowledge exercise process controls. It will be important to understand what mechanisms are used by IS project managers who lack IS project-related knowledge and whether their choice of controls changes over time as they gain IS project knowledge. Prior work suggests that IS project managers who lack IS project-related knowledge are more likely to rely on informal controls, such as clan control or self control (Kirsch 1997; Kirsch et al. 2002). The IS literature would benefit from work that examines the cross-level effects of informal controls, such as clan control, on individual outcomes in a variety of process maturity contexts, i.e., varying levels of CMMI maturity. It is possible that the exercise of such control modes may be both structurally and psychologically empowering in a way that motivates individual developers to exert greater effort in executing their assigned tasks (Chua et al. 2012).

CONCLUSIONS

We develop a multilevel model to explain the mechanisms by which IS project managers mitigate the negative effects of technical IS project risk on the performance and psychological stress of individual developers. Our three-level model provides a cohesive explanation of why and how knowledgeable IS project managers can promote the enactment of process controls to mitigate the detrimental impacts of technical risk in IS projects on not only the performance, but also the well-being of individual developers. Our results provide strong support for the cross-level moderation effects of IS project manager project-related knowledge on the relationship between technical IS project risk and individual developer outcomes through the enactment of internal and external IS project process controls. The multilevel theoretic lens provides a more holistic understanding of the mechanisms by which IS project managers can influence the outcomes of individual developers and takes an important step toward bridging the macro-micro gap in IS project management research by examining the micro-level impact of IS project control.

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ONLINE SUPPLEMENTAL MATERIAL
Appendix A. Measures for Variables in Research Model

Individual performance (Obtained from supervisor ratings); Anchors: 1 = "needs much improvement", 7 = "excellent"
Please rate [team member name] on their performance on the project in terms of:
1. Quantity of work output.
2. Quality of work output.
3. Accuracy of work.
4. Completing work tasks on-time.

Psychological stress (Keller, 2001); Anchors: 1 = "strongly disagree", 7 = "strongly agree"
1. I have experienced tension during this project.
2. Aspects of this project have been a source of frustration for me.
3. There has been no strain from working on this project. (r)
4. I never felt pressured during this project. (r)

Client Satisfaction with Project (Nidumolu 1995); Anchors: 1 = "very poor", 7 = "very good"
1. Ease of use of software.
2. Ability to customize outputs to various user needs.
3. Range of outputs that can be generated.
4. Overall responsiveness of software to users.

Internal Process Controls (Mathieu et al., 2006); Anchors: 1 = "strongly disagree", 7 = "strongly agree"
Transition processes
1. Members of my team discuss our performance vision.
2. Members of my team discuss what we can do day to day to make our performance vision a reality.
3. Members of my team discuss our project team's objectives.

Action processes
1. Members of my team take the time we need to share task-related information.
2. Members of my team actively learn from one another.
3. Members of my team effectively communicate with each other throughout the workday.

Interpersonal processes
1. Members of my team create an environment of openness and trust.
2. Members of my team really trust each other.
3. Members of my team think in terms of what is best for the team.

External Process Controls (Ancona and Caldwell 1992); Anchors: 1 = "strongly disagree", 7 = "strongly agree"
Task coordinator activities
1. When design problems arise, we resolve them with the client.
2. We coordinate our activities with the client.
3. Our team discusses delivery deadlines and schedules with the client.
4. We review the project design with the client.
5. On this team, we ask the client to help us make decisions about the project design.

Ambassador activities
1. Absorb outside pressure for the team so that it can work free of interference
2. Protect the team from outside interference
3. Prevent “outsiders” from overloading the team with too much information or too many requests
4. Scan the internal organizational environment for threats to the team
5. Persuade other individuals that the team’s activities are important
6. “Talk up” the team to outsiders
7. Acquire resources (e.g., new members, money/budget, technology) for the team
8. Find out whether others in the organization support or oppose the team’s activities
9. Keep other groups in the company informed of the team’s activities

Scouting activities
1. Find out what competing teams are doing on similar projects
2. Scan the environment inside or outside the organization for design ideas/expertise
3. Collect technical information/ideas from individuals outside of the team
4. Scan the environment inside or outsides the organization for technical ideas/expertise

IS Project Manager Project-Related Knowledge; Anchors: 1 = “not at all”, 7 = “to a great extent”
To what extent does this IS project manager demonstrate knowledge of:
Technical project-related knowledge
1. programming languages
2. detailed technical design
3. technical design constraints
4. code testing and debugging procedures
5. development tools and coding environments

Project management knowledge
1. how to set out project milestones
2. how to estimate the project schedule
3. how to detail key activities for achieving project objectives
4. how to monitor project progress
5. how to manage relationships with clients
6. how to facilitate client interaction

Appendix B. Supplemental Analysis

In underscoring the importance of understanding whether and how IS project managers can influence individual developer performance through process control interventions, we argued that such efforts may very well have implications for IS project success. Complex knowledge-intensive undertakings, such as IS development, are highly task interdependent. Thus, low performance by an increasing proportion of individual developers can derail the IS project as a whole. To determine the extent to which individual task performance impacts IS project success, we computed the average performance of individuals in each IS project team. We also controlled for the within-team standard deviation for individual performance to ensure that we isolated the effects for mean individual performance. These data were used to predict client satisfaction with the IS project, which was measured using a four-item scale by Nidumolu (1995). Clients responded to the scale four months after the system was delivered and implemented. The results of the analysis are shown in Table C1 below. As the results indicate, mean individual performance had a positive relationship with client satisfaction ($\beta = .23$, $p < .001$), supporting the idea that efforts to promote individual task performance can also benefit the IS project overall. Additionally, the within-team standard deviation of individual developer performance had a negative relationship with client satisfaction ($\beta = -.13$, $p < .05$), indicating that disparities in performance between different developers can negatively affect project performance. This further reinforces the importance of examining the implications of various project-level interventions for individual developer outcomes.

Table B1. Multilevel Model Predicting Client Satisfaction with IS Project

	Client satisfaction		
Variable	1c	2c	3c
Level-1 (controls):			
Intercept	.10 (.017)	.05 (.019)	.03 (.021)
Team size	.06 (.020)	.04 (.021)	.02 (.023)
Team experience	.10 (.020)	.08 (.022)	.05 (.025)
Project size	-.17** (.003)	.15** (.004)	-.13* (.005)
Project complexity risk	-.16** (.003)	-.14* (.004)	-.12* (.004)
Requirement risk	-.10 (.010)	-.08 (.012)	-.07 (.013)
Level-1 (main effects):			
Individual performance (team mean)			.23*** (.005)
Individual performance (coefficient of variation)			-.13* (.004)
Internal process control		.14* (.008)	.10 (.013)
External process control		.13* (.010)	.07 (.015)
Level-2 (controls):			
Age (project leader)	.06 (.008)	.05 (.009)	.03 (.010)
Gender (project leader)	.03 (.011)	.02 (.012)	.01 (.013)
Organizational tenure (project leader)	.12* (.012)	.10 (.013)	.06 (.015)
Level-2 (main effects):			
Managerial project-related knowledge	.20** (.003)	.17** (.004)	.13* (.004)
IS project manager development knowledge	.17** (.002)	.15* (.003)	.12* (.003)
Random effects:			
Level-1 variance (r_{ij})	.42***	.38***	.32***
Level-2 variance (U_{0j})	.37***	.31***	.25***
Deviance	4008.20	3860.10	3015.51
χ^2	712.39***	662.13***	528.17***
R^2	.19	.25	.32

Notes:

1. Level-1, n = 1,230; Level-2, n = 130; Level-3, n = 20.
2. Standard errors are shown in parentheses.
3. * p < .05; ** p < .01; *** p < .001.

Appendix C. Results of Confirmatory Factor Analysis

Table C1. Fit Indices for Confirmatory Factor Analysis

Model	χ^2	χ^2/df	CFI	GFI	SRMR	RMSEA
A. First-order (8 constructs; 6 controls + 2 outcomes)	462.20	0.90	.96	.92	.05	.04
B. First-order (6 controls constructs)	430.51	1.45	.95	.91	.06	.05
C. Second-order (6 first-order controls constructs + 2 second-order constructs)	481.35	1.58	.95	.91	.07	.06

Notes:

1. Model A included eight freely correlating first-order constructs—i.e., the six process controls constructs and the two individual outcome constructs. Model B included the six freely correlating internal and external process constructs. Model C included two second-order reflective constructs (one for internal process control and another for external process control) and 6 first-order internal/external process controls constructs, thereby gaining eight degrees of freedom relative to Model B.
2. As expected, the first-order loadings were almost identical across models A, B and C. Specifically, all first-order loadings in the models were identical to the second decimal place.
3. CFI = confirmatory fit index, GFI = goodness of fit index, SRMR = standardized root mean square residual, RMSEA = root mean square error of approximation.
4. * $p < .05$, ** $p < .01$, *** $p < .001$.
5. The target coefficient (T) (the ratio of the chi-square statistic of a first-order factor model to a second-order factor model) comparing models B and C was .894, providing further support for the second-order factor models for internal and external process controls (Marsh and Hocevar 1985). As internal and external process controls have three dimensions each, their individual second-order models are just identified with T coefficients of 1 for these models.

Table C2. Item Loadings for Model A

Indicators:	AVE	Square root of AVE	1	2	3	4	5	6	7	8
Individual performance1	.62	.79	.82							
Individual performance2			.80							
Individual performance3			.75							
Individual performance4			.77							
Psychological stress1	.56	.75		.73						
Psychological stress2				.75						
Psychological stress3				.77						
Psychological stress4				.75						
Transition process1	.61	.78			.74					
Transition process2					.75					
Transition process3					.84					
Action process1	.67	.82				.83				
Action process2						.80				
Action process3						.82				
Interpersonal process1	.57	.75					.79			
Interpersonal process2							.77			
Interpersonal process3							.75			
Task coordinator activities1	.67	.82						.76		
Task coordinator activities2								.85		
Task coordinator activities3								.84		
Task coordinator activities4								.80		

Task coordinator activities5								.84		
Ambassador activities1	.58	.76							.75	
Ambassador activities2									.77	
Ambassador activities3									.79	
Ambassador activities4									.80	
Ambassador activities5									.83	
Ambassador activities6									.75	
Ambassador activities7									.77	
Ambassador activities8									.70	
Ambassador activities9									.71	
Scouting activities1	.56	.75								.75
Scouting activities2										.74
Scouting activities3										.76
Scouting activities4										.75

Notes: Loadings shown are for the item loadings on their respective first-order constructs (CFA constrains cross-loadings to 0 as indicated by the grayed cells), AVE = average variance extracted.

Table C3. Loadings of First-order Factors on Second Order Factors in Model C

Indicators:	Internal	External
Transition processes	.80	
Action processes	.82	
Interpersonal processes	.85	
Task coordinator activities		.77
Ambassador activities		.85
Scouting activities		.83

Notes:

1. Loadings shown are for the first-order construct loadings on their respective second-order constructs (CFA constrains cross-loadings to 0 as indicated by the grayed cells).
2. The first-order loadings for Model C were almost identical to those reported in Table B1 for Model A, with a few differences only at the third decimal place.

Appendix D. Results of Tests of Mediated Moderation

Table D1. Results of Indirect Moderating Effect of IS Project Manager Project-related Knowledge through Internal Process Controls

Moderator	Predictor	Individual performance			Individual psychological stress			Support for hypothesis
Technical IS project risk:	IS project manager knowledge:	Point estimate (SE)	95% Confidence interval		Point estimate (SE)	95% Confidence interval		
			CI-low	CI-high		CI-low	CI-high	
Project complexity risk	Project management knowledge	.05 (.04)	.012	.085	-.04 (.04)	-.084	-.011	Yes
	Technical knowledge	.06 (.04)	.021	.105	-.05 (.03)	-.085	-.024	Yes
Requirement risk	Project management knowledge	.05 (.03)	.019	.088	-.04 (.03)	-.074	-.012	Yes
	Technical knowledge	.06 (.04)	.018	.104	-.05 (.04)	-.097	-.010	Yes

Notes: Bootstrap estimates are based on 10,000 resamples, SE = standard error.

Table D2. Results of Indirect Moderating Effect of IS Project Manager Project-related Knowledge through External Process Controls

Moderator	Predictor	Individual performance			Individual psychological stress			Support for hypothesis
Technical IS project risk:	IS project manager knowledge:	Point estimate (SE)	Confidence interval		Point estimate (SE)	Confidence interval		
			CI-low	CI-high		CI-low	CI-high	
Project complexity risk	Project management knowledge	.04 (.04)	.009	.082	-.04 (.04)	-.082	-.007	Yes
	Technical knowledge	.04 (.04)	.008	.082	-.04 (.04)	-.084	-.009	Yes
Requirement risk	Project management knowledge	.05 (.03)	.014	.089	-.04 (.03)	-.071	-.009	Yes
	Technical knowledge	.05 (.04)	.011	.102	-.04 (.04)	-.081	-.006	Yes

Notes: Bootstrap estimates are based on 10,000 resamples, SE = standard error.