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Andrew Gemino
Simon Fraser University

Blaize Horner
UBC Okanagan

Chris Sauer
University of Oxford

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Andrew C. Gemino
Simon Fraser University
gemino@sfu.ca

Blaize Horner Reich
UBC Okanagan
blaize@telus.net

Chris Sauer
Saïd Business School
University of Oxford
Chris.Sauer@sbs.ox.ac.uk

ABSTRACT

The challenge of understanding IT project performance is examined by consolidating literature on software development risk, extending the concept of risk management process and including the notion of project volatility. An integrated project performance model (PPM) including constructs of a-priori risk, risk management process, project volatility, project process performance and project product performance is proposed. Hypotheses surrounding the relationships between these constructs are provided. A survey of IT project managers in five Project Management Institute (PMI) chapters in Ohio has been collected to test these hypotheses but results are not discussed in this paper.

Keywords

Project Management, Project Performance, Software Project Risk, Project Volatility

INTRODUCTION

Decades of research has focused on IT project performance in the areas of software development risk, risk management and software development performance (Zmud, 1980; McFarlan, 1981; Bohem, 1989; Barki et. al., 1993, 2001; Ropponen and Lyytinen, 2000; Schmidt et. al., 2001). This research has made three basic contributions: 1) a variety of classifications of software development risks (Bohem, 1989; Barki et. al. 1993; Keil et. al. 1998; Wallace and Keil, 2004), 2) suggestions for effectively managing software development risks (Boehm, 1989; McFarlan, 1981; Ropponen and Lyytinen, 2000; Tiwana and Keil, 2004;) and 3) theoretical models and frameworks addressing software development risks and risk management (Barki et. al., 1993; 2001; Nidumolu, 1995;1996; Aubert et. al, 2005). While researchers generally agree that risk management can improve the performance of IT projects, the relationship between risk management and performance is not clear. Much of the research has focused on risk identification and our models relating risk to performance remain incomplete.

The objectives of this study are to address the challenge of IT project performance by: 1) consolidating the literature on a-priori risk identification; 2) extending the concept of risk management process and measure the impact of process in project performance 3) examining the impact that knowledge embedded in critical project "roles" can have on project performance and 4) including the notion of project. The contributions of this article are to provide a more holistic model of IT project performance that integrates the effects of a-priori risks, risk management process and volatility. A survey has been developed to measure the impact of various constructs on project performance but results are not discussed in this paper.

DEVELOPING AN INTEGRATED PROJECT PERFORMANCE MODEL

The attention focused on risk and risk management has led to an increased sophistication related to the construct of "risk". Risk, when viewed as a probabilistic variable requiring quantitative estimates of event probabilities, can prove challenging to assess. Event probabilities are often difficult to estimate and the subjective estimates of impacts can vary widely. Probabilities are also required to combine the various risk exposures to develop a project's overall risk exposure. Boehm (1989) suggested the use of approximation techniques and prioritized checklists designed to address some of the estimation challenges in assessing risk.

Barki et. al. (1993) suggested an alternative definition. Development risk was estimated using the uncertainty surrounding the entire project and the magnitude of potential loss associated with project failure. Software development risk was defined as the project uncertainty multiplied by the magnitude of potential loss due to project failure. This narrowed the estimate of impacts to a single item – project failure. Individual risk items could then be characterized by their impact on the uncertainty of a project, where the impact of every risk was the loss associated with project failure. Nidumolu (1995) extended software development risk to include "*the extent of difficulty in estimating performance-related outcomes of a project, regardless of the specific estimating technique being used*" (Nidumolu, 1995, p. 195). Performance was defined by several measurable outcomes such as project budget or schedule.

Identifying Performance Risk

A large number of studies have provided suggestions for categorizing uncertainties in IT projects. Boehm (1989) provided a top 10 checklist of risks associated with projects. Ropponen and Lyytinen (2000) used this list to develop six risk components which included: 1) scheduling and timing risks, 2) system functionality risks, 3) subcontracting risks, 4) requirement management risks, 5) resource usage and performance risks, and 6) personnel management risks. Barki et. al. (1993) identified five risks including: 1) novelty, 2) application size, 3) lack of expertise, 4) application complexity and 5) organizational environment (lack of resources and support). Interestingly, the agreement between these two lists is relatively small with perhaps two items, application complexity and personnel management risks (including lack of expertise and requirements management risks), showing significant overlap.

Keil et. al. (1998) and Schmidt et. al. (1999) provide a framework for categorizing project risks created using 40 project managers across several countries. The framework identified categories of risk that differ in term of importance and controllability. These two dimensions create a 2 by 2 matrix that is used to establish four risk categories including: 1) customer mandate (uncontrollable and high importance), 2) scope and requirements (controllable with high importance), 3) Execution risk (controllable with moderate importance) and 4) Environment risks (uncontrollable with moderate importance).

It can be argued that the four risk categories identified by Keil et. al (1998) captures all of the risk items identified by Barki et al. (1993) and Roppenen and Lyytinen (2000) except for application size. The four categories also cover risks suggested by Zmud (1980) including technological complexity, the degree of novelty or technological change but again does not include project size. The same is true for the risk identified by McFarlan (1981) which included experience with the technology, project structure and project size. The four categories also fit well with risk categories identified by practitioners (Standish Group, 2003). The categories created by Keil et. al. (1998) and augmented with project size therefore represent a relatively robust categorization of uncertainties in software development projects. This discussion is summarized in Table 1 below.

Table 1: Summarizing Categories of Uncertainties/Risks

Risk Categories Keil et. al. (1999)	Zmud (1980)	McFarlan (1981)	Barki et. al. (1993)	Ropponen and Lyytinen (2000)	Standish Group (2003)
Customer Mandate	User Involvement		Organizational environment		Top Management Support, User Involvement
Scope and Requirements	Technological complexity, Degree of novelty		Novelty, Application complexity	system functionality, requirement management,	Minimize scope, Firm Requirements, Reliable estimates
Environment		Project structure	Organizational environment		Formal methods,
Execution	Personnel changes	Experience with the technology	Lack of expertise	schedule and timing, subcontracting, resource usage and performance, personnel management	Experienced PM, Standard Software Infrastructure
Project Size*	Project Size	Project size	Application Size		

*** Not included as a category in Keil et. al. (1998).**

An additional consideration in the uncertainties identified by Keil et. al. (1998) is the time that the uncertainty can be established. For example, while uncertainty regarding requirements can be identified near the start of the project, changes in organizational management during the project cannot be identified until the project is well under way. Wallace and Keil (2004, p. 72) provide a list of 53 specific project uncertainty factors that are divided into the four categories. Of particular note in considering this list is that risks in the Customer Mandate and Environment categories are primarily discoverable after the project has started, whereas many of the uncertainties in the Scope and Requirements and Execution categories are potentially discernable before the project begins.

On the basis of this discussion we suggest the definition of A-priori Performance Risks. These risks are present before the project begins execution and include two general types of uncertainties that can be related but are best considered separately: 1) project risk factors which include project size characteristics such as budget, duration, effort, relative size as well as characteristics such as novelty, application complexity and uncertainty in requirements and 2) people risk factors that include characteristics of critical people (sponsors, client managers, project managers, project team, users etc.) involved in the project and include lack of expertise, lack of experience with industry, lack of experience with technology and lack of knowledge.

A-priori Risks and Project Performance

Much of the industry literature surrounding projects has linked a-priori risks to project performance (Standish Group 2001). Researchers have converged on the importance of considering two elements of project performance: process performance and product performance (Barki et. al. 2001; Faraj and Sproull, 2000; Nidumolu, 1995; Roppenen and Lyytinen, 2000; Wallace and Keil, 2004). Process performance refers to the efficiency of the project and is often measured by considering how the project adhered to costs and time estimates (Nidumolu, 1995;Wallace and application complexity application complexity Keil, 2004). Product performance refers to the quality of the developed system, that is, the outcome of the project itself (Barki et. al., 2001). The separation of process and product performance enable these measures to be addressed separately as process and product performance can in some instances are traded off.

Project Performance and Risk Management Processes

While some literature assumes a direct link between a-priori risk and performance, the majority of research suggests that a-priori risk are managed, and modified, through a risk management process. The failure to identify and manage risks has been clearly linked to poor project performance (Boehm, 1989; Charette, 1989). The management of performance risk is therefore an important consideration for software development project managers.

Not all performance risks are knowable a-priori. For example, the lack of top management support is not truly revealed until the project is executing. These “risks” differ from a-priori risks because they develop as the project executes. Support expected from sponsors can certainly be assessed before projects execute, however, the risk of top management support is better attributed to a-priori risks such as the inexperience of project sponsor/manager/team, project size or uncertainty of requirements. These a-priori risks can be viewed as root causes that reveal subsequent challenges for project managers.

Project size, complexity, and uncertainty are elements of a project that are difficult to avoid and are defined as a-priori risks. The amount of top management support is an example of a critical resource for effective risk management. Critical resources such as top management support can counteract the influence of a-priori risks. Poor project performance may emerge from a “lack of” these critical resources such as a lack of user participation, top management support, administrative coordination or expertise coordination. For this reason, we argue that the level of critical management resources reflects the ability to manage risk and not the risk inherent in the project itself. We therefore suggest a construct labeled “Risk Management Processes” that represents a pool of techniques and resources that can be used to address risks to project performance. The larger the process pool, the more likely that a-priori performance risks can be mitigated.

Several studies have provided suggestions for managing risk related to software development projects (Barki et. al. 2001; Keil et. al. 1998; Nidumolo, 1995; Ropponen and Lyytinen 2000; Wallace and Keil, 2004). Traditional methods include involving users, using standard development methods, including experienced people and providing administrative controls for the development process. Nidumolu (1995) extended this discussion by defining and testing the impact of Vertical and Horizontal Coordination. Vertical coordination was similar to administrative controls and development methods that provided formalized, hierarchical communication between the development team and stakeholders in the project. Horizontal coordination referred to communication methods that were undertaken through mutual and lateral means at both personal and group levels. Faraj (2000) introduced an argument for the consideration of expertise coordination in managing risk. Expertise coordination included three elements: 1) expertise location (knowing where the experts were), 2) expertise needed (knowing what knowledge is required) and 3) binging the expertise to bear. Faraj (2000) showed that expertise coordination was a significant contributor to performance above and beyond the traditional management methods.

This discussion suggests that elements of risk management process should include traditional elements of management as well as extensions suggested by Nidumolu (1995) and Faraj (2000). In particular, the process of risk management should include a consideration of administrative controls (representing formal methods and vertical communication), the integration of users and the coordination of expertise throughout the project team.

The Contingency Approach to Risk Management

Theory related to the IT risk management has been largely centred on the structural contingency approach in Organization Theory (Nidumolu, 1995; Barki et. al, 2001). Models created using this perspective suggest the importance of a "fit" between the uncertainties presented in a software project and the management practices used to address these uncertainties. Nidumolu (1995) used a structural contingency perspective to hypothesize that performance risk could be managed through appropriate use of vertical and/or horizontal coordination. He suggested that coordination between IS staff and users was critical to project performance. Vertical coordination referred to structured, hierarchical coordination through authorized entities. Horizontal coordination referred to lateral communication through persons and groups throughout the team. Results provided support for the hypotheses.

Barki et. al. (2001) offered an integrative contingency model using the perspective of information processing capacity. They argued that information processing capacity could be represented by three risk management constructs: formal planning, internal integration and user involvement. These three constructs were used to create two ideal risk management profiles; one for low risk exposure projects and one for high risk exposure projects. The contingency approach from Organizational Theory was used to hypothesize that "the better the fit between the risk exposure in a software development project and its management profile, the higher the project's performance" (Barki et. al., 2001, p. 42).

The insights provided by the structural contingency perspective suggest that the management of risk can mediate initial risk exposure and result in improved project performance. We have suggested a-priori performance risks can be managed through risk management processes. The impact of a-priori risks are therefore either unmanaged (and hence directly affect project performance) or are managed and influenced to some degree by risk management.

Project Volatility

It is impossible to identify and manage all performance risks. External shocks such as altered economic factors, changes in organizational priorities and others exogenous influences suggest that any model of project performance must take into account the important factors surrounding projects that are either difficult or impossible to predict and influence.

The construct of volatility introduced by Sauer et. al. (2006) provides a mechanism for considering the need for project stakeholders to adapt to changing project conditions. Two aspects of project volatility were identified: 1) target volatility, which addresses changes in project targets such as budgets and schedules and 2) governance volatility which reflects changes in key project personnel. Increases in either target or governance volatility signal unplanned adaptations to project plans. These unplanned changes may be caused by a number of factors including poor planning, poor communication, personnel changes, external shocks and/or inappropriate management resources. While the source of the volatility may not be easily discernable, it is clear that volatility reflects a reaction by managers to unsatisfactory project conditions. The larger the volatility surrounding a project is, the larger the number of unplanned changes and the clearer the message that the project is not performing well.

The concept of volatility can be related to "environmental" risks described in Keil et. al. (1998). These risks emerge largely due to external factors that extend beyond the influence of project managers and sponsors. External factors can affect performance in a similar manner to volatilities. The net affect of these external factors is to influence the level of performance risk. The management of these external risks affects the volatility associated with the project as management adapts to unplanned changes.

Taken together, volatility and environmental risk add to our understanding of how risk changes during a project by adding elements that are not directly under management control. Figure 1 provides an integrated model of project performance that includes a-priori risks, risk management process, project volatility and project performance.

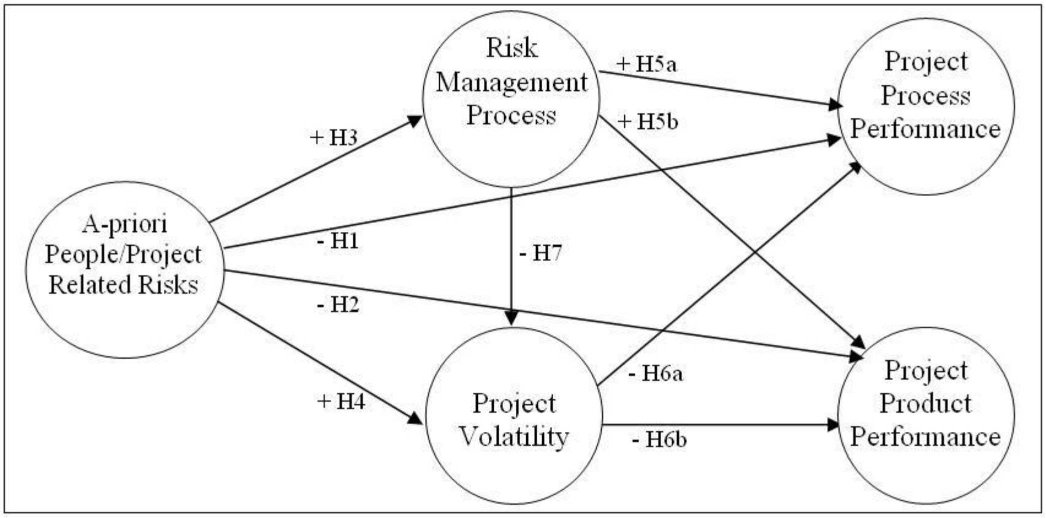

Figure 1: Integrated Project Performance Model

HYPOTHESES

The integrated Project Performance Model (PPM) provides a framework for exploring the effects of various elements of the risk management process on project performance. The model includes a combined motion of a-priori risks which include both project and people characteristics. These risks can act directly on project performance (process and product). Risks are mitigated through a collection of risk management processes which act to reduce impacts of a-priori risk on project performance categories. Finally, a-priori risks influence the level of volatility as measured by unplanned changes in the project targets or personnel. This volatility has negative consequences on project process and product performance. Six hypotheses emerge from the model provided in Figure 3 and are discussed below.

H1: Direct Effect of A-priori Risks on Project Process Performance

Industry literature (Standish Group, 1995) suggests a direct negative relationship between the level of a-priori risks and project process performance. This has prima facie appeal as the more risky the project the more likely the schedule and budget variances associated with the project will be negatively affected. We therefore expect a negative relationship between a-priori risks and project process performance. Sauer et. al. (2006) found that IT projects underperform on process performance measures at a rate of approximately 25% regardless of project effort, budget, duration or team size. This suggests some residual level of risk remains in IT projects. It should be noted, however, that in the presence of large risk it is likely that project stakeholders will make efforts to mitigate the risk. It can therefore be argued that the larger the risk, the greater the potential positive impact of using risk management. This issue is addressed directly in hypotheses H3a and H3b.

H2: Direct Effect of A-priori Risks on Project Product Performance

The argument for a direct negative relationship between the level of a-priori risks and project product performance is analogous to the discussion in the previous section. The product performance is related to the quality of the delivered product and the benefits that can be derived from the project deliverables. While the quality and benefits are notoriously difficult to measure, it is understandable that high levels of a-priori risks are likely to make the achievement of high levels of quality and consequent benefits more difficult to deliver. The same argument regarding the managerial response to high levels of risks noted above also apply to this hypothesis and are considered in the following section.

H3: Managerial Response to A-priori Risks

The earlier discussion noted that management techniques such as top management support, expertise coordination, user involvement and administrative coordination could be used to mitigate some of the a-priori risks associated with a project. We would therefore tend to expect to see high levels of this type of risk management activity when levels of a-priori risks were high. This would be supported by arguments from Strategic Contingency Theory which suggest that managers attempt to create a level of fit between level of risk and risk management techniques. Barki et. al. (2001) would argue that the level of risk management is contingent on several types of a-priori risks. Prior research therefore suggests a positive relationship exists between the level of a-prior risk and the level of risk management process.

A positive relationship between a-priori risk and risk management process assumes that project stakeholders are relatively adept at identifying risk and adapting management techniques to levels of risk. It should also be noted that hypothesis H3 suggests management reacts to risk to mitigate its effect. This would act to reduce the direct effect of risk on project performance (as noted in hypotheses H1 and H2).

H4: A-priori Risks and Volatility

Volatility is a measure of the changes in the number of project targets or project personnel. Higher levels of requirements uncertainty, for example, likely lead to a more frequent need to adjust project targets such as budget, schedules and scope. The same is true for a-priori risks such as project duration. The longer the project is open, the great the chance for unplanned events to occur. We would expect, therefore, a positive relationship between the level of a-priori risk and the measure of volatility. This again assumes that risk management processes are unable to completely dampen the effects of a-priori risks.

H5a and H5b: Risk Management Processes and Project Performance

Prior research from Barki et. al. (2001) and Nidomolu (1996), suggests that the level of risk management will be positively related to project performance when the level of a-priori risk is high (but lower when a-priori risk is lower). This appropriate level of management is therefore contingent on the level of a-priori risk. They found that the effect of risk management techniques were stronger on project process performance than on product performance. Research from Faraj and Sproull (2000) suggested that the level of expertise coordination, an example of a risk management process, has a positive effect on project performance and that this was not contingent on level of risk.

While the notion of fit is appealing, it can be difficult to argue that increased levels of important resources such as top management support or user involvement would lead to poorer project outcomes. The important consideration of fit is that these management processes are costly to implement and therefore there is an appropriate level of management for a given level of risk. In developing this hypothesis we have used the notion of risk management process provided in Faraj and Sproull (2000). We therefore hypothesize a direct positive relationship between the level of risk management processes on the level of project process and product performance.

H6a and H6b: Volatility and Project Performance

The link between volatility and project performance was developed in Sauer et. al. (2006). The argument was that larger numbers of changes in either project target or project personnel signal that project stakeholders are attempting to overcome negative effects on project performance by instituting unplanned changes to the project. As noted earlier, many of these changes may not be easily to forecast. Whether they are easy to foresee or not the fact remains that changes needed to be made. The more changes made, the more trouble the project has faced and the greater the likelihood that project deliverables will not be met. We therefore expect a negative relationship between the level of volatility and the level of both project process and project product performance.

H7: Risk Management Process and Volatility

Risk management processes are designed to improve planning and communication and therefore reduce the need to change targets and people within a project. For this reason, we hypothesize a negative relationship between risk management processes and volatility. It should e noted that we are it may prove beneficial to differentiate between volatility caused by project factors and external shocks in the environment in that these changes develop duew to different conditions and perhaps should not be treated interchangeably.

RESEARCH METHODS

Respondents

A survey was developed to test the hypotheses. Email invitations and a follow up request to participate were sent to IT project managers in five Project Management Institute (PMI) chapters in Ohio, USA during August /September 2004. A total of 264 responses were collected using an online survey instrument created using www.SurveyMonkey.com. Respondents were asked to provide information about the most recent project they had completed (either implemented or cancelled). The reason for considering the most recently completed project was to ensure that respondents were considering projects for which there was a defined outcome while maintaining reasonable recall of project details. Respondents indicated that 93% of the completed projects were implemented and 7% cancelled. The ratio of cancelled projects is similar to industry reports (Standish Group 2003) suggesting the responses have some external validity.

The respondents were experienced and knowledgeable project managers with an average age of 43, including an average of 15 years of industry experience and approximately 34 days of formal project management (PM) training. A good variation of project sizes was also demonstrated in the sample suggesting no project size bias was evident. The average reported project budget was just under $15 million (US) with an average effort of 172 person months and an average duration of 15 months. A profile of the 218 projects on various size characteristics is provided in Table 2.

Attribute	Mean	Median	Min	Max
Budget (000's $US)	$14,892	$875	$10,000	$1,700,000
Duration (months)	15	12	1	71
Effort (person months)	172	25	2	3400

Table 2: Profile of Projects

Instrument

The questionnaire developed for the study underwent both a pre-test and pilot phase. A large number of scales were used to collect information on the various constructs in the model. Information about the items and scales used in the questionnaire are summarized in Table 3 below.

Construct	Scales	Number of Items	Source adapted from
A-priori Risk	Requirements Uncertainty	3	Barki et. al.(2001)
	Novelty	3	Barki et. al.(2001)
	Technical Complexity	2	Barki et. al. (2001)
	Size	Budget ($), Duration (months), Effort in Person Months, Relative Size in (Likert scale)	
	Sponsor Knowledge	4	Bassellier et al. (2003)
	Client Manager Knowledge	4	Bassellier et al. (2003)
	Team Knowledge	4	Bassellier et al. (2003)
Risk Management Process	Administrative Coordination	3	Nidumolu (1995)
	Integrative Coordination	3	Nidumolu (1995)
	Expertise Coordination	5	Faraj et. al. (2000)
	Executive Support	4	Developed
	Client Manager Participation	3	Developed
Volatility	Target Volatility	3	Sauer et. al (2006)
	Governance Volatility	3	Sauer et. al (2006)
	External Volatility	3	Developed
Project Performance	Process Performance	Budget and Schedule Variance	Sauer et. al (2006)
	Product Performance	Benefits and Quality Variance	Developed

Table 3: Information on items used in Questionnaire

Preliminary Results

The PPM model is in development and the constructs used in the PPM are primarily formative. For this reason the model will be tested using PLS which handles formative constructs. (Gefen et. al. 2000). Early results indicate that the direct relationship between a-priori risks and project performance are mediated by risk management process. In addition, the path between a-priori risks and risk management process appear to be significant. These combined results provide evidence that a-priori risks are being mediated through risk management practices.

Preliminary work shows that Project Volatility has a significant positive relationship with a-priori risk. Increased volatility is also negatively related to project process performance. While analysis is preliminary, the findings to date suggest that the integrated project performance model provides significant explanatory power. Further work is required to develop the analysis and a more complete analysis can be provided at the conference.

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