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PROJECT RISK DIFFERENCES BETWEEN VIRTUAL AND CO-LOCATED TEAMS

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ABSTRACT

Although software development projects increasingly incorporate virtual team members, most research performed on project risk to date was conducted on projects using traditional co-located teams incorporating face-to-face communications. This paper identifies a set of risk factors particularly important to virtual teams but rarely discussed. Results, from a survey of over 150 Information Technology (IT) practitioners, are based on actual project experiences. Out of fifty-five risk factors included in the survey, seven factors showed significant differences in effect on the successful completion of projects based on project environment. Notably, the results showed a significantly greater impact for all seven risk factors in virtual software development environments, when compared to development using traditional face-to-face teams. This increased risk is termed the Magnifier Effect. Anticipating the Magnifier Effect can allow practitioners who are managing projects in a virtual environment to anticipate and mitigate the added risks of using virtual software development teams.

Keywords: IT Project Management, Virtual Teams, Risk Management.

INTRODUCTION

Virtual project teams are increasingly used in many areas of information technology, especially as a part of outsourcing arrangements. Therefore, the importance of research on topics related to virtual project teams is also increasing. Since prior studies on IT project risk have focused on traditional projects involving co-located teams, the objective of this research study was to identify which risk factors have significantly different degrees of impact on IT projects conducted using virtual project teams. To provide a background for this research, we now consider first the rapid growth of virtual teams, and then prior research into project risk factors.

Virtual project teams, by definition, are groups of people working together toward a common goal. Whether, they are called virtual or distributed, the team members are not co-located; they can reside in different cities, states or countries. Since these team members work in the context of a project, there is a definite beginning and end to the work and the time schedule. Thus, the definition for the purposes of this research does not include teleworkers or members of an operational department who work together regularly at a distance.

When virtual teams are used in outsourcing that involves other countries, the situation is referred to as offshoring. Dunn et al. note, “The offshoring decision has become a major strategy aimed at improving or maintaining profitability in highly competitive industries” [10]. In information technology, survey results indicate 49% of employers reported on average they save over $20,000 per head while 15% percent of employers reported they are saving more than $50,000 per head [25]. Besides cutting costs, outsourcing can also reduce implementation times and alleviate talent shortages. Alami et al. report, “India is the largest software exporter to North America and Europe with an estimated US$ 8 billion and an annual growth of 40%” [2].

Many driving forces, including advances in telecommunications, globalization, and the cost and dangers of business travel [13] also have fostered a move away from the traditional co-located project teams and toward use of virtual project teams. Research by Xue, et al. clearly indicates that outsourcing involves virtual teams [26]. This fact makes the performance of virtual teams crucial to the success of the outsourcing initiatives [25]. While the use of virtual project teams is growing [24], the amount of research on this emerging project environment lags well behind the volume of research on traditional, co-located projects. As Xue, et al. noted, “the factors that make virtual teams work together well are not well understood” [25]. Neither is project risk within a virtual environment.

In prior literature, researchers have theorized that risk management is vital to avoiding project problems, project failures and even project disasters [1] [6]. One group of researchers concluded high project failure rates could be attributed to the lack of good risk management practices [14]. For traditional co-located project teams, Boehm, as early as 1991 identified risk management to be critical to eliminating or reducing the occurrence of project risk. More recently, Chua reiterated the need for risk management in his research on project disasters, wherein he emphasized how identification and discussion of risk factors early in the project can be beneficial in helping IT projects avoid pitfalls [5]. More recent work views risk from the lens of success factors and has identified risk as a “facilitating function” critical to project success. In this scenario, project managers are charged with assessing risk “early and constantly throughout the life of the project” [21]. Risk management techniques generally require two steps. The first step is risk identification, which is an attempt to identify and document all possible risks for a specific project. The identification phase is followed by risk control, which involves devising a strategy to detect, address, and control each identified risk.

Researchers have produced lists of the “top” risks on projects such as resource expertise, team diversity, technology and/or application complexities and unrealistic budgets and schedules to

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name a few [3] [4] [14] [23] [21]. These “top ten” style risk lists are considered beneficial in the risk identification phase, useful as a guide for project management practitioners to common risks that may occur on a project [3]. A chart comparing the top risk lists identified by other researchers can be found in the Appendix. Unfortunately, due in large part to the time when this prior risk identification research was conducted, virtual projects were generally not considered. A survey of prior literature reveals no prior research into the differences in risk between traditional and virtual project environments. Thus, the objective of this research study was to identify which risk factors may have significantly different degrees of impact on virtual versus co-located project teams.

This paper continues now with background information on virtual teams and risk, followed by a description of research methodology. Next, detailed results illustrate how seven risk factors were found to have a significantly greater degree of impact on virtual software projects than on co-located software projects. A model is presented showing this Magnifier Effect. Results are then analyzed in a discussion section. A brief discussion of future research and limitations precedes a concluding section.

BACKGROUND

Prior literature does exist on virtual teams and virtual organizations, much of which focuses on investigating characteristics of virtual project teams such as trust, conflict and communication [15] [13] [17]. Other research identifies areas of difference between virtual and traditional co-located teams, such as Majchrzak, et al. who specifically identified three major areas where virtual teams differ from traditional co-located teams: (1) language and cultural differences, (2) work style differences and (3) problem solving approaches [18]. Certain aspects of virtual teams, such as trust and communication [8] have been researched in some depth. Some researchers focused on communication differences. Damian, et al. found some communication-related benefits in virtual project teams over traditional co-located teams when negotiating requirements among team members with “conflicting perspectives.” They felt the lack of verbal cues that occurs without face-to-face communication might have actually been beneficial in resolving differences [7]. On the other hand, Dube and Robey in their research on virtual team paradoxes, found a need for face-to-face communication in some instances, and benefits to not having face-to-face communication in others. [9] Finally, prior literature emphasizes the need for careful team member selection when building virtual teams due to differences in style, i.e. flexible work styles versus structured work environments. Virtual teams were in general found to be more flexible and have more ambiguities, while co-located teams were more structured [9].

Despite considerable research into virtual teams and into risk factors on traditional projects, there has been no empirical study of the important risk factors on virtual software development projects [20]. This gap in the research prompts the following questions: Are the most important risk factors on software development projects that employ virtual teams the same risks that were previously identified for traditional, co-located projects? Do risks have approximately the same level of effect on the success of both co-located and virtual projects? A study of over 150 IT professionals was undertaken to determine the answers to these questions.

METHODOLOGY

The research methodology for this study was modeled after research methods used by prior researchers identifying project risk factors, including Boehm, Barki, and Wallace [4] [3] [22]. In those studies, questionnaires were generally used to identify top risk factors on co-located software projects. The questionnaire for the current study specifically was modeled after a questionnaire by Wallace [22]. Development of the questionnaire followed a series of steps. First, a review of literature was conducted to identify as comprehensive a list as possible of project risk factors. Next, face-to-face interviews were conducted with project management practitioners using the first version of the questionnaire. Open-ended questions in the questionnaire were used to identify a list of risk factors from the practitioner point of view and to validate the list of risks identified from the literature. Additionally, rich data was collected from the practitioners as they described a specific project and the major issues they encountered. This step was followed by an electronically facilitated focus group session, which was held to identify any risk factors that may have been missed and to validate those found in the literature review and the face-to-face interviews. The large amount of data on potential risks collected from these steps went through an iterative process of sorting and combining to produce a comprehensive list of fifty-five potential risk factors. These became the variables investigated in the study, as shown in Table 1.

Survey participants were asked to rate each of the fifty-five risk factors on the degree of impact each risk had on the successful completion of their particular projects. Here success was defined as being completed within a reasonable percentage of the estimated time schedule, budget and requested requirements. A three-point Likert scale was used for this rating process where “1” indicated the risk factor had no impact on the project or simply did not occur during the course of the project, “2” indicated the risk factor had a minor impact on the successful completion of the project and “3” indicated the risk factor had a major impact on the successful completion of the project.

The questionnaire was piloted and then the revised version was distributed as an online survey. Most survey participants were contacted through a list of 4,000 names purchased from a project management website and through solicitation of the international project management association, Project Management Institute (PMI). Participants were either invited to take the survey or were self-selected when they accessed the survey through a website link. 154 IT practitioners, i.e. project managers/leaders and systems analysts completed the survey. 47 participants were from the purchased list or personal contacts while 107 were from the PMI link. PMI, which had approximately 260,000 members in 171 countries at the time, was selected to ensure a diversity of responses. Survey participants were asked to answer the questionnaire based on a recent virtual software project if possible. If no experience with a virtual software project was available, a recent co-located project could be substituted. This approach yielded data about both virtual and traditional software projects allowing for some comparisons between project environments. This approach also resulted in replies based on actual project experiences, as opposed to student team experiences. Further, having participants base risk ratings on actual project experiences with a specific project, rather than general opinion leads to a more reliable result, in accordance with Flanagan’s critical incident technique [11].

TABLE 1 — Fifty-Five Potential Risk Factors (alpha order)

Catering to desires and wants of a few stakeholders	Loading up project with excess resources to resolve issues
Company politics and/or lack of integrity	Loss of key resource(s) that impact the project
Conflict among team members	Misidentification of stakeholders
Cost overruns	No contingency planning
Creation of meaningless intermediate deliverables to give the impression deadlines are being met	No sponsors or wrong sponsors
Cultural or language differences	Personnel turnover
Developed application or product doesn't satisfy requirements	Poor decision making process
Developed application or product unacceptable to end-user	Poor quality deliverables
Excessive wait for funding approval, no funding or loss of funding	Poor vendor performance
Forced to work within dictated constraints	Poor vendor relationship
Geopolitical issues	Poorly written, unclear or vague project requirements
Hidden agendas impact the project	Project critical to the organization
Idle people resources, for example due to early staffing or project windup	Project manager replaced during project
Inadequate project management and/or inexperienced project manager	Project scope too limited or vague
Inadequate technical resources, i.e. hardware, processing availability	Project scope was scaled back from original scope
Inexperienced end users	Project team members resist change
Insufficient knowledge transfer	Resource inexperience with company and its' processes
Integration of project components is complex	Team members are not accountable for bad or poor decisions
Lack of appropriately skilled resources	Technical connectivity issues hinder communication
Lack of balance or diversity on the project team	Technology hardware new to the organization
Lack of commitment from management	Technology software new to the organization
Lack of coordination among vendors	Too many meetings
Lack of end user buy-in	Too many scope changes/scope creep
Lack of knowledge needed for successful integration of project components	Unclear project objectives
Lack of needed training	Unidentified technical constraints
Lack of or inadequate communication	Unrealistic Estimate/Budget expectations
Lack of project team cohesion	Unrealistic time estimate
Lack of stakeholder or end-user involvement in project	

RESULTS

Demographics from the study are presented here to provide a clearer picture of the participants, projects, and organizations that were the basis for the replies. Background on the research participants' roles appears in Table 2. The demographics indicate survey participants had held different roles on project teams, although most managed the project, a small percentage (6%) were team members. For those who managed, the majority were knowledgeable, with more than 5 years of experience. However, experience with the business application varied more widely.

Table 3 provides information on the characteristics of the projects that were the subject of the survey. As shown in Table 3, 69% of the participants were involved with virtual projects, while only 31% used a co-located project to answer the survey questions. The large number of participants who worked on a virtual project is consistent with the rise in outsourcing and the increasing use of virtual teams for software development documented earlier in this manuscript. Project costs and duration varied widely, as did the number of team members on the project. Approximately 60% of the projects were six months to two years in duration. Almost half of the teams contained team members who used a mix of English and non-English languages.

TABLE 2 — Survey Respondent Background

Participant's Role on Team	Project Manager/Leader	64%
	Team Lead	17%
	Team Member	6%
	Other	12%
Project Manager Experience	>10 years	31%
	>5 to 10 years	29%
	>2 to 5 years	18%
	1 to 2 years	10%
	Not the Proj Mgr	12%
Experience with the Business Application	>5 years	22%
	>2to 5 years	34%
	1 to 2 years	18%
	<1 year	15%
	No experience	11%

TABLE 3 — Project characteristics

Project Environment	Virtual Projects Co-located Projects	69% 31%
Project Type	New Development Package Installation Software Upgrade Other	48% 17% 24% 11%
Project Cost	<\$100K >\$100K to \$500K >\$500K to \$1M >\$1M	22% 30% 10% 33%
Project Duration	0 to 6 months <6 months to 1 year 1 to 2 years 2 to 3 years >3 years	19% 34% 27% 12% 8%
Project Team Size	1 to 5 people 6 to 10 people 11to 15 people >15 people	14% 30% 46% 39%
Team Languages	English & Non-English locations All English locations All non-English locations	43% 54% 3%

TABLE 4 — Organization characteristics

Firm Size	Large (>20K) Medium (1K to 20K) Small (<1K)	31% 41% 27%
Industry	IT Services Finance/Banking Manufacturing Business Consulting Insurance/Real Estate	14% 13% 13% 8% 8%

Organization characteristics, shown in Table 4, indicate a range of sizes, measured in the number of employees, as well as a broad spectrum of industries, with the largest three industries, each representing just 14% or less of the responses.

Data analysis on the risk variables was conducted using Chi-Square statistics. Of the fifty-five risk factors considered, the results of the survey revealed a set of seven risk factors that displayed dissimilar effects based on the project environment. Table 5 shows all seven of these variables with their corresponding participant response percentages, grouped by type of project, i.e. virtual or co-located. A p-value under 0.05 was used to determine significance. Note that the research reported upon here is a portion of a larger study, and results are only shown for those risk factors showing significant differences between traditional and virtual projects.

The following section will discuss each of these seven variables in terms of the differences between the two groups, highlighting potential reasons for the observed differences.

DISCUSSION

Knowledge Transfer

Of all fifty-five risks, *Insufficient knowledge transfer* showed the most significant difference in degree of impact between virtual and co-located teams (p-value < 0.003). Knowledge in this context can refer to details of a software application, business processes and procedures, or project team workings. Project risk occurs when the successful transfer of crucial details between individuals does not take place. Of the virtual project team respondents, 28.40% indicated this risk factor caused a major impact on project success, while only slightly less than half that number of participants on co-located projects (14.89 %) concurred. At the other end of the spectrum, 61.70% of co-located project respondents indicated this risk factor had no impact or simply did not occur on their projects, while only 31.78% of virtual project respondents agreed. Thus, this risk factor is more of an issue in a virtual environment than in a co-located environment. This difference between virtual and co-located project types may have occurred because knowledge

TABLE 5 — Seven Risk Factors with Significant Differences in Impact on Virtual vs. Co-located Projects

	Virtual Projects			Co-located Projects			
Risk Factor Description	**No Impact or Did Not Occur %**	**Minor Impact %**	**Major Impact %**	**No Impact or Did Not Occur %**	**Minor Impact %**	**Major Impact %**	**p-value**
Insufficient knowledge transfer	31.78	40.19	28.04	61.70	23.40	14.89	*0.0023
Lack of project team cohesion	41.12	41.12	17.76	70.21	23.40	6.38	*0.0034
Cultural or language differences	44.86	41.12	14.02	70.21	23.40	6.38	*0.0143
Inadequate technical resources, i.e. hardware, processing availability	47.66	40.19	12.15	72.34	21.28	6.38	*0.0179
Resource inexperience with company and its processes	38.32	34.58	27.10	55.32	36.17	8.51	*0.0240
Loss of key resource(s) that impact the project	39.25	28.97	31.78	61.70	19.15	19.15	*0.0360
Hidden agendas impact the project	36.45	36.45	27.10	57.45	27.66	14.89	*0.0453

transfer methods are naturally different in the two environments. Lack of face-to-face communication is likely to make knowledge transfer much more difficult in a virtual environment. Direct communication of more structured information, for example status reports, can easily be accomplished via e-mail or other forms of electronic communication. However, in co-located projects, knowledge transfer usually involves conversation, as well as sharing of documents. Email does not lend itself to conversational exchanges of complex material. Although Damian, et al. found "multimedia meeting systems" enabled virtual project teams to be more effective, especially when there was conflict, communication tools that work well for exchanging implicit knowledge, such as teleconferencing, video conferencing or web conferencing, may not be available to virtual project team participants" [7]. Certainly, they are unlikely to be used for spur-of-the-moment exchanges. Further, knowledge transfer may not be a significant problem on most traditional projects because much of this transfer takes place casually, simply as a result of people being near one another. Jones, et al. indicate information sharing can be a challenge on virtual teams due to the absence of things like routine face-to-face update meetings that are not available in a virtual environment [13]. All of this leads us to conclude that virtual project managers must extend themselves to facilitate knowledge transfer, particularly with respect to knowledge that is tacit, rather than explicit. Notably, other communication-related variables in the survey, such as *lack of or inadequate communication* or *technical connectivity issues that hinder communication,* did not show significant differences between project environments. Of all the communication variables, only knowledge management stood out as a significantly greater risk on virtual projects.

Team Cohesion

The *Lack of project team cohesion* factor also showed a significant difference in degree of impact on virtual projects (p-value < 0.004). Problems with team cohesion can occur when there is conflict between team members or when the relationships necessary for the team to function do not develop. In the current research, survey results showed 17.76% of the virtual project team respondents indicated this risk factor caused a major impact on their project success while less than half that percentage of participants on co-located projects (6.38 %) agreed. At the same time, the lack of importance for this variable was suggested by more than two-thirds (70.21%) of the co-located project respondents, while less than half (41.12%) of virtual project respondents agreed. The large percentage of co-located project respondents who felt this variable had no impact indicates this risk factor often is a non-issue in the co-located environment. While the major impact percentages in the virtual environment suggest this variable is not one of the top critical risks, it nonetheless is substantially more important in a virtual environment, and thus a risk that needs to be monitored. Results of this study are supported by the research of Xue et al. [26], who found group cohesion to be one of several variables exhibiting significant differences between these two types of teams. The difference for team cohesion may have occurred because co-located teams can form a bond more quickly than virtual teams without face-to-face contact. Although a virtual project team may eventually form a bond, it is more difficult for some people to build relationships through the exclusive use of electronic media. Xue, et al. suggest there is still a limit to the richness of the technologies used by virtual teams to communicate [26]. The problem of team members feeling isolated also can contribute to less cohesion on a team. Jones, et al. indicate a feeling of isolation is one of the most common problems when working on a virtual team [13]. Xue, et al. found team members varied in their feelings about collaborating virtually, and that time zone differences contributed to group cohesion problems [26].

Cultural/language differences

The *Cultural or language differences* risk factor showed a significant difference in degree of impact between the two types of teams (p-value < 0.02). Communication may be impaired by team members who speak different languages or who must communicate in the designated project language, which is not their native language. Cultural differences can also occur when team members from different countries have a different understanding of a concept, such as timeliness or deadlines. When neither cultural group is sufficiently aware of these differences, missed meetings and unmet deadlines are more likely to occur. Cultural differences can be harder to detect than language differences because they are such an integral part of a team member's behavior that underlying causes may be overlooked. In the survey reported upon here, 14.02% of the virtual project team respondents indicated this variable caused a major impact on their project success, while less than half that number of participants on co-located projects agreed (6.38 %). On the other hand, more than two-thirds (70.21%) of co-located project respondents indicated this variable had no impact or simply did not occur on their projects while less than half of virtual project respondents agreed (44.86%). Over half (55.14%) of virtual project respondents felt this variable had some impact on the successful completion of the project, either major or minor. More importantly, the difference between the degree of impact in a virtual environment and a co-located environment is significant. This difference likely occurred because virtual teams simply are more likely to incorporate different languages and cultures. These findings are in line with Lipnack and Stamps who indicate virtual teams are certain to have difficulties with differences in culture, custom and languages [17]. However, the same authors also believe co-located teams occasionally can have just as many difficulties because they do not expect these barriers and consequently are not prepared for them. Dube and Robey list cultural differences as an area that creates challenges for virtual team members [9]. Interestingly, Lipnack and Stamps theorize that cultural differences can be just as severe between team members with different professional backgrounds as those from different countries [17]. Majchrzak, et al. found cultural differences to be one of the three major differences between virtual and traditional co-located teams [18]. Future research could explore this question in more depth by inquiring about the source of the cultural difference, for example, country of origin, industry experience, or profession.

Inadequate technical resources

The *Inadequate technical resources, i.e. hardware, processing availability* risk factor showed a significant difference (p-value < 0.02) between the two types of teams. This risk factor occurs, for example, if the team needs to run test cycles on the company's mainframe computer, but cannot get sufficient CPU processing time. Survey results show 12.15% of the virtual project team respondents indicated this variable caused a major impact on their project success, while less than half that number of participants on co-located projects agreed (6.38 %). The triviality of this variable on co-located projects is supported by the more than two-thirds (72.34%) of co-located project respondents who indicated this variable had no impact or simply did not occur on their projects. Although the major impact percentage was low, the major and minor impact percentages for this risk in the virtual environment together were 52.34%. More importantly, the difference between the degree of impact in a virtual environment and a co-located environment is significant.

Gaining access to adequate technical resources may be a greater problem for virtual teams simply because of the communication difficulties involved in requesting and campaigning for such resources. Virtual environments may make political maneuvering to gain needed resources more difficult. Alternatively, on some teams, this difference may have occurred because technical resources such as video conference equipment that are not usually required for co-located projects may be deemed more essential in virtual projects but be harder to arrange. Even smaller items such as scanners might be needed more in a virtual environment to aid in the exchange of hand written diagrams, processes or procedures from users. The need for a variety of technical tools on virtual project teams has been documented in literature. Mayer describes the critical role of connectivity in virtual operations as "ubiquitous connectivity" that requires technical tools [19]. In virtual environments, she refers to the need to communicate with anyone in any location at any time [19]. Damian, et al. also found a need for "multimedia meeting systems" to improve virtual team effectiveness [7]. Further research could establish the extent to which the differences seen between virtual and traditional teams in terms of gaining access to adequate technical resources are due to virtual teams' needs for additional technical resources, or their added difficulties requesting such resources via long distance.

Team inexperience

Team inexperience with the company and its processes showed a significant difference in degree of impact between the two types of teams (p-value < 0.03). This type of inexperience is not the lack of experience with technology. Instead, this risk factor describes issues that may occur if the project team members are not familiar with the company as a whole and its inner workings, including its key goals and objectives, or even procedures, such as those for implementing software or requesting test cycle runs. 27.10% of the virtual project team respondents indicated this variable caused a major impact on their project success, while only about a third of that number of participants on co-located projects agreed (8.51 %). Irrelevance of this variable is supported by more than half (55.32%) of co-located project respondents, while only 38.32% of virtual project respondents agreed. The difference in degree of impact between the two types of teams may have occurred because it is more common for virtual teams to include contractors or others new to the company or the application. Similarly, virtual teams often have members who work at different company site locations. Even within the same company, there may be differences in the processes and procedures from one work site to another, and team members may not realize this unless a problem occurs while trying to complete a task together. On the other hand, team members at the same location may experience some differences in processes and procedures from department to department, but they may be able to resolve these more easily with face-to-face communication. Jones et al. explained that these types of problems can occur in decentralized organizations (with many site locations), when no centralized function exists to "mandate standards" [13].

Team member loss

The *Loss of key resource(s) that impact the project* factor showed a significant difference in degree of impact (p-value < 0.04). This risk factor is defined as the risk that the project may be thrown off course when an important team member leaves the project before project completion. 31.78% of the virtual project team respondents indicated this variable caused a major impact on their project success while only 19.15% of participants on co-located projects agreed. Almost two-thirds (61.70%) of co-located project respondents indicated this variable had no impact or simply did not occur on their projects while less than half (39.25%) of virtual project respondents agreed. Again, the importance of these percentages is the significant difference in the responses from virtual software project respondents as compared to co-located software project respondents. This risk factor may be about *superstar syndrome*, where a team member has so much expertise they are elevated to a higher level of importance than other team members. Some virtual teams have the advantage of being able to recruit the "best of the best", i.e. superstars from anywhere in the world, simply because location is not a barrier. If the virtual project team includes these types of "superstar" experts, then the loss of one of them as a team member could have a greater impact due to a rare level of expertise that may be difficult to replace. Alternatively, a greater sense of team member interdependence may cause a larger gap to fill once a resource leaves a virtual team [12]. Then again, as noted earlier in the case of inadequate technical resources, virtual teams may suffer from the inability to campaign as successfully for the resources they need. Which explanation or combination of explanations is correct is an area for future research.

Hidden Agendas

The *Hidden agendas impact the project* factor showed a significant difference in degree of impact between the two types of teams (p-value < 0.05). This risk factor describes the issues that can occur when one or more project team members or managers have a hidden agenda or personal goals that they use the project to try to advance. 27.10% of the virtual project team respondents indicated this variable caused a major impact on their project success while 14.89% of participants on co-located projects agreed. More than half (57.45%) of co-located project respondents indicated this variable had no impact or simply did not occur on their projects while slightly more than a third (36.45%) of virtual project respondents agreed. The difference in project impact between the two environments may be related to better communications in co-located projects leading to fewer hidden agendas. When they exist, hidden agendas can be easier to mask on a team where there is little or no face-to-face communication. The lack of non-verbal cues can keep a hidden agenda truly invisible to virtual team members. Alternatively, the difference in risk impact between the two environments may be related to trust. Teams with a high level of trust would be expected to have a low level of hidden agendas. Hoefling indicates trust is the most common barrier for virtual teams [12]. Yet another possibility is that hidden agendas are more easily dealt with when team members are co-located. Further research is needed to determine the underlying factors leading to the greater risk from hidden agendas on virtual projects.

Silent Killers

To summarize, Figure 1 compares response percentages for the “No Impact” rating. Conversely, Figure 2 compares response percentages for the “Major Impact” rating. In each figure, the differences in column heights give an indication of the variation in risk level between virtual and traditional projects. Clearly, each of the seven risks isolated by this study are worthy of consideration in a virtual project environment. Yet, these seven risks easily could be overlooked by those new to a virtual environment because a project manager typically would not have experienced

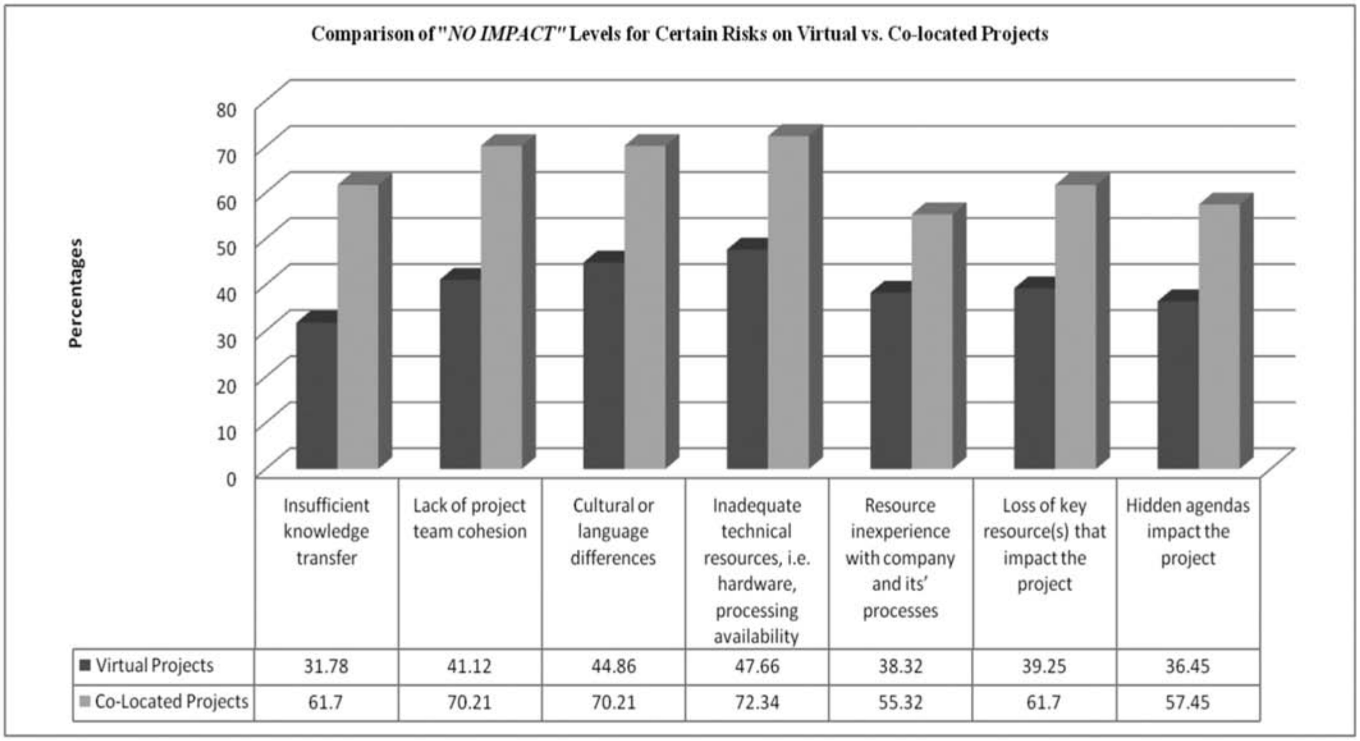

FIGURE 1: Comparison of “NO IMPACT” Levels on Virtual vs. Co-Located Projects

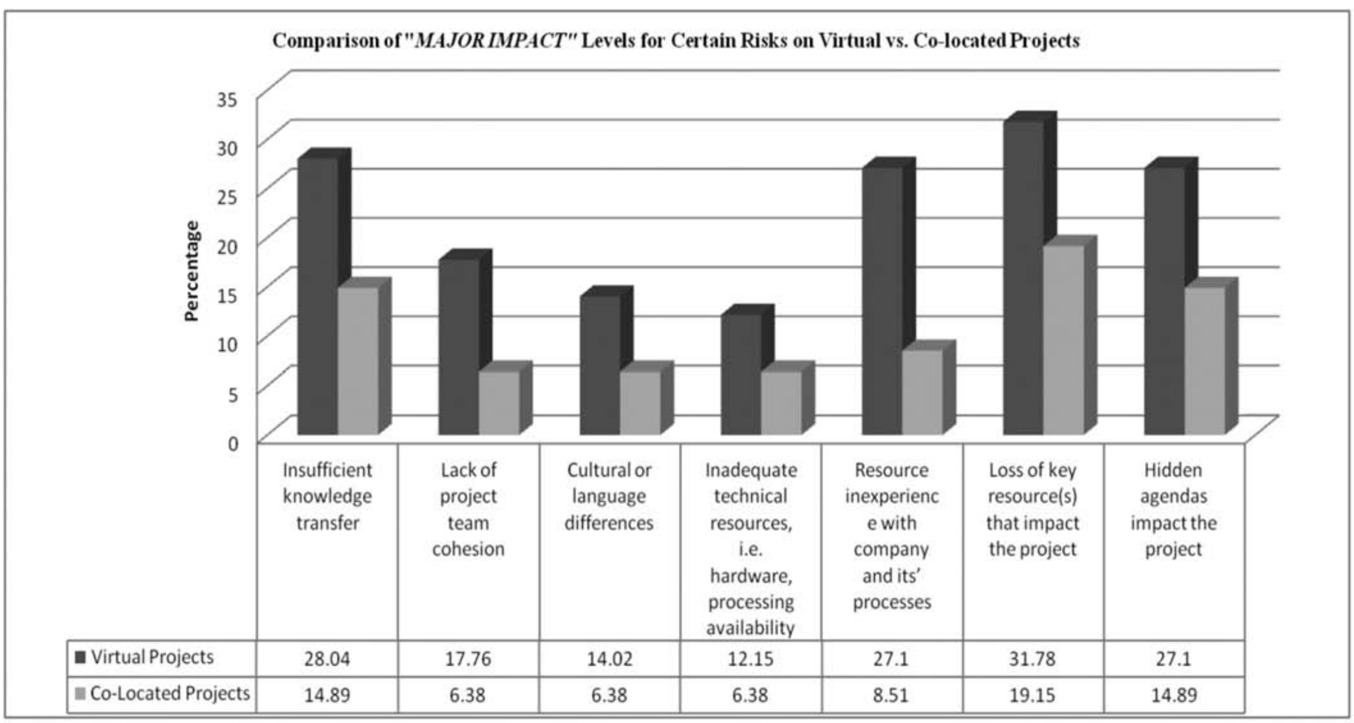

FIGURE 2: Comparison of “MAJOR IMPACT” Levels on Virtual vs. Co-located projects

the same risk levels in prior traditional projects. Thus, a virtual environment can transform these risks into "silent killers."

Practical Implications

The "silent killers" identified here are crucial knowledge for practitioners managing virtual software development projects. Simply knowing that some risks are higher on virtual projects is in itself valuable. Beyond this, through a deeper understanding of specifically which virtual project risks differ from the traditional project risks that are documented in the literature, virtual project managers can both better avoid the "silent killers" and implement plans to more effectively mitigate their damages when they do occur. Thus, such knowledge has the potential to reduce project failure for virtual software development projects. The model in Figure 3 illustrates the concept of how differing impacts of these seven risks results in a Magnifier Effect when the same risks are considered in a virtual team environment. While Figure 3 incorporates major risk percentages from the study reported upon here, the importance is not so much in the specific numbers as in the direction and general magnitude of change when these traditional project risks appear in a virtual project environment.

Limitations and Future Research

There are inherent limitations of this research study, such as self-reporting bias in areas like cost, duration, quality and performance. Those leading a project often are responsible for the outcome and therefore may tend to be biased in their reporting of those previously mentioned sensitive areas. In addition, the survey reported upon here used a convenience sample where the participants were self-selected, which may have led to sampling bias. For example, it is possible that participants who chose to take the survey were those who had more positive project outcomes [16]. For these reasons, while we recognize that it is difficult to convince individuals to be open about project failures, we believe that a study with a random sample should be undertaken if possible. Beyond this, one promising future research study lies in repeating this study in a few years to determine if time alters the critical risk factor list. We would hope that it will. As virtual project teams become more commonplace, the methods of managing them should improve and comfort levels with virtual collaboration tools should grow. These events, along with knowledge of the Magnifier Effect identified here, should enable virtual project managers to increase their success rates over time. In addition, research should be conducted to further investigate each of the seven individual risk factors subject to the Magnifier Effect, including understanding how each specific risk best could be anticipated and recognized, and its most likely negative impacts on final project outcome mitigated.

CONCLUSION

The overwhelming majority of prior studies on project risk were done sufficiently long ago that the projects primarily involved traditional, co-located team members. This study set out to identify risk related distinctions between projects involving such teams and projects involving virtual project teams. The study began with a comprehensive list of fifty-five project risk factors previously identified by the literature, as well as by our

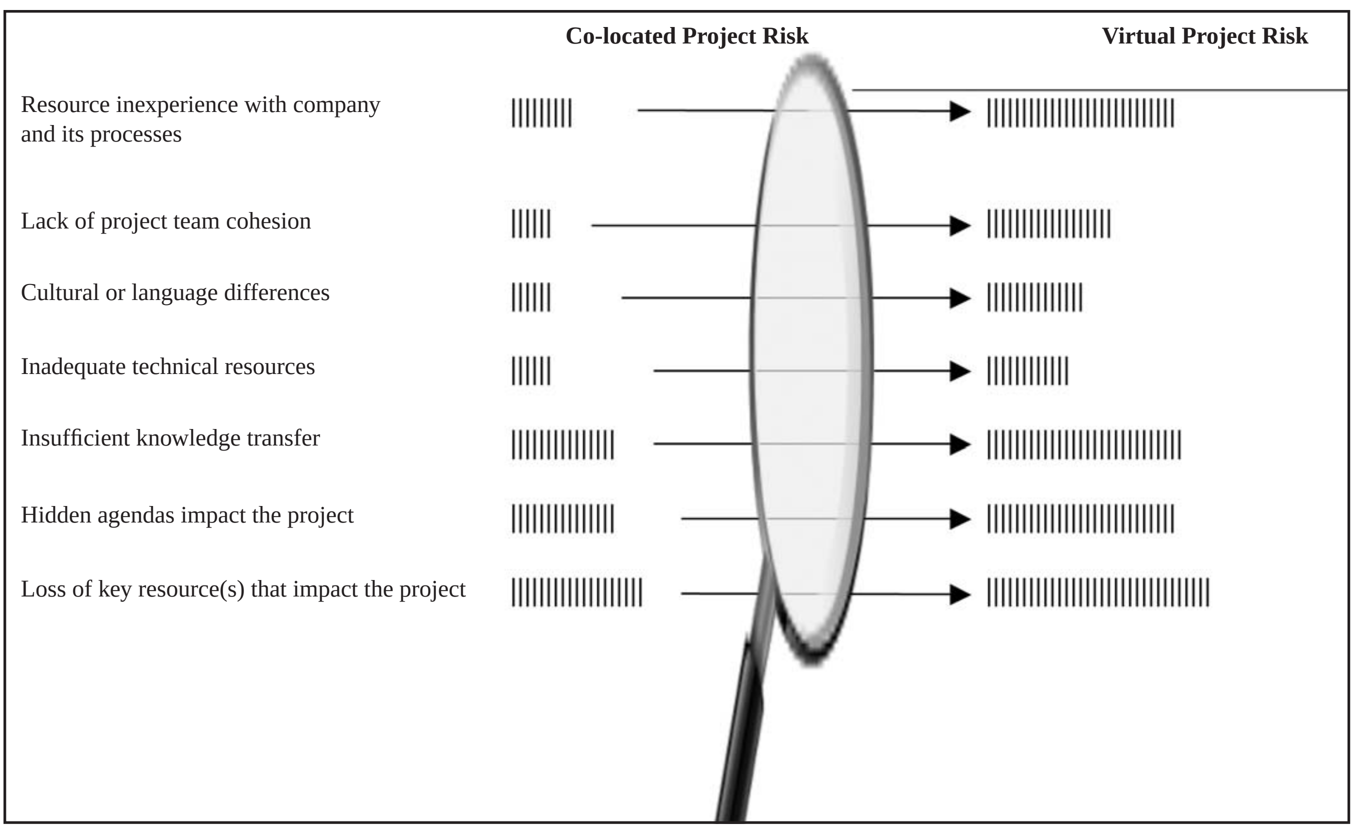

FIGURE 3: Magnifier Effect of a virtual team environment

own focus group and interviewees. Of these fifty-five, seven (insufficient knowledge transfer, lack of project team cohesion, cultural or language differences, inadequate technical resources, inexperience with company and its processes, loss of key resource(s), and hidden agendas) showed significantly greater risk for virtual than for traditional projects. This increase in certain types of risk on virtual projects is termed the Magnifier Effect. The seven risks identified here take on substantially more meaning in a virtual project environment. In the discussion section of this article, the work of others on virtual teams has been used to deduce why these risks might occur with greater frequency in a virtual environment. However, more research is needed into each of these risks, both to dissect and analyze it and to determine how it might best be mitigated within a virtual project. Notably, some of the seven variables identified here are somewhat intuitive risks for a virtual project. Risks like cultural or language differences or lack of project team cohesion might be anticipated to increase in a virtual environment. However, other increased virtual risks, like loss of key resource(s) or hidden agendas that might impact the project, are not nearly so obvious. The risks identified here as subject to the Magnifier Effect, taken individually, may or may not be critical. However, like all risks, they can compound. Our evidence indicates that the very existence of a virtual project environment makes all these risks more likely to occur and to cause damage. Because none of these seven are traditionally critical risks, they are termed "silent killers." These risks are substantially more likely to occur on virtual projects, yet those who have customarily focused on co-located teams are unlikely to consider them of importance. While innocent risks on most traditional projects, these risks should be being placed on a virtual project "watch list," especially for organizations, teams, or project managers new to the virtual environment.

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APPENDIX. Comparison of Focus Group and Seminal Literature Risk Factors

	Focus Group Participant risk factors	Risk Factors Boehm [4]	Uncertainty Factors Barki, Rivard & Talbot [3]	Risk Factors Keil, Cule, Lyytinen & Schmidt [14]	Risk Dimensions Wallace [22]
RESOURCES	**Resources** • Resource shortage • Lack of necessary skills or wrong resource mix • Loss of key resource and resource turnover • Lack of application knowledge • Throwing resources at a late project, Mythical man-month • Human factor • Lack of needed training • Team members need to be accountable for their decisions **Decision Making** • Need for core team decision makers • Decision making by democratic process (majority rules) in inappropriate • Wrong decision makers **Communication** • Communication needed for coordination • Lack of communication leads to confusion • Miscommunication/ poor communication can cause arguments & rework • Too much communication, meeting overload leaves little time for work • Difficulty in knowledge transfer **Project Management** • Lack of clear direction • Inexperienced/poor leadership • Micromanagement • Inconsistent project tracking **Diversity** • Creates a balanced team where all expertise can be leveraged **Cultural/Language Barriers** • Language and cultural barriers **Contingency** • Lack of contingency plan	**Personnel Shortfalls** • Personnel availability • Mix of software disciplines represented • Team's expertise • Management's approach	**Lack of Expertise** • Lack of team general expertise • Lack of development expertise in team • Team's lack of expertise with task • Team's lack of expertise with application • Lack of user experience & support **Application size** • Team diversity • Number of people on team • Number of users in organization • Relative project size • Number of hierarchical levels occupied by users	• Lack of required knowledge/skills in project personnel • Insufficient/ inappropriate staffing	**Team** • Team member turnover • Staffing buildup • Insufficient knowledge among team members • Cooperation • Motivation • Team communication issues

APPENDIX *continued*. Comparison of Focus Group and Seminal Literature Risk Factors

	Focus Group Participant risk factors	Risk Factors Boehm [4]	Uncertainty Factors Barki, Rivard & Talbot [3]	Risk Factors Keil, Cule, Lyytinen & Schmidt [14]	Risk Dimensions Wallace [22]
TECHNOLOGY	**Technology** • Unidentified technical constraints • Untried technology • Technology does not work for client **Integration** • Lack of understanding of systems to be integrated • Inconsistent data integration	**Straining computer-science capabilities** • Complex technology	**Technological Newness** • Need for new software • Number of software suppliers • Need for new hardware • Number of hardware suppliers • Number of users outside organization **Application Complexity** • Number of links to future systems • Number of links to existing systems • Technical complexity	• Introduction of new technology	**Project Complexity** • New technology • Complex processes being automated • Large number of links to existing systems • Large number of links to external entities
ENVIRONMENT	**Conflict** • Resistance to change • Resource contention within infrastructure **Politics** • Political issues can derail a project • Hidden agendas • Catering to particular stakeholders • Geopolitical issues • Lack of integrity **Project Sponsor** • Lack of management commitment • Lack of project sponsor can lead to failure • Wrong/inappropriate project sponsors		**Organizational Environment** • Extent of changes • Intensity of conflicts • Lack of clarity of role definitions • Resource insufficiency • Task complexity	• Lack of top management commitment to the project	**Organizational Environment** • Organizational politics • Stability of organizational environment • Organizational support for a project
REQUIREMENTS	**Requirements** • Last minute interface changes by users or technical team can cause failure • Too many revisions • Project scope creep • Vague requirements can lead to major changes late in the game • Limited scope • Major changes introduced late in project that change all previous work cause scope creep and jeopardize project completion • Key resource or stakeholder changes project scope	**Developing the wrong functions & properties** • Size & complexity of requirements • Level of hardware imposed constraints • Number of system interdependencies • New technology or application • Requirements stability **Gold-plating** • Lack of quality in requirements & product **Continuing stream of requirements changes** • Changing requirements		• Misunderstanding the requirements • Changing scope/ objectives • Lack of frozen requirements	**Requirements** • Uncertainty surrounding system requirements • Changing requirements • Incorrect, unclear, inadequate, ambiguous or unusable requirements

APPENDIX *continued*. Comparison of Focus Group and Seminal Literature Risk Factors

	Focus Group Participant risk factors	Risk Factors Boehm [4]	Uncertainty Factors Barki, Rivard & Talbot [3]	Risk Factors Keil, Cule, Lyytinen & Schmidt [14]	Risk Dimensions Wallace [22]
PLANNING	**Cost** • Cost increases due to internal or external factors • Unrealistic estimate/ budget expectations • Insufficient or loss of funding & overspending • Funding limitations can affect quality **Time** • Time management is important • Lack of or insufficient time to complete project • Unreasonable time constraints	**Unrealistic schedules & budgets** • Unrealistic schedules • Unrealistic budgets			**Planning & Control** • Unrealistic schedules • Unrealistic budgets • Lack of visible milestones to assess production of intended deliverables • Inaccurate estimates leading to inaccurate resource forecast
END USER	**Users** • Trying to please too many users • Lack of user involvement in design & testing • Lack of time or budget for user research **Stakeholders** • Stakeholders lose interest • Too many stakeholders • Missing stakeholders	**Developing the wrong user interface** • Poor quality user interface		• Failure to gain user commitment • Lack of adequate user involvement • Failure to manage end user expectations • Conflict between user departments	**User** • Lack of user involvement in development • Unfavorable user attitude toward project
QUALITY	**Quality** • Poor quality, i.e. designs, not technically feasible • Quality/functionality is the compromised constraint to meet budget and/or deadlines • Solution does not address the need, wrong solution produced • Designed product is not carried out, and not implemented • Vague requirements are incorrect and lead to poor quality product	**Shortfalls in externally performed tasks** • Poor quality work from external resources **Real-time performance shortfalls** • Lack of performance quality **Shortfalls in externally furnished components** • Lack of quality in external components			