

Software Development Project Risk Management: A New Conceptual Framework

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ABSTRACT

The frequently observed positive impact of adopting risk management strategies on projects' overall outcome has led many software development organizations to appreciate its significant role in the pursuit of cost reduction, schedule overruns decrease and, generally, improved performance. In line with this issue, this study investigates a wide range of relevant literature, proposes a new conceptual framework for managing risk in software development projects, introduces new conceptual factors, brings out their interrelation, and suggests new prospects and managerial implications for both practitioners and academics. The conceptual framework has two basic axes. Firstly, the determination of the impact of constructs such as Project Characteristics, Project Risk Management Team, Risk Identification Approaches, and Project Quality on the level of Project Risk. The majority of the items used to measure these constructs are proposed for the first time in the literature. Additionally, the assessment of the impact of Project Risk (and all of the dimensions that compose it), simultaneously with the estimation of the impact of the Residual Performance Risk on the final subjective and objective Project Performance could provide project managers with a better picture of the effectiveness and adequacy of their risk management practices.

Keywords: Project Risk, Performance Risk, Project Performance, Software Development, Project Quality

1. Introduction

Risk management has been applied to various fields like the national security, exploration of space, nuclear reactors, security, construction industry and financial investments [1]. This research will focus on the study of various approaches of risk management applied to software development projects. Although they have been applied with success in the last decades, dealing with problems in the development of various systems, the fact that a large percentage of the systems is never completed, or fails to operate effectively and efficiently [2-11], renders the study of these approaches even more imperative.

The fact that the majority of the software development organisations perceive risk in a different and not systematic way contributes to the increase of project development instability and ineffectiveness. Kwak and Ibbs [12] identified risk management as the least applied scientific field among the various knowledge areas of project management. In line with Kwak and Ibbs study, Adams and Pinto [13] research states that risk management has not received sufficient attention and

does not appear to be widely accepted within the software engineering community. Dedolph [14] implies that the reason for the software risk management neglect is primarily the organizational inertia and their native resistance to change, due to the difficulty of risk management value assessment, the lack of resources, the need for structural changes and other.

Given the complexity of most software projects and the several risk types emerged during the development/implementation stages, the abandonment of risk management to human intuition and initiative [15] can sometimes be proven effective, yet remains an insufficient substitute of the constant professional and stable approach of risk management.

Risk management of software development projects was recognised as an independent field of research in 1989, when Barry W. Boehm lead the way with his pioneering book "Software Risk Management". Since then, this particular issue has been discussed and studied quite thoroughly, especially in the beginning of '90s. The work of Boehm [16,17] and Charette [18,19] laid the foundations for the extensive contribution of the Soft-

ware Engineering Institute (SEI) in the middle of '90s [20-25], that even today acts as an archetype in several references in risk management literature.

The goal of the current study is the creation of a new research model, which emerged from a thorough examination of the literature, and will be used to measure various conceptual factors and their relationships in order to achieve a better and more complete understanding of risk management as an organisational process. In doing so, the effect of several organisational strategies and characteristics on the determination of the risk level of software projects, as well as its consequential influence on the total project performance, will be assessed. In Sections 2 and 3 the conceptual framework and the research questions are presented, respectively, while some concluding remarks are provided in Section 4.

2. Literature Review

2.1. Risk Identification Approaches

As Schoenthaler [26] mentioned, based on his practical experience, it is undeniable that the systematic use of risk management into the project development process will have a considerable negative impact on project risks level. In an attempt to promptly, effectively and easily identify risk, managers of software projects have been using various methods. Four of them are going to be discussed below, in a similar way as they were classified by Kulik and Weber [27].

The first one is the Ad-hoc Approach, which provides an assessment of risks when the initial symptoms appear on the project, as well as their mitigation with unofficial way. The second approach is called Informal Approach [28] and includes a discussion with people, who are directly or indirectly involved with the project, concerning the several risk issues that appear (or will possibly appear) and the recording and documentation of the risks for future use. The third is named Periodic Approach and, as it can be understood from its title, involves the use of repetitive procedures for the identification and specification (quantitatively and qualitatively) of the risks. Finally, the fourth approach is the Formal Approach for the identification of the various risks [29]. According to this approach, a thorough and in-depth assessment of each risk by independent individuals is performed.

An international research on software development risk management, carried out in 2001 by the Research Corporation KLCI, indicated that the most common risk identification approach is the informal, used by 37% of the respondents, while Ropponen's [30] study enforces the impression of the absence of a framing thinking about software risk concept and managerial implications by

project managers.

2.2. Project Characteristics

The factors that characterize and, in many occasions, shape the development process of a project, affect to a great extent the determination of its risk level. In the present research, five main characteristics of the software development projects will be studied.

The first of these is Project Scope, which in this case is going to be studied through an indicator, Project Duration [31,32]. This indicator is selected as the measure for project scope because, as Wallace *et al.* [32] propose, the collection of duration information is easy for most projects and it is suitable to survey-based data collection procedures.

The second characteristic has to do with whether a project is carried out totally In-house or in collaboration with external providers (Outsourcing) [33]. It has been stressed that outsourcing, as a strategy of gaining competitive advantage for a company, is particularly effective yet equally risky (due to the complexity and sometimes the vagueness that characterize its procedures) compared with the in-house method [32,34,35]. Still, despite the rapid increase of outsourcing in developing software projects in the past few years (in 2005, 75% of the USA organizations outsource to some extent), its effect on the projects' risk level, and especially on those taking place in countries with less developed infrastructures, have been studied poorly by literature [36].

The third characteristic of a software project that will be examined by this study is its Strategic Orientation [32,37]. The strategic nature of a system can be measured by the classification of the projects as 1) strategic, 2) organizational and 3) informational.

Moreover, Project Diversity constitutes a structural form that is expressed in work specialization terms [38]. In this research, the project diversity will refer to the differentiation level that appears in the knowledge background, capabilities and experience among the project development participants [39].

The fifth and final characteristic is the Type of System being developed [5,40,41]. The failure to identify, understand and confront the risks that are connected to different project types is an important and defining factor for the problems during the realization of the project, concealing the real project risks from their developers (that is, by differentiating the perceptions that they have formed for them) [42]. Six main types of software development projects can be distinguished [5], in spite of Glass [3] statement for curious biases and omissions in Jones' list: 1) Management Information Systems, which are the most common software applications, 2) System Software, like for example the operating systems involv-

ing software that facilitates software applications (Application Software), 3) Commercially-marketed Software, 4) Military Systems, which are created for securing rules and models in military data, 5) Contract or Outsourced Software projects in the civilian domain, and 6) End-user Software projects (software developed by users, not programmers).

2.3. Risk Dimensions

Barki *et al.* [43] suggest that the software project risks consist of interrelated dimensions and their assessment should not be made with the use of a one-dimension scale, but, on the contrary, every dimension should be defined separately, theoretically as well as empirically. The multidimensional assessment of risk can supply a clear specification for research and practical purposes [44].

Despite the significance of studying risk through its dimensions, very few researches have been carried out on this issue. McFarlan [45] found three major dimensions of risk in the software development process: project size, technology experience and project structure. He suggested, also, that project administrators should develop a complete and aggregated software risk profile for every software project. Boehm [17] proposed a software risk management framework that included the evaluation and control of risk and conducted a list with the top ten risks based on his personal professional experience. In spite of all these, Boehm's list was lacking some theoretical substantiation [46] and, moreover, due to its complexity and other factors that characterize software projects (e.g. invisibility, flexibility and conformity) [47], it ceased having any diachronic value. Barki *et al.* [43] conducted a comprehensive review of studies related to software development risk and then they proposed 35 measures for its estimation. These measures were categorized in five dimensions: technological newness, application size, expertise, complexity of the application and organizational environment. Although this research delivered a quite useful and understandable instrument for measuring risk, it was noticed that the risk evaluation scale was extremely complicated [46,48]. Heemstra and Kusters [49], based on previous studies and their professional experience, composed a list of 36 risk variables that were later grouped into 9 categories. Moynihan [50], in co-operation with 14 experienced Irish application developers, evolved a total of 21 points that are risk related. Roppo-nen and Lyytinen's [51] questionnaire was relied on Boehm's [17] checklist, and distinguish 6 risk components based on a survey of project managers including almost 1100 projects. Furthermore, the Hierarchically Holographic Modeling framework, introduced by Longstaff *et al.* [52], brings out 32 risks in seven dimensions

of systems integration. Houston [53] also proposed a list of 29 software development risk factors, considering them as the most important and frequently cited in the existent literature. Cule *et al.* [54] categorize risks into four dimensions according to their source (task, client, environment, self), which includes 55 software risks, and they proposed a risk management strategy for each dimension. Sumner [55], through structured interviews, compared the differences of software risks between MIS and ERP projects and proposed nine risks that are unique in ERP projects. Kliem [56] developed a list of 38 risks in BPR (Business Process Reengineering) projects, which were categorized in 4 main dimensions: people, management, business and technique. Schmidt *et al.* [57] identified 53 risk variables that were categorized in 14 factors and suggested that the difference in the culture of the three countries (Finland, China and USA) where their research was carried out, could affect considerably the list of risks. They finally concluded that only 11 of them have cross-cultural application. Addison [58] has used the Delphi technique to collect the opinions of 32 specialists and then presented a list of 28 risks for e-commerce projects.

This research will mainly be based on the dimensional distinction of a quite recent approach, the one proposed by Wallace *et al.* [48]. They proposed 27 software development risks that could be grouped into six dimensions, those referring to: Users [57,59-61], System Requirements [18,59,62,63], Project Complexity [43,64,65], Planning and Control [57,59,66,], Team [63,67-69] and Organizational Environment [5,43,70].

However, in contrast to the Wallace *et al.* [48] study, that evaluates only the extent to which each risk statement characterized the projects, and in line with Han and Huang [59] research, this study will attempt to assess both the probability of occurrence and the impact for each risk by the respondents, determining the risk level of each dimension. In order to calculate the risk exposure (RE) for each risk item, the formula of Cooper *et al.* [71] will be adopted. They propose that the traditional measurement of RE, as the product of possibility and consequence ($RE = P * C$) [17,28,49,59,72-74,] has significant disadvantages due to the fact that elements with high consequence, yet low possibility, can return low risk exposure factors and as so they can be falsely considered as insignificant. More specifically, they measure the RE with the following formula: $RE = P + C - (P * C)$ (the equation works only if the possibility of a risk to occur and the severity of its impact are in a scale from 0 to 1) [71]. The adoption of this formula in this study will hopefully give more stabilized, objective and realistic data about the significance, and hence the impact, of each risk dimension on the project.

2.4. Project Risk Management Team

Many critical decisions are made by teams rather than by individuals, because group decisions are more consistent with rationality than individual ones [75]. In this study, the concept of the project risk management team will be also examined. This concept incorporates many diverse roles, such as the compilation and evaluation of the required project risk information and its sharing with the project risk manager, and also requires a detailed understanding of the current project risk management methodology being used [76]. However, nowadays, most risk analysis projects are unsuccessful since the internal experts and subject matter experts are excluded from the process [77], or there is not sufficient information about their personal characteristics, abilities and attitude towards risk. Ward [78] underlined this insufficiency and attempted to trace and theoretically analyze the most significant characteristics of the project participants who have taken on the difficult task of risk management. These characteristics include the Capability and Experience of the participants, their Motivation for accepting to undertake initiatives, which importance has been stressed by Boehm [79], and the Perceived Responsibilities in risk management. Despite the thorough and analytical theoretic foundation of the project risk management team concept, Ward [78] did not provide a research instrument for the measurement of this construct. In order to operationalize this construct, a deductive scale development approach will be utilized, while the development of the items will be based on the theoretical definition of the construct [80].

2.5. Residual Performance Risk

The primary performance influence mechanism of a software project is a risk called Performance Risk which represents the difficulty in evaluating the final performance in terms of cost and schedule overruns [81]. According to Nidumolu [65,81], the estimated performance risk that is detected in the final development stages of a project is called Residual Performance Risk. This definition is used to clearly distinct it from the risk that is found during other phases in the project's development life cycle. Therefore, this risk refers to the difficulty in assessing the consequences of executing the project, during the final phase of its development.

Meyer *et al.* [82] introduced a more "forward thinking" approach that emphasizes on the uncertainty frame of a project. These researchers have agreed that, apart from the predictable uncertainty that can be controlled by the traditional methods of risk management, an unexpected uncertainty and a general chaos appears in many innovative projects. As a consequence of this notion of

the project risk profile, the residual performance risk can be decomposed in two parts, based on the following equation [36,83]:

$$\text{Residual Performance Risk} = \text{Residual Controllable Risk} + \text{Unforeseeable Risk}$$

The Residual Controllable Risk is expressed by the uncertainty that continues to exist during the final stages of the software development projects that can be controlled, and even limited, with various ways. The Unforeseeable Risk is the uncertainty that cannot be identified or controlled while planning the project. However, despite the intention of previous studies [83] to examine these two dimensions of residual performance risk separately, no effort of this kind is recorded until today in the international literature. In the present study, a first attempt of disintegrating the factor of residual performance risk will be made, on the basis of the variables defined by Na *et al.* [83, 36] and their classification according to their notional coherence to the theory.

2.6. Project Performance

The present research will concentrate on the project performance related results since performance is the dependable variable of most vital importance [81].

The performance of a software development project can be divided, for reasons of better, deeper and more circumstantial studying, into two main categories: the subjective and the objective performance [36]. These two categories used for measuring the performance are quite important for software developers, and users as well, since both of them affect directly or indirectly the execution and implementation of every project [84].

The factor of subjective project performance refers to the efficiency and efficacy by which a software development project is completed (according to the people involved in the project) [85] and bears in mind two basic dimensions [72,83,86]: the process performance and the product performance.

Process Performance is an efficiency measure for the software development process and can be described by three dimensions [81]: 1) the increase in the gained knowledge during the implementation of the project which is called Learning, 2) the management level in the development process that is named Control and 3) the quality of the relationship among the various participants (managers, technicians, analysts, programmers, external specialists, users etc.) through the duration of the software development process, that is called Quality of Interactions [87].

Product Performance is a measure for registering and illustrating the performance of the final product and is described by the following three dimensions [65,81]: 1) the technical performance of the software, that is called

Operational Efficiency, 2) the respond quality to the needs of the software users, that is noted by the term Responsiveness and 3) the ability of the software to provide perceptible support to new products and functions and its Flexibility to the interchangeable organizational needs.

These two dimensions of project performance need to be estimated separately since there is not necessarily a high relationship between them [72]. For example, it is quite possible that a project with cost or schedule overruns problems will deliver a high quality product and vice versa.

Although the measurement of subjective performance has the plain advantage of the easy collection of necessary data [36], it deals intensely with the problem of standardization, since the evaluation of a project depend on personal judgement or moreover the mood of a certain manager [84].

Contrary to the subjective performance of a project, the objective performance includes some more quantified metrics like, for example, excess in terms of cost, effort and schedule. According to literature [36,88,89], it is suggested to measure both subjective and objective project performance, due to the special nature that characterizes software development projects.

2.7. Project Quality

Another factor that can significantly define risks, as well as the level of their presence during the process of a project's software development, is project quality [90,91]. In the present study, the total quality of a project will be defined through the measurement of two main factors and the variables that define them according to literature [92,93]. These two fundamental factors are: process quality [94] and people quality. To begin with, people quality is divided into two main sub-factors, so that it can be measured with the utmost detail. These two sub-factors that compose it are management quality and staff quality.

Management quality includes variables like communications management adequacy, subcontract management adequacy, interaction management adequacy and internal management quality [95]. On the other hand, people quality involves the quality of non-administrative staff that is occupied with a project. For its measurement, variables like staff turnover, staff experience, staff motivation, staff training and programming language experience are used [92].

Process quality is a complex factor for defining project quality; it associates the project specification clarity with the development and testing process quality. Specification clarity is defined by the variables of specification

process quality and requirements difficulty. Development and testing process quality consists of variables measuring the regularity of reviews, the quality of documentation and the level of independent testing. In the AgenaRisk manual of software risk modelling [95] for measuring the development and testing process quality, one more indicator is used—a model of the maturity of the capabilities that an organization has in executing specific organizational procedures, the Capability Maturity Model (CMM) [96]. In the present research CMM was omitted, mainly due to the non-categorisation of many companies worldwide (especially in underdeveloped or developing countries) to its five levels [47,97].

A summary of the research constructs that compose the general risk management model is presented in **Table 1**, along with the number of items that measure them.

What's more, **Figure 1** illustrates the relationships that exist between them, which will be examined thoroughly in the following section.

Table 1. Summary of research constructs.

Factors	Sub-factors	Items	References
Project Characteristics	<i>Strategic Orientation</i>	3	
	<i>Project Scope</i>	1	
	<i>Outsourcing</i>	1	[5,31-33, 37-39,98]
	<i>Project Type</i>	3	
	<i>Project Diversity</i>	3	
Risk Identification Approaches	-	4	[27]
Risk Dimensions	<i>User</i>	5	
	<i>System Requirements</i>	4	
	<i>Project Complexity</i>	4	[5,17,31,40, 43,45, 48-50,52, 54-68,70]
	<i>Planning and Control</i>	7	
	<i>Team</i>	3	
	<i>Organizational Environment</i>	4	
Project Risk Management Team	-	3	[62,78]
Residual Performance Risk	<i>Residual Controllable Risk</i>	2	[36,45,65, 81-83,99]
	<i>Unforeseeable Risk</i>	4	
Project Quality	<i>People Quality</i>	10	
	<i>Process Quality</i>	6	[47,90-96]
Project Performance	<i>Subjective Performance</i>	24	[36,48,59, 65,72,81, 83,86,88, 89,97,100]
	<i>Objective Performance</i>	3	

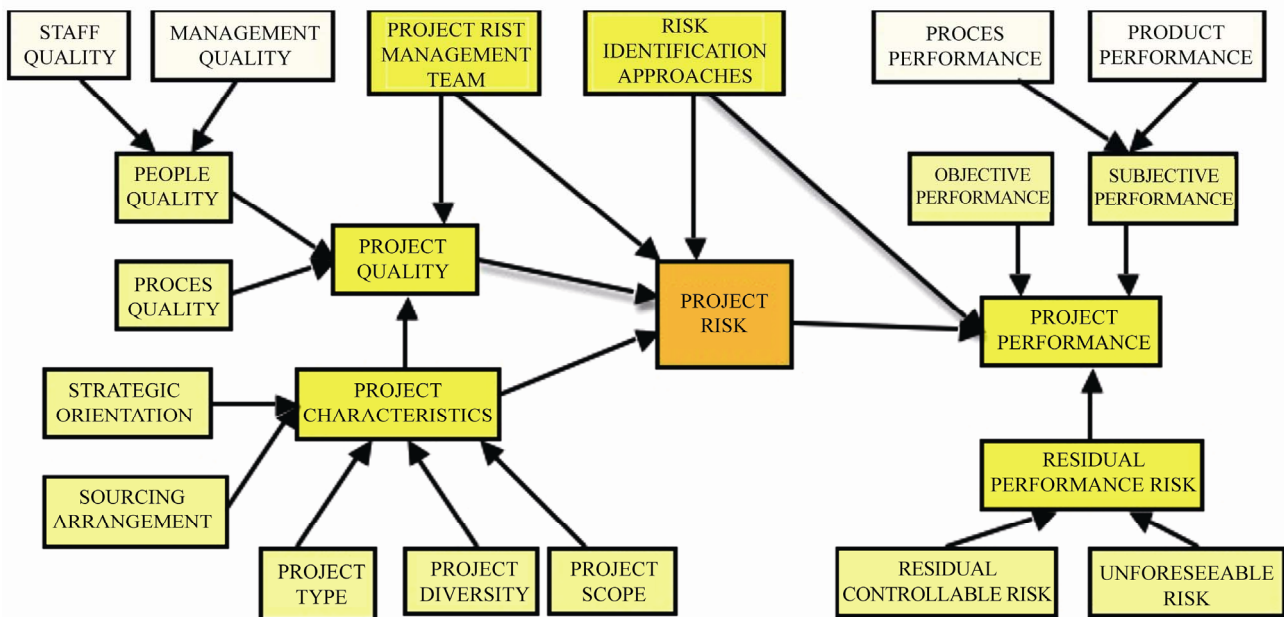


Figure 1. Conceptual framework.

3. Conceptual Framework

3.1. The Relationship between Project Characteristics and Project Risk

In literature, there is a lack of studies that attempt to examine the various characteristics of software projects and the way different risk dimensions, especially, and the total level of risk, in general, are affected by them. This research will examine, five project characteristics, emerged from the literature, which have been discussed above [5,32,38].

First, the development of an application with strategic orientation has fundamental differences from the development of an application for automating various transactions or decision-making. For example, the survey of Wallace *et al.* [32] showed that strategic applications involve more complexity risk than information or transaction oriented applications. Yet, though it seems quite possible that projects of strategic nature differ from non-strategic projects in terms of risk, far too few empirical researches have been carried out examining the role various project characteristics play in the appearance and magnitude of these risks.

Moreover, although the relationship between project scope and software project risk is known from unpublished experiences, it has not been empirically tested in depth. However, a research by Huang and Han [46] elevated the fact that a parameter of the project scope, its duration, affects to a great extent some of the dimensions of risk, like those of planning and control, team, user and

requirements as well. In total agreement with the survey of Huang and Han [46], two earlier surveys, those of Wallace *et al.* [32] and Zmud [101], verified this parallel relationship of project scope with risk. Wallace *et al.* [32] detected a clear influence of project scope on all risk dimensions, while Zmud [101] suggested that the higher level of uncertainty that is observed on projects with long duration is an outcome of the co-dependence between the various project procedures and the high level of co-operation that should be accomplished for the harmonic and effective management of people, of requirements and complexity.

Wallace *et al.* [32] revealed the insufficiency of surveys about the relationship between the use of outsourcing and project risk, and they verified that the use of outsourcing would bring a different risk profile compared to the complete use of intra-organizational resources for the development of a project. The use of one indicator for the two different strategies (in-house and outsourcing), in conjunction with the risk dimensions metrics, can lead to the exploration and projection of the main sections of a project that become more or less risky, according to the selection or not of an outsourcing strategy for their development. Through the empirical results of their survey, Wallace *et al.* projected the highest levels of risk on the dimensions of team and planning and control, in those cases that an organization decides to make use of the outsourcing strategy. In order to explain this limited relationship of outsourcing with the total level of risk (as it is defined by its 6 aforementioned dimensions), they stated

that projects that are liable to outsourcing practices, justifiably tend to encounter greater challenges and difficulties, in terms of team communication and co-operation, provided that at least two organizations are engaged.

The issue of project diversity - although it has been a matter of examination in the field of software development many times in the past [38,39,98], concerning its relation and effect on the degree of success and performance of a project- is obviously absent from the international literature, as regards the examination of its relationship with the risk level of software projects.

Last but not least, Jones [5] defined six basic categories of software projects and correlated them with the most risky factors of the project, recognizing that different risks affect different software systems with different weight. Though, the Application Taxonomy catalogue that Jones presented constitutes an interesting contribution in the field of risk management, his research suffers many paradoxical tendencies and omissions that should be improved through future research. The present study is going to proceed towards this direction.

The main research question that emerges from the above discussion, illustrated in **Figure 1**, is the following:

Research Question 1: How the characteristics of a project affect the level of risk during the development process?

3.2. The Project Risk Management Team Relationship with Project Risk

The importance of selecting the appropriate team that will carry out the risk management process, so as to enhance the effectiveness and performance of a project, was recognized by Ward [78]. Ward expressed the view that an effective risk management requires from project development team members to have the necessary motivation, capability and experience, as well as a deep understanding of their responsibilities both for the process and the outcome. He also stated that, if one of these requirements (motivation, capability and experience, perceived responsibilities) is missing, or cannot be elevated, then it will be desired to find a more adequate party for managing risk. Recognizing the importance of project participants' characteristics for the risk management process, as well as their effect on the total project performance, an attempt will be made to connect these characteristics with the software development risk. The examination of this link is another goal of the present study.

Research Question 2: How the characteristics of the risk management team affect the level of project development risk?

3.3. The Relationship between Project Characteristics, Project Risk Management Team and Project Quality

After the analysis of those variables that define some of the elements that characterize a software project as well as its stakeholders, and their connection to the project risk, an attempt will be made to examine their interaction with project quality. The specific conceptual connection among these volatile factors, despite its obvious theoretical and practical value, has not been studied in depth in the past, at least not in the restricted framework of software development. For this reason, the examination and interpretation of these relationships were considered essential, despite their indirect reference to the main issue of the emergence, impact, mitigation and overall management of project risks. No matter what results-conclusions will be derived, a wider research framework in the field of risk management in the international literature will be hopefully triggered.

Research Question 3: How Project Characteristics affect Project Quality?

Research Question 4: How Project Risk Management Team Characteristics affect Project Quality?

3.4. The Relationship of the Risk Identification Approaches with Project Risk and Project Performance

Kulik and Weber [27] classified the risk identification approaches for software projects in four main groups: ad-hoc, formal, informal and periodic. In the present research a step forward is going to be made, attempting to connect directly the risk identification approaches with the level of risk in the software development project and with the project performance. These relations will be studied in order to estimate the importance, uniqueness and effectiveness of every approach on the overall project risk assessment (as well as with each risk dimension) and on project performance, respectively.

Research Question 5: How does the use of different risk identification approaches on software projects affect the level of project risk involved?

Research Question 6: How does the use of different risk identification approaches on software projects affect project performance?

3.5. The Relationship between Project Quality and Project Risk

Despite the fact that the quality issue in software development project has been taken into consideration in many research papers in the past (see Section 2.7), none of these studies investigated its importance and relationship with the conceptual factor of software development

risk. In this study, a first attempt will be made to conceptualize this framework using the items suggested by Fenton's *et al.* [92] research for measuring project quality.

Research Question 7: How does the level of project quality affect its risk?

3.6. The Relationship of Residual Performance Risk with Project Performance

Nidumolu [81] was the first to examine the relationship between project's residual performance risk and its actual performance. Data from 64 software development projects in the USA provided substantial foundation for his model. Nidumolu used residual performance risk as an intermediate factor among those of standardization, uncertainty of requirements and project performance. After the statistic analysis and the examination of the hypotheses, Nidumolu enunciated the existence of a negative consequence of residual performance risk on the process and product performance of the project.

Na *et al.* [83] attempted to examine the original model of Nidumolu's survey in the software development industry of Korea. By using identical structural models and by gathering data from Korean software projects that were developed from 1999 to 2000, they compared the findings of Nidumolu from the USA with those of their research. The analysis indicated that the mean of residual performance risk and its effect on the subjective performance of a project differs significantly between the two studies and the two countries, since the correlation coefficients between both residual performance risk and the two aspects of project performance are not statistically important for the data of the Korean research. According to Na *et al.* [83], a possible explanation for this observed difference is that in technologically developing countries like Korea, where the systematic use of risk management is still in early stages, the residual performance risk is less important and substantial for software development companies.

Extending the previous research, Na *et al.* [36] carried out a survey in three of the largest software development companies in Korea (companies that occupied at least 25.000 employees). In this survey, Na and his colleagues attempted to measure (in 123 software development projects), among others and the relationship between the residual performance risk and the objective performance of projects. They reported the existence of a positive and statistically important relationship between these factors.

A recent study by Jiang *et al.* [99] measured and evaluated the effect of the residual performance risk on the subjective performance of 151 organizations in the USA. This research verified the negative relationship between these two factors.

Furthermore, since the Korean research [83] was designed to copy the previous American research [81], Na *et al.* did not try to collect data that would allow them to analyse the two elements of residual performance risk. As a result, they could not define the proportion of the unforeseeable risk and the residual controllable risk (through the aforementioned control techniques, at the final stage, though, of the development of a project), in the total residual performance risk. For this reason, another contribution of the present study would be the selection of appropriate data that will allow us to study and analyse thoroughly these two elements of a project's residual performance risk. Na *et al.* [83] stated that since managers of software projects continue to improve risk management practices, the mean residual controllable risk would gradually decrease. However, as the software development becomes more and more innovative and the development technology continues to improve rapidly, the risk of unexpected uncertainty and chaotic situations could emerge and quickly take gigantic dimensions.

Research Question 8: How does residual performance risk affect the performance (subjective and objective) of a project?

Research Question 9: How does unforeseeable risk and residual controllable risk affect the residual performance risk of a project?

3.7. The Relationship of the Project Risk with the Project Performance

The relationship between the risk level of a project and its performance has been examined by several researches in the past [32,48,59,100]. In particular, Jiang and Klein [100] agreed that the various risks in software development consist a great problem that affects project performance. Wallace *et al.* [32] composed a model – that was established in the literature of project management and the sociotechnical theory, along with the special risk metrics – that is based on six risk dimensions and explains to a great extent the variability that occurs on the project performance. Wallace *et al.* [48] designed a model measuring project's performance and risk level, and they underlined the reverse relationship between the two concepts (especially the process instead of the product). Recently, Han and Huang [59] examined the relationship of software risks and their effect on project performance. In their article, they displayed the findings of an empirical research that was based on 115 software projects, about the possibility of appearance and the consequence of the six different dimensions of risks on project performance.

Considering the above surveys, and since the empirical data that describe the relationship between risk and project performance are rare and often fail to take into con-

sideration the several risk factors that prevent their successful outcome, this study may emerge as a general framework for future research, so as to investigate the impact of project risk on both dimensions (subjective and objective) of performance, and to further examine those risk factors that are less projected in literature and have an important effect on project performance.

Research Question 10: How does the level of project risk affect the performance (subjective and objective) of a project?

4. Concluding Remarks

In spite of the indisputable fact that in the past 20 years there have been noticed remarkable efforts internationally (found in literature), it is true that quite enough issues concerning risk management in software development projects remain unexamined and lack theoretical and practical support. The expected goal of this research is to bridge the gap between the existing literature and the appropriate practices in the management of software development projects by evaluating practitioners' needs for the successful management of software risks.

Through a brief literature review and the construction of a new research framework, an explicit conceptual framework has been formed. In this framework, a group of factors has been added for the determination of the total risk level and, moreover, its effect (and all of the dimensions that compose it) on the final subjective and objective project performance. The ineffective performance of many software projects and the consequential costs and time overruns, missed business prospects, and the rise of social distrust in the information technologies, give cause for reflection in the software project management field; this study will hopefully help in the evaluation and estimation of several project performance related aspects.

Part of the value of this framework lies in the conceptual representation of factors and the examination of the possible relationships between them, which have not received the appropriate attention when thinking about managing software development projects. While the value of the risk management has already been underlined in the past, and the fact that its theory has made a lot of advancements, there is no complete model yet describing and analyzing the relationships between all these organizational concepts in detail. More specifically, within the field of software development project risk management, there is not an extensive, well-grounded, distinct and applicable system, which will be able to guide project managers to follow reliable and successful management mechanisms. The proposed framework is considered to be an original and complete model that intends to contribute to literature by exploring the link-

ages among software project risk, risk identification approaches, project characteristics, project risk management team, residual performance risk, project quality and project performance.

In addition, it must be stressed that another significant goal of this paper is the recording and examination of these parameters of risk management in software development projects that can induce and motivate managers or project team members, to a more energetic role in the risk management practices. This study has provided many visions of software project risk that project managers should utilize in order to manage the potential risks related with a particular project and to evaluate effectively the possible alternatives. The multi-dimensional theoretical background of these practitioners is almost certain that will provide the necessary spark for the use of a thorough and systematic approach of risk management in the whole project lifecycle (in which risk is assessed in each phase of the project), and to develop the appropriate risk mitigation strategy in more timely and scientific way.

Finally, the project risk management issues are not usually in the agenda of the software development organizations (and especially at the small ones), because of the sensitive information that includes and the adherence to the "shoot the messenger" syndrome, which frequently discourages the members of the development team from bringing forthcoming or pending problems to the attention of management. So, this study may help to get over this lack of communication between project team members (who will find some helpful and practical insights in the theoretical framework of this research) and, mainly, by changing and integrating a new effectual culture considering the risks that their projects face.

The research model suggested here has to be validated using real life data. Authors have already constructed a structured questionnaire which has been refined in several pre-test stages and interviews with academics and practitioners (project managers and programmers) experts in software project development. The data collection process will commence by the end of January, 2011, while the first results are expected by the end of March, 2011.

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