Praise Worthy Prize

International Review on Computers and Software (I.RE.CO.S.), Vol. 8, N. 11
ISSN 1828-6003 November 2013

Managing Software Project Risks (Design Phase) with Proposed Fuzzy Regression Analysis Techniques with Fuzzy Concepts

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Abstract – *This Regardless how much effort we put for the success of software projects, many software projects have very high failure rate. Risk is not always avoidable, but it is controllable. The aim of this paper is to present the new mining technique that uses the fuzzy multiple regression analysis techniques with fuzzy concepts to managing the risks in a software project and reducing risk with software process improvement. Top ten software risk factors in design phase and thirty risk management techniques were presented to respondents. The results show that all risks in software projects were important in software project manager perspective, whereas all risk management techniques are used most of time, and often. However, these mining tests were performed using fuzzy multiple regression analysis techniques to compare the risk management techniques to each of the software risk factors to determine if they are effective in mitigating the occurrence of each software risk factor by using statistical package for the Social Science (SPSS) for Manipulating and analyzing the data set, MATLAB 7.12.0 (R2011a), wolfram mathematic 9.0,. Also ten top software risk factors were mitigated by using risk management techniques except Risk 3 "Developing the Wrong User Interface". We referred the risk management techniques were mitigated on software risk factors in Table XV. The study has been conducted on a group of software project managers. Successful project risk management will greatly improve the probability of project success.* ***Copyright © 2013 Praise Worthy Prize S.r.l. - All rights reserved.***

Keywords: *Software Project Management, Software Risk Management, Design Phase, Software Risk Factors, Risk Management Techniques, Fuzzy Multiple Regression Analysis Techniques, Correlation Analysis, Statistical and Mining Techniques*

I. Introduction

Despite much research and progress in the area of software project management, software development projects still fail to deliver acceptable systems on time and within budget. For some of these reasons corrective action is often difficult to cost-justify or to implement efficiently in practice [1]. Much of the failure could be avoided by managers pro-actively planning and dealing with risk factors rather than waiting for problems to occur and then trying to react. Project management and risk management has been proposed as a solution to preserve the quality and integrity of a project by reducing cost escalation [2].

Due to the involvement of risk management in monitoring the success of a software project, analyzing potential risks, and making decisions about what to do about potential risks, the risk management is considered the planned control of risk. Integrating formal risk management with project management is a new phenomenon in software engineering and product management community. It requires that project managers need to be involved in a project from the concept phase to the product's retirement [3]. In addition, risk is an uncertainty that can have a negative or positive effect on meeting project objectives.

Risk management is the process of identifying, analyzing and controlling risk throughout the life of a project to meet the project objectives [2]. Clearly, the success or failure of software projects are generally assessed in three dimensions: budget, schedule, product functionality and quality [4].

However, the goal of risk management at early identification and recognition of risks and then actively changes the course of actions to mitigate and reduce the risk [5]. In the process of understanding the factors that contribute to software project success, risk is becoming increasingly important. This is a result of the size, complexity and strategic importance of many of the information systems currently being developed. Today, we must think of risk is a part of software project lifecycle and is important for a software project survival [6]. On the other hand, risk management aims to read risks as improvement opportunities and provide inputs to growth plans [6]. Risk management is well recognized as an important means of mitigating software failure [7].

Also software projects are difficult to manage and too many of them end in failure [8]. Masticola described risk management to mean any activity that is intended to help software project managers to understand and manage the risk of serious budget overruns in software projects [1].

In fact, software projects are various form and probability more hard than other engineering projects as they are described by high complexity and high chances of project failure [9]. In addition, software projects fail to meet the budget, schedule, scope, and quality expectations is the risk related of requirements deriving [10]. Risk is associated with all phases of the software project such as planning, analysis, design, implementation, and maintenance.

In our paper, we identified risk factors and risk management techniques that are guide software project managers to understand and mitigate risks in software development projects. However, Software Development Life Cycle according to [11], is the process of creating or altering systems, and the models and methodologies that people use to develop these systems. Also it includes these phases as follow [11]: Planning, analysis, design, implementation, and maintenance. In addition, we focused on design phase: It involves the actual creation and design of a system. This involves putting together the different pieces that will create the system. According to Taylor we should be applied techniques consistently throughout the software project risk management process [12]. Risk management is a practice of controlling risk and practice consists of processes, methods, and tools for managing risks in a software project before they become problems [13].

Therefore, Boehm talked about value-based risk management, including principles and practices for risk identification, analysis, prioritization, and mitigation [14].

The objective of this study is: To identify the risk factors of software projects in the Palestinian software development organizations, to rank the software risk factors according to their importance, severity and occurrence frequency based on data source, to identify the activities performed by software project managers to manage the software project risks which identified, To present models for predicting that mitigate software project risks based on statistical and mining Techniques.

The organization of this paper as will be as follows. Section 2 presents an overview of the literature. Section 3 introduces the software risk factors (Design Phase) relevant to the study. Section 4 introduces the common risk management techniques to these risks. Section 5 presents the empirical work. Section 6 concludes the article and glimpses on future work.

II. Literature Review

We improved quality of software projects of the participating companies while estimating the quality–affecting risks in IT software projects. The results show that there were 40 common risks in software projects of IT companies in Palestine. The amount of technical and non-technical difficulties was very large. The most of the risks were very important. The study has been conducted on a group of managers to improve the probability of project success [15].

According to [16], they described an approach to modelling software risk factors and simulating their effects as a means of supporting certain software development risk management activities.

This simulator is a tool designed specifically for the risk management activities of assessment, mitigation, contingency planning, and intervention. Also, the development of a fuzzy decision support system (FDSS) for risk assessment in e-commerce (EC) development and a risk analysis model for EC development using a fuzzy set approach is proposed and incorporated into the FDSS [17]. Furthermore [18], they presented a risk management supporting tool, detailing its functionality and the user interface appearance as well as giving some design and implementation details. The tool provides in particular: Automatic risk identification from interactively answered on-line checklists, qualitative risk evaluation. However, why do software development projects fail? Most researchers are considering this equation. Although software has been successfully applied in a large variety of areas, software development project has a reputation for failure [19].

In addition, software projects are exposed to various risk factors where risk factors are understood as a possibility of loss, damage or disadvantage [18]-[20]. According to [21], they provided additional insights into this phenomenon made by examining the impact on software project performance by the interaction between interpersonal conflict and requirement uncertainty.

Consequently, they surveyed the top 1600 companies in Taiwan and the results indicated that requirements instability would lead to possible interpersonal conflict was directly related with requirements diversity which, in turn negatively with final project performance has been assigned. Furthermore [22], they described key success software project factors in software organizations which are software process and process improvement.

Therefore, without process, a software organization cannot produce high quality, mitigating risk and it will fail to reach its objectives. Software companies of Bangladesh are facing the problem of specific in a software process model. In addition, they identified a number of risk factors such as missing in target set for software process and improvement, low involvement of quality control activities, and absence of standard business expertise practice. Really, we put for the success of software projects, many software projects have very high failure rate. In addition, we presented a new technique by which we can study the impact of different control factors and different risk factors on software projects risk. The new technique uses the chi-square (χ^2) test to control the risks in a software project. Fourteen risk factors and eighteen control factors were used. The study has been conducted on a group of managers [23]. In addition, we used new techniques the regression test and effect size test proposed to manage the risks in a software project and reducing risk with software process improvement. Fourteen risk factors and eighteen control factors were used in this paper.

The nine of fourteen factors mitigated by using control factors. The study has been conducted on a group of managers [24]. Furthermore, we used the new stepwise regression technique to managing the risks in a software project. Top ten software risk factors in implementation phase and thirty control factors were presented to respondents. These tests were performed using regression analysis to compare the controls to each of the risk factors to determine if they are effective in mitigating the occurrence of each risk factor and selecting best model [25]. Ref. [26], focused on experienced project manager's perceptions of software project risks and controls. This work reports on the more significant risks and controls that are utilized to reduce the occurrence of the risk factors. The effectiveness of various controls to reduce the occurrence of risk factors was also identified and discussed. According to [27], described method associated with a special fuzzy operator, namely a two-additive Choquet integral that enables modeling different effects of importance and interactions among risks. The potential of the proposed methodology is exposed through an empirical case study conducted in a Turkish software company.

However, the methods and tools always used to measure software risk factors and explain scores are be defined. Also, scoring methods are important in the qualitative, quantitative and mining analysis risk to reduce the effects of subjectively and objectively assigning a value to software risk factors. Also, the risk assessment model, methods and techniques are widely used to control risk in a software development[28]. Therefore, it is important to identify those software risk factors that increase probability of success project. As well as managing software project risks associate with qualitative risk analysis techniques, quantitative risk analysis techniques and mining risk analysis techniques. Actually problem, how to estimate risk by methods and techniques, so it is difficult to estimate risk due to some of factor [29]. Furthermore, they designed to solve two problems in the project risk management: What kind of risk factors occurred in the software development process (risk identification) and which of these factors did the project managers consider most important (risk assessment)?[30]. On the other hand, risk management is not a discrete single activity but a dynamic process, that is continuously more refined through its repetition throughout a software project's life cycle [31]. Respectively again risk management associated with all activities, a conditions and events, which can affect the organization, and its ability to achieve the organization's goals [32]. However, risk management is to identify risky situations and develop strategies to mitigate the likelihood of occurrence and the negative effect of risky events[33]. Risk management focuses on assessment the likelihood of risk occurring, risk event drivers, risk events, the likelihood of impact and the impact drivers before the risk actually takes place [28].

Ref. [20], presented a process model-based approach to software project risk identification.

Their approach involves explicit modelling of software processes and identifying risk by two techniques: Metrics of process structure and focuses on the differences between the actual and the referential model. Also Miler explained risk identification: Identification of risk incidents threatening the success of project as well as their risk factors, recognize of the risk scenarios [4].

Consequently, risk prioritization requires analyzing the potential effects of the risk event and impact value.

The degree of risk depends upon two properties: The likelihood and impact on the software project if it works [34]. Also, risk analysis contribute to analyze probability and consequences in the risk identification phase and estimate the impact, sensitivity, relationships of risks, the relationship between risk factors and risk management techniques with new techniques, analysis of risk mitigation options, analyze a certain risk mitigation strategy. In addition, risk analysis assesses the loss likelihood and loss size impact for each identified risk item and it assesses compound risks in risk-item interactions. Therefore, techniques include performance models, cost models, network analysis, statistical decision analysis, and quality-factor analysis [35].

According to Deng and Bian [36], controlling risk can be defined as that, in order to reduce the probabilities of different kinds of risks, together with reducing losses caused by risk incidences, project managers carry out optimal techniques for holding identified risks. Only risk controlling is done well, can say that enterprises have succeeded in managing risks. Control– when a process of continually monitoring and correcting the condition on the project is used. This process involves the development of a risk reduction plan and then tracking the plan [37]. Also, not every risk factor is fully controllable, and several risk factors exceed the authority of software managers [28]. Indeed, mitigation is to reduce the risk exposure. This can be accomplished by reducing the likelihood of the risk occurring, reducing the cost of experiencing the risk, or both [38].

According to Dash and Dash [28], risk management consists of the processes, methodologies and tools that are used to deal with risk factors in the Software Development Life Cycle (SDLC) process of Software Project. Also dash described risk management is defined as the activity that identifies a risk; assesses the risk and defines the policies or strategies to alleviate or lessen the risk. Also Oracle Corporation described risk management solutions enable a standardized approach for identifying, assessing and mitigating risk throughout the software project lifecycle [39]. However, many authors are defined risk management, but difficult in practice to measure the likelihood of impact of risk factors and determines risk management techniques, especially in software development projects [40].

Finally, risk management methodology that has five phases: Risk identification (planning, identification, prioritization), risk analysis (risk analysis, risk evaluation), risk treatment, risk controlling, risk communication and documentation these relied on three categories techniques as risk qualitative analysis, risk quantitative analysis and risk mining analysis throughout the life of a software project to meet the goals.

III. Top 10 Software Risk Factors (Design Phase)

We displayed the top software risk factors in software development project lifecycle (Design phase) that most common used by researchers when studying the risk in software projects. However, the list consists of the 10 most serious risks to a project ranked from one to ten, each risk's status, and the plan for addressing each risk.

These factors need to be addressed and thereafter need to be controlled. Consequently, we presented 'top-ten' based on survey Boehm's 10 risk items 1991 on software risk management[35], the top 10 risk items according to a survey of experienced project managers, Boehm's 10 risk items 2002 and Boehm's 10 risk items 2006-2007, Miler [4], The Standish Group survey [41], Addison and Vallabh [26], Addison [42], Khanfar, Elzamly et al. [23], Elzamly and Hussin [24], Elzamly and Hussin [15], Aloini et al.[43], Han and Huang [44]-[45], Aritua et al. [46], Schmidt et al. [47], Mark Keil et al. [8], Nakatsu and Iacovou [48], Chen and Huang [49], Mark Keil et al. [50], Wallace et al. [51], Sumner [52], Boehem and Ross [53], Ewusi-Mensah [54], Pare et al. [55], Houston et al. [16], Lawrence et al.[56], Shafer and Officer [57], hoodat and Rashidi [58], Jones et al. [59], Jones [60], Taimour [61], and another scholars, researchers in software engineering to obtain software risk factors and risk management techniques, these software project risks are shown in Table I.

IV. Risk Management Techniques

Through reading the existing literature on software risk management, we listed thirty control factors that are considered important in reducing the software risk factors identified; these controls are:

C1: Using of requirements scrubbing, C2: Stabilizing requirements and specifications as early as possible, C3: Assessing cost and scheduling the impact of each change to requirements and specifications, C4: Develop prototyping and have the requirements reviewed by the client, C5: Developing and adhering a software project plan,C6: Implementing and following a communication plan, C7: Developing contingency plans to cope with staffing problems, C8: Assigning responsibilities to team members and rotate jobs, C9: Have team-building sessions, C10: Reviewing and communicating progress to date and setting objectives for the next phase, C11: Dividing the software project into controllable portions, C12: Reusable source code and interface methods, C13:Reusable test plans and test cases, C14: Reusable database and data mining structures, C15: Reusable user documents early, C16: Implementing/Utilizing automated version control tools, C17: Implement/ utilize benchmarking and tools of technical analysis, C18: Creating and analyzing process by simulation and modeling, C19: Provide scenarios methods and using of the reference checking, C20: Involving management during the entire software project lifecycle, C21:Including formal and periodic risk assessment, C22:Utilizing change control board and exercise quality change control practices, C23: Educating users on the impact of changes during the software project, C24: Ensuring that quality-factor deliverables and task analysis, C25: Avoiding having too many new functions on software projects, C26: Incremental development(deferring changes to later increments), C27: Combining internal evaluations by external reviews, C28: Maintain proper documentation of each individual's work, C29: Provide training in the new technology and organize domain knowledge training, C30: Participating users during the entire software project lifecycle. The literature review revealed the following question: Do experienced project managers control software project risk factors by using the controls identified in this paper? To answer this question, the following objectives for the empirical work have been set forth: Identify the risk factors of software projects in the Palestinian software development organizations, to rank the software risk factors according to their importance, severity and occurrence frequency based on data source, to identify the activities performed by software project managers to manage the software project risks which identified.

TABLE I
ILLUSTRATE TOP TEN SOFTWARE RISK FACTORS IN SOFTWARE PROJECT LIFECYCLE (DESIGN PHASE) BASED ON RESEARCHERS

Dimension	No	Software risk factors	Frequency
Design	1	Introduction of new technology	5
	2	Developing the wrong software functions and properties	5
	3	Developing the wrong user interface	4
	4	Insufficient procedures to ensure security, integrity and availability of the database	4
	5	Lack of integrity/consistency	4
	6	Lack of architecture, performance, quality software project	3
	7	Absence of quality architectural and design documents	3
	8	Failure to redesign and design (blueprints) software processes	2
	9	Lack of effective software project team integration between clients, the supplier team and the supply chain	1
	10	Misalignment of software project with local practices and processes	1
		Total frequency	32

V. Empirical Strategy

Data collection was achieved through the use of a structured questionnaire and historical data for assist in estimating the quality of software through determine risks that were common to the majority of software projects in the analyzed software companies. Top ten software risk factors and thirty control factors were presented to respondents.

The method of sample selection referred to as 'snowball' and distribution personal regular sampling was used. This procedure is appropriate when members of homogeneous groups (such as software project managers, IT managers) are difficult to locate.

The seventy six software project managers have participated in this study. The project managers that participated in this survey are coming from specific mainly software project manager in software development organizations.

Respondents were presented with various questions, which used scales1-7. For presentation purposes in this paper and for effectiveness, the point scale as the following: For choices, being headed 'unimportant' equal one and 'extremely important' equal seven. Similarly, seven frequency categories were scaled into 'never' equal one and 'always' equal seven. All questions in software risk factors were measured on a seven–point Likert scale from unimportant to extremely important and software control factors were measured on a seven–point Likert scale from never to always.

Therefore, the more extreme categories were combined in a way such that seven-point scale has been reduced to five-point scale as the following: A category called 'somewhat important' was created, combining the two ratings very slightly important' and 'slightly important'. Similarly, a category called 'very important' combined the two ratings 'very important' and 'extremely important'. Similarly, seven frequency categories were re-scaled into five sub-categories for presentation purposes. 'rarely' combined the two ratings 'rather seldom' and 'seldom'. 'never', 'Sometimes' and 'often' was unchanged, while 'most of the time', combined the two ratings 'usually' and 'always'.

However to describe "software Development Company in Palestine" that have in-house development software and supplier of software for local or international market, we depended on Palestinian Information Technology Association (PITA) Members' webpage at PITA's website [PITA 2012www.pita.ps/], Palestinian investment promotion agency [PIPA 2012 http://www.pipa.gov.ps/] to select top IT manager and software project managers. In order to find the relation among risks that the software projects confronts and the counter measures that should be done to reduce risks, many researchers used different statistical methods.

In this thesis, we used correlation analysis, fuzzy multiple/simple regression analysis techniques with fuzzy concepts by using statistical package for the Social Science (SPSS) for Manipulating and analyzing the data set, MATLAB 7.12.0 (R2011a), wolfram mathematic 9.0, excel 2010 and online equation solver (http://www.numberempire.com/equationsolver.php on 18/2/2013).

Correlation analysis:

Clearly, the preceding analysis states that there are correlations between determining variables besides correlation between risk factors and all determining control factors [50]. However, the equation of Correlation Coefficient is the following as [51] - [52]:

$$r=\frac{n\left[\sum(Xi\cdot Yi)\right]-\left(\sum Xi\right)\left(\sum Yi\right)}{\sqrt{\left[n\left(\sum Xi^2\right)-\left(\sum Xi\right)^2\right]\left[n\left(\sum Yi^2\right)-\left(\sum Yi\right)^2\right]}} \quad (1)$$

Regression analysis model:

Regression modeling is one of the most widely used statistical modeling technique for fitting a response (dependent) variable as a function of predictor (independent) variables [52]. Indeed, software risk factor is dependent variable while control factors are independent variables. A linear equation between one and many independent variables (multiple regression) may be expressed as:

$$Y=b_0+b_1x_1+b_2x_2+\dots\dots+b_nx_n \quad (2)$$

where b_0, b_1, b_2 , ...and b_n are constants; x_1, x_2,... and x_n are the independent variables, and y is the dependent variable. The values of b_0, b_1, b_2 ,....and b_n of the multiple regression equation may be obtained solving the next linear equations system [52].

Regression Model with Fuzzy Concepts:

Fuzzy regression analysis is an extension of the classical regression analysis in which some elements of the models are represented by fuzzy numbers [62].

Additionally, mining algorithms usually assume that the input data is precise and clean, which is unrealistic in practical situations [63].

On the other words, fuzzy multiple regression model in which response variable is fuzzy variable and part of the covariates are crisp variables [64]. Therefore, fuzzy regression methods have considerably they are helpful or widened the field of application of classical regression methods in such a way that in determining regression relations from fuzzy initial data, which can be either quantitative and qualitative [65]. Also the same authors explained, when one or some data points are greatly influenced by random factors, there must be a difference between the result gained and the actual values. At that time, the classical regression analysis is not applicable.

Although real data tends to be imprecise, no previous research has ever developed mining algorithms to find knowledge directly from imprecise data [63]. However, identifies the various data types that may appear in a questionnaire.

Then, we introduce the questionnaire data mining problem and define the rule patterns that can be mined from questionnaire data. A unified approach is developed based on fuzzy techniques so that all different data types can be handled in a uniform manner [66]. Therefore, in order to discover rules from a questionnaire dataset, we need a brand new approach that can deal with different data types occurring [66].

Therefore the same authors explained all data types could be represented and operated from fuzzy points of view.

Furthermore, we must extend the crisp association rules to fuzzy association rules from questionnaire data.

Fuzzy Concepts with Membership Function:

Fuzzy concepts help us to find the deviation of each data from fitness equation, so we define a normal distribution membership function as follow [67]:

$$U_i = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{Yi-\mu}{\sigma}\right)^2} \tag{3}$$

where μ is average of sample points and σ is square root of variance math. If we add fuzzy domain to regression method, the effect of discrete data points on the fitness result will be reduced and the effect of concentrated data points on the fitness result will be enhanced.

Indeed, a membership function is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1 [62].

Specifically, the simplest membership functions are formed using straight lines such as triangular membership function (specified by 3 parameters) and trapezoidal membership function [50]-[56]- [57].

***Fuzzy Parameters*:** A group of equations to obtain the fuzzy parameters are provided as [53]-[58]:

$$\begin{aligned} &s11b1+s12b2+\ldots+s1kbk=s1y\\ &s21\,b1\ +s22b2+\ldots+s2kbk=s2y\\ &s31\,b1\ +s32b2+\ldots+s3kbk=s3y\\ &s41\,b1\ +s42b2+\ldots+s4kbk=s4y\\ &s51\,b1\ +s52b2+\ldots+s5kbk=s5y\\ &\ldots\\ &sk1\,b1\ +sk2b2+\ldots+skkbk=sky \end{aligned} \tag{4}$$

here:

$$sij=\sum u\sum uXiXj-\sum uXi\sum uXj$$

and:

$$siy=\sum u\sum uXiy-\sum uXi\sum uy$$

According to this group of equations, first we can obtain the values of variables $b_1, b_2, \ldots, b_k$, and finally b_0 is gained by:

$$\begin{aligned} b_0 = &\frac{\sum uy}{\sum u} - b_1\frac{\sum ux_1}{\sum u} - b_2\frac{\sum ux_2}{\sum u} \ldots + \\ &-b_k\frac{\sum ux_k}{\sum u} \end{aligned} \tag{5}$$

Coefficient of Determination:

Coefficient of determination is used to assess the quality of estimation models and expressed by R^2. The coefficient R^2 calculated by [65]:

$$R^2 = \frac{\sum_{i=1}^{n}(\hat{y}-\bar{y})^2}{\sum_{i=1}^{n}(y-\bar{y})^2} \tag{6}$$

here, $\bar{y}$ express the mean value of random variables.

Obviously, the coefficient R^2 describe the percentage of variability and the value is between 0 and 1; when an R^2 is close to 1, it indicates that this model can explain variability in the response to the predictive variables, so called there is a strong relationship between the independent and dependent variables.

Importance of risk factors in Design phase:

All respondents indicated that the risk of "introduction of new technology" was the highest risk factors and important.

In fact, all risk factors were important; aggregating the responses resulted in the following ranking of the importance of the listed risks (in order of importance): Risk1, Risk 2, Risk 4, Risk 5, Risk 7, Risk 8, Risk 3, Risk 6, Risk 10, and Risk 9.

TABLE II
MEAN SCORE FOR EACH RISK FACTOR (DESIGN PHASE)

Risk	N	Mean	Std. Deviation	% percent
r1	76	3.829	0.737	76.579
r2	76	3.803	0.633	76.053
r4	76	3.737	0.772	74.737
r5	76	3.711	0.708	74.211
r7	76	3.645	0.725	72.895
r8	76	3.632	0.709	72.632
r3	76	3.632	0.69	72.632
r6	76	3.605	0.784	72.105
r10	76	3.592	0.615	71.842
r9	76	3.566	0.736	71.316
Total		3.675	0.451	73.5

Ranking of importance of risk factors for project managers' experience:

As we see the results in the table show that most of the risks are important the overall ranking of importance of each risk factor for the three categories of project managers' experience.

TABLE III
THE OVERALL RISK RANKING OF EACH RISK FACTOR

Phase	Risk	Experience 2-5 years	Experience 6-10 years	Experience >10 years
Design	R 1	r1	r4	r1
	R 2	r2	r2	r2
	R 3	r10	r1	r5
	R 4	r8	r3	r7
	R 5	r7	r6	r6
	R 6	r4	r5	r8
	R7	r3	r9	r4
	R 8	r5	r8	r10
	R 9	r9	r7	r9
	R 10	r6	r10	r3

Frequency of occurrence of controls:

Table IV shows the mean and the standard deviation for each control factor. The results of this paper show that most of the controls are used most of the time and often.

TABLE IV
THE MEAN SCORE FOR EACH CONTROL FACTOR

Control	Mean	Std. Deviation	% percent
c29	4.408	0.803	88.15789
c30	4.368	0.907	87.36842
c20	4.184	0.668	83.68421
c27	4.171	0.755	83.42105
c21	4.171	0.7	83.42105
c19	4.158	0.612	83.15789
c28	4.158	0.767	83.15789
c25	4.132	0.718	82.63158
c26	4.118	0.653	82.36842
c23	4.105	0.741	82.10526
c22	4.092	0.786	81.84211
c18	4.079	0.726	81.57895
c10	4.079	0.726	81.57895
c17	4.066	0.718	81.31579
c24	4.066	0.639	81.31579
c8	4.066	0.736	81.31579
c5	4.053	0.728	81.05263
c11	4.039	0.756	80.78947
c15	4.039	0.621	80.78947
c9	4.039	0.756	80.78947
c14	4.013	0.683	80.26316
c7	4.013	0.721	80.26316
c16	4	0.693	80
c12	3.987	0.841	79.73684
c6	3.987	0.739	79.73684
c4	3.987	0.757	79.73684
c3	3.974	0.783	79.47368
c2	3.934	0.66	78.68421
c1	3.895	0.665	77.89474
c13	3.868	0.754	77.36842

The overall ranking of importance of each control factor for the three categories of project managers' experience. Shows that the controls (29, 30, 17, 18, 28, 16, 27, 19, 20 ,26 ,26 ,8 ,25 ,23 ,21 ,15 ,24) are the most frequently used by the least experienced (2–5 years) project managers, whereas the controls (22, 9, 7, 13, 14, 11, 5, 4, 3, 12) are used often and sometimes by them. Also the controls (30, 10, 29, 22, 20, 21, 25, 27, 19, 5, 15, 6, 28, 26, 9, 8) are the most frequently used by the experienced (6–10 years) project managers, whereas remained the controls are used often by them. Also all the controls are the most frequently used by the most experienced (10 and above years) project managers.

TABLE V
OVERALL CONTROL FACTOR RANKING

Control	Experience 2-5 years	Experience 6-10 years	Experience >10 years
C1	c29	c30	c29
C2	c30	c10	c30
C3	c17	c29	c7
C4	c18	c22	c23
C5	c28	c20	c21
C6	c16	c21	c2
C7	c27	c25	c27
C8	c19	c27	c24
C9	c20	c19	c20
C10	c26	c5	c11
C11	c8	c15	c28
C12	c25	c6	c26
C13	c23	c28	c3
C14	c21	c26	c6
C15	c15	c9	c19
C16	c24	c8	c12
C17	c22	c11	c10
C18	c9	c4	c5
C19	c7	c24	c25
C20	c13	c14	c14
C21	c14	c23	c1
C22	c11	c12	c9
C23	c5	c18	c22
C24	c4	c17	c4
C25	c3	c3	c18
C26	c12	c16	c15
C27	c10	c2	c13
C28	c6	c1	c8
C29	c1	c7	c17
C30	c2	c13	c16

Relationships between risks and control variables:

Regression technique was performed on the data to determine whether there were significant relationships between control factors and risk factors. These tests were performed using fuzzy regression analysis modelling, to compare the controls to each of the risk factors to determine if they are effective in mitigating the occurrence of each risk factor. Relationships between risks and controls, which were significant and insignificant, any control is no significant, we are not reported according to the fuzzy risk model.

R1: Risk of 'Introduction of New Technology' Compared to Controls.

TABLE VI
ILLUSTRATE THE VALUE OF CORRELATION

C1	C2	C3	C4	C5	C6	C7
.275*	.288*	.513**	.346**	.347**	.304**	.304**
C8	C9	C10	C11	C15	C23	
.256*	.343**	.331**	.305**	.234*	.233*	

* Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Tables show that the significant value is less than the assumed value at the $\alpha = 0.05$ level of significance, so there is a positive relation among controls 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 23 and risk 1. Also control 3 has an impact on the risk 1. In addition, the results show that the control 3 has a positive impact value of 0.513 and the value of adjusted R^2 is 0.066.

This interprets as a percentage of 6.6 % from the dependent variable of risk 1.

According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\text{Fuzzy Risk 1} = 3.610150317 + 0.252944641 \times C3 \quad (7)$$

R2: Risk of 'Developing the Wrong Software Functions and Properties' Compared to Controls.

TABLE VII
ILLUSTRATE THE VALUE OF CORRELATION

C4	C19	C28
.276*	.249*	.252*

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among control 4, 19, 28 and risk 2. Also the control 4 has an impact on the risk 2.

In addition, the results show that the control 4 has positive impact value of 0.276, and the value of R^2 is 0.0356. This interprets as a percentage of 3.56 % from the dependent variable of risk 2. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\text{Fuzzy Risk2} = 4.158787224 + 0.136910247 \times C4 \quad (8)$$

R3: Risk of 'Developing The Wrong User Interface' Compared to Controls.

The result show that the significant value is greater than the assumed value at the α = 0.05 level of significance, so there is no relation among controls and risk 3, We not reported controls that have not a relation (no significant). Also we found the model is not fit.

R4: Risk of 'Insufficient Procedures to Ensure Security, Integrity and Availability of The Database' Compared to Controls.

TABLE VIII
ILLUSTRATE THE VALUE OF CORRELATION

C2	C4	C8	C9	C10	C19
.274*	.267*	.300**	.229*	.277*	.335**
C23	C24	C25	C26	C28	
.256*	.273*	.251*	.263*	.289*	

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls 2, 4, 8, 9, 10, 19, 23, 24, 25, 26, 28 and risk 4. We described the controls 19 and 24 have an impact on the risk 4.

In addition, the results show that controls 19, and 24 have a positive impact value of 0.335 and 0.273 respectively, also a multiple correlation value is 0.335, and the value of R^2 is 0.0565. This interprets as a percentage of 5.65 % from the dependent variable of risk 4. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{Fuzzy Risk4} = 2.892838896+\\&+ 0.223693596 \times C19 + 0.139313479 \times C24\end{aligned} \quad (9)$$

R5: Risk of 'Lack of Integrity/Consistency' Compared to Controls.

TABLE IX
ILLUSTRATE THE VALUE OF CORRELATION

C1	C2	C3	C4	C7	C8
.246*	.372**	.389**	.267*	.244*	.269*
C9	C10	C13	c19	c21	c23
.333**	.258*	.226*	.228*	.235*	.384**
c24	c25	c26	c27	c28	c29
.387**	.233*	.373**	.398**	.279*	.240*

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls1, 2, 3, 4, 7, 8, 9, 10, 13, 19, 21, 23, 24, 25, 26, 27, 28, 29, and risk 5.

Also controls 24 and 27 have an impact on the risk 5. In addition, the results show that the control 24, and 27 have a positive impact value of 0.387 and 0.398 respectively, also a multiple correlation value is 0.480, and the value of R^2 is 0.0730. This interprets as a percentage of 7.30 % from the dependent variable of risk 5. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{FuzzyRisk5}=3.245067322+ 0.19878942 \times C24 +\\&+ 0.099091138 \times C27\end{aligned} \quad (10)$$

R6: Risk of 'Lack of Architecture, Performance, and Quality Software Project' Compared to Controls.

TABLE X
ILLUSTRATE THE VALUE OF CORRELATION

c1	c2	c3	c4	c10	c11
.324**	.331**	.328**	.268*	.312**	.241*
c23	c24	c26	c28	c29	c30
.227*	.376**	.420**	.315**	.240*	.358**

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls 1, 2, 3, 4, 10, 11, 23, 24, 26, 28, 29, 30 and risk 6. Controls 26 and 30 have an impact on the risk 6. In addition, the results show that controls 26, and 30 have a positive impact value of 0.420 and 0.358 respectively, also a multiple correlation value is 0.474, and the value of R^2 is 0.0965.

This interprets as a percentage of 9.65 % from the dependent variable of risk 6. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{Fuzzy Risk 6}=2.648617968+\\&+0.273625288 \times C26 +0.095128781 \times C30\end{aligned} \quad (11)$$

R7: Risk of 'Absence of Quality Architectural and Design Documents' Compared to Controls.

TABLE XI
ILLUSTRATE THE VALUE OF CORRELATION

C1	C2	C7	C10	C24	C26
.227**	.355**	.241**	.280**	.251**	.283**

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls1, 2, 7, 10, 24, 26 and risk 7. Also controls 2 and 15 have an impact on the risk 7. In addition, the results show that a multiple correlation value is 0.418, and the value of R^2 is 0.027.

This interprets as a percentage of 2.7 % from the dependent variable of risk 7. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{Fuzzy Risk7} = 4.293730253 + \\ &+ 0.160303774\times C2 - 0.092317336\times C15\end{aligned} \tag{12}$$

R8: Risk of 'Failure to Design (Blueprints) and Redesign Software Processes' Compared to Controls.

TABLE XII
ILLUSTRATE THE VALUE OF CORRELATION

C2	C3	C4	C9	C10	C20
.311**	.382**	.379**	.280*	.288*	.286*
C21	C24	C27	C28	C29	
.290*	.315**	.254*	.283*	.407**	

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls 2, 3, 4, 9, 10, 20, 21, 24, 27, 28, 29 and risk 8. Also controls 4, 5, 24, and 29 have an impact on the risk 8.

In addition, the results show that controls 4, 24 and 29 have a positive impact value of 0.379, 0.315, and 0.407 respectively, also a multiple correlation value is 0.570, and the value of R^2 is 0.145. This interprets as a percentage of 14.5 % from the dependent variable of risk 8. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{Fuzzy Risk8} = -0.002345077 + 0.3867\times C4 + \\ &+0.0172\times C5 + 0.511\times C24 + 0.0002\times C29\end{aligned} \tag{13}$$

R9: Risk of 'Lack of Effective Software Project Team Integration Between Clients, The Supplier Team and The Supply Chain' Compared to Controls.

TABLE XIII
ILLUSTRATE THE VALUE OF CORRELATION

C4	C16	C19	C20	C24	C25
.276*	.261*	.273*	.226*	.368*	.288*
C26	C27	C28	C29	C30	
.302**	.332**	.250*	.269*	.257*	

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls 4, 16, 19, 20, 24, 25, 26, 27, 28, 29, 30, and risk 9. Also controls 4, 24 and 27 have an impact on the risk 9. In addition, the results show that controls 4, 24 and 27 have a positive impact value of 0.276, 0.368 and 0.332 respectively, also a multiple correlation value is 0.526, and the value of R^2 is 0.117. This interprets as a percentage of 11.7 % from the dependent variable of risk 9. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{Fuzzy Risk 9} = -0.003997482 - 0.0959\times C1 + \\ &+0.4367\times C4 + 0.5532\times C24 + 0.0003\times C27\end{aligned} \tag{14}$$

R10: Risk of 'Misalignment of Software Project with Local Practices and Processes' Compared to Controls.

TABLE XIV
ILLUSTRATE THE VALUE OF CORRELATION

C3	C13	C14
.293**	.324**	.309**

Tables show that the significant value is less than the assumed value at the α = 0.05 level of significance, so there is a positive relation among controls 3, 13, 14 and risk 10. Also controls 3 and 13 have an impact on the risk 10. In addition, the results show that a multiple correlation value is 0.451, and the value of R^2 is 0.0781.

This interprets as a percentage of 7.81% from the dependent variable of risk 10. According to the fuzzy concepts in multiple regression analysis to produce fuzzy multiple regression model by solving these equations, the final fuzzy model:

$$\begin{aligned}&\text{Fuzzy Risk10} = 3.709819819951 + \\ &+ 0.164126065\times C3 - 0.088752354\times C8 + \\ &+ 0.116056172\times C13\end{aligned} \tag{15}$$

Software Risk factors identification checklists and control factors (risk management techniques):

Table XV shows risk factors identification checklist with risk software projects based on a questionnaire of experienced software project managers. He can use the checklist on software projects to identify and mitigate risk factors on lifecycle software projects by risk management techniques.

VI. Conclusion

The concern of our paper is the managing risks of software projects. The results show that all risks in software projects were important in software project manager perspective, whereas all controls are used most of time, and often. Therefore, the software risk factors in design phase from risk number 1, 2, 4, 5, 7, 8, 3, 6, 10, 9 were identified as important, aggregating the responses resulted in the following ranking of the importance of the listed risks (in order of importance): Risk 1, Risk 2, Risk4, Risk 5, Risk 7, Risk 8, Risk 3, Risk 6, Risk 10, and Risk 9.

TABLE XV
SOFTWARE RISK FACTORS MITIGATED BY RISK MANAGEMENT TECHNIQUES

No	Software Risk Factors	Risk Management Techniques
1	Introduction of new technology.	C3: Assessing cost and scheduling the impact of each change to requirements and specifications.
2	Developing the wrong software functions and properties.	C4: Develop prototyping and have the requirements reviewed by the client.
3	Developing the wrong user interface.	----
4	Insufficient procedures to ensure security, integrity and availability of the database.	C19: Provide scenarios methods and using of the reference checking, C24: Ensuring that quality-factor deliverables and task analysis.
5	Lack of integrity/consistency.	C24: Ensuring that quality-factor deliverables and task analysis, C27: Combining internal evaluations by external reviews.
6	Lack of architecture, performance, quality software project.	C26: Incremental development (deferring changes to later increments), C30: Participating users during the entire software project lifecycle.
7	Absence of quality architectural and design documents.	C2: Stabilizing requirements and specifications as early as possible, C15: Reusable user documents early.
8	Failure to design (blueprints) and redesign software processes.	C29: Provide training in the new technology and organize domain knowledge training, C4: Develop prototyping and have the requirements reviewed by the client, C24: Ensuring that quality-factor deliverables and task analysis, C5: Developing and adhering a software project plan.
9	Lack of effective software project team integration between clients, the supplier team and the supply chain.	C24: Ensuring that quality-factor deliverables and task analysis, C4: Develop prototyping and have the requirements reviewed by the client, C1: Using of requirements scrubbing, C27: Combining internal evaluations by external reviews.
10	Misalignment of software project with local practices and processes.	C13: Reusable test plans and test cases, C3: Assessing cost and scheduling the impact of each change to requirements and specifications, C8: Assigning responsibilities to team members and rotate jobs.

The results of this paper show also that most of the top ten controls are used most of the time. However, "provide training in the new technology and organize domain knowledge training" is the highest; aggregating the responses resulted in the following ranking of the importance of the listed controls (in order of importance): C29, C30, C20, C27, C21, C19, C28, C25, C26, and C23. These tests were performed using fuzzy regression analysis with fuzzy concepts, to compare the controls to each of the risk factors to determine if they are effective in mitigating the occurrence of each risk factor Relationships between risks and controls, which were significant and insignificant, any control is no significant, we are not reported.

However, we determined the positive correlation between risk factors and risk management techniques, then measure impact risk in software project lifecycle.

We used correlation analysis, fuzzy regression analysis techniques proposed.

However, we referred the risk management techniques were mitigated on software risk factors in Table XV. Through the results, we found out that some control haven't impact, so the important controls should be considered by the software development companies in Palestinian.

In addition, we cannot obtain historical data form database until using some techniques. As future work, we will intend to apply these study results on a real-world software project to verify the effectiveness of the new techniques and approach on software project. We can use more techniques useful to manage software project risks such as neural network, genetic algorithm, Bayesian statistics, and so on.

Appendix

Appendix illustrates and discuses software risk factors in design phase briefly:

Risk 01: Introduction of new technology.

Introduction of new technology usually will bring about a number of training needs. This technology may be used operationally in such processes as packaging, manufacturing, quality testing, money transmission, etc[71]. Surely, the required technology may be previously introduction of a new technology [71]- [72].

Also a shortage of technical know-how and concern is with the level of expertise (Ewusi-Mensah, 2003). Consequently, project involved the use of new technology, high level of technical complexity [43]- [44].

In particular [6]: Caper Jones's Risk, slow technology transfer and poor technology investments, technical issues such as complexity and experience [74]. Hence technology illiteracy as being a major issue [40]-[74]. Also new technology being introduced[76]. Likewise Boehm's Top 10 Systems Engineering Risk Items: Survey 2006-2007 referred to lack of technology knowledge and technology maturity [77].

Risk 02: Developing the wrong software functions and properties.

According to [28]-[34], developing the wrong functions and properties. Also a good many other software project did an adequate job on software functionality [78].

Risk 03: Developing the wrong user interface.

Suggested by [28]- [34]- [72], developing the wrong user interface.

Likewise Boehm's Top 10 2002 - Software Risks referred to user interface mismatch. In addition, they combined between development of the wrong software functions and user interface[13]. Therefore, explained a good many other projects did an adequate job software functionality, but created every unfriendly user interface[78].

Risk 04: Insufficient procedures to ensure security, integrity and availability of the database.

According to[42], insufficient procedures to ensure security, integrity and availability of the database.

Risk 05: Lack of integrity/consistency.

However, integrated project management[79]: Develop and use an integrated and defined set of processes that are tailored from the organizations set of standard processes. Also, one of the main factors associated with failure is lack of integration software components[52]. According to [43], referred to low degree of integration and flexibility. Furthermore, explianed lack of integration in some implementations and processes are carried out in isolation with other processes[80].

Risk 06: Lack of architecture, performance, quality software project.

Certainly, poor software company structures[6]: Caper Jones's Risk. On the other hand, organizational process performance: Provide process performance data and quantitative models to understand the organization's standard processes[79].

Risk 07: Absence of quality architectural and design documents.

According to [6]: Caper Jones's Risk, lack of reusable documentation, inadequate system documentation. Therefore, It is also important to recognize that the lack of a well–designed and documented process is a characteristic of the initial level of maturity[81].

Risk 08: Failure to redesign and design (blueprints) software processes.

Develop a correction/recovery strategy to ensure that the design for identified software reduces or delete the likelihood for failures of the system [81]. However [6]: Caper Jones's Risk, lack of reusable designs (blueprints) [43]. According to [12], the phrase develop detailed design is very descriptive of the activity–it means to develop to the greatest detail possible the design for each component of the product.

Risk 09: Lack of effective software project team integration between clients, the supplier team and the supply chain.

The project selected exiting suppliers as the main delivery partners, and did not seek a wider evaluation of their requirements from the market. Although suppliers on technical governance boards were represented, project delays negatively on impacted working relationships and there was a lack of communication channels [82].

Risk 10: Misalignment of software project with local practices and processes.

According to [83], aligning the new system and local work practices despite the measures specified previously, the intensity of the risks related with the usability risk dimension remained relatively high for most sites because of the lack of consistency between the new system and local work practices as mentioned. Also [55] referred to initial Taxonomy of CIS Project Risks; misalignment of CIS with local practices and processes.

Acknowledgements

This work is supported by Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia.

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1828-6011(201311)8:11;1-5

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