# Managing Software Project Risks with the Chi-Square ($\chi^2$) Technique

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**[Abstract]** Regardless how much effort we put into software projects to make them succeed, many software projects have very high failure rate. The aim of this paper is to present a new technique by which we can study the impact of different control factors and different risk factors to determine software project risks. The new technique uses the chi-square test to control the risks in a software project. Fourteen risk factors and eighteen control factors were used in this paper. A group of managers was used in this study. Successful project risk management will greatly improve the probability of project success.

**[Keywords]** Software project management; risk management, risk factors, risk controls, Chi-Square test

## Introduction

Despite much research and progress in software project management, software development projects still fail to deliver acceptable systems on time and within budget. Much of the failure could be avoided if managers proactively planned for and dealt 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. Due to the involvement of risk management in monitoring the success of a project, analyzing potential risks, and making decisions about what to do about potential risks, risk management is considered to be the planned control of risk. Integrating formal risk management with project management is a new phenomenon in the software engineering and product management community. It requires project managers be involved in a project from the concept phase to the product's retirement (McNair, 2001). 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 (Schawlbe, 2006). The goal of risk management is to preserve the quality and integrity of a project by reducing cost escalation and project slippage (Down, et al., 1994).

In the process of understanding the factors that contribute to software project success, risk management is becoming increasingly important. This is a result of the size, complexity and strategic importance of many of the information systems currently being developed. In order to find the relation among risks that the software projects confront and the countermeasures that should be included to reduce risks, many researchers used different statistical methods, such as regression analysis and One-Way ANOVA. In this paper, we use the chi-square ($x^2$) technique that has not been used by researchers in this fashion before. A chi-square ($x^2$) statistical technique is used to investigate whether the distributions of categorical variables differ from one another. Chi-square tests can only be used on actual numbers and not on percentages, proportions, means, etc. There are several types of chi-square tests that can be used, depending on the way the data was collected and the hypothesis being tested. The objective of this study is to identify the risks involved in software projects in Jordanian companies, rank the risks according to their importance and occurrence frequency, and identify the activities performed by project managers to control the risks identified. The organization of this paper as will be as follows. Section two presents an overview of the literature. Section three introduces the risks relevant to the study. Section four introduces the common controls to these risks. Section five presents the empirical work. Section six concludes the article and glimpses on future work.

## Literature Review

Freimut et al., (2001) proposed an industrial case study of implementing software risk management; the results showed that the risk method is practical, added value to the project, and that its key concepts are understood and usable in practice. Padayachee (2002) proposed a framework for a field investigation of risk management in the context of a particular software development organization. It was experimentally tested within several companies. This framework was designed to provide an understanding of software development risk phenomena from a project manager's perspective and gave an indication of how this perspective affects their perception. According to the author, this study can be used as a precursor to improving research into the creation of new software risk management frameworks.

Addison and Vallabh (2002) focused on experienced project managers' 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 risk factors. The effectiveness of various controls to reduce the occurrence of risk factors was also identified and discussed. Flinn and Stoyles (2004) described a risk management approach for building confidence and trust for Internet users. This approach helps users build an awareness of the risks they might encounter and supplies them with timely guidance.

Josang et al. (2004) described a method for risk analysis based on the approach used in CRAMM; it used subjective belief about threats and vulnerabilities as input parameters and used the belief calculus of subjective logic to combine them. The results show that the computed risk assessments will better reflect the real uncertainties associated with those risks. Taylor (2005) describes key risks identified by a group of Hong Kong project managers working for vendor IT firms who offered package implementation solutions both locally and overseas. In this study a number of new risks from the vendor perspective have been identified, which indicate that vendor project managers typically have a broader focus on risks than their in-house counterparts.

Wallace and Keil (2004) explored how different types of risk influence both process and product outcomes in software development projects by analyzing input from more than 500 software project managers representing multiple industries. Truta et al. (2003) introduced minimal, maximal, and weighted disclosure risk measures for the micro-aggregation disclosure control method. They introduced an information loss measure for micro-aggregation. They showed that the proposed disclosure risk and information loss measures perform as expected in real-life situations using simulated medical data.

Vaidyanathan and Devaraj (2003) presented a framework that helps understand the various risks involved in B2B (business to business) commerce. The conceptual framework presented examines risk from five critical dimensions—services, business models, technology, fulfillment, and processes. Also, they listed external and internal sources of risk for all five factors. Teo et al. (2003) described a dynamic access control architecture which uses risk to determine whether to allow or deny access by a source connection into the network.

### Software Project Risks

The risk factors listed below are considered in this paper. These factors are the most common factors used by researchers studying the risk in software projects. These factors need to be addressed and thereafter need to be controlled. These risks are as follows:

Risk 01: Unclear or misunderstand scope and objectives;
Risk 02: Failure to fully complete detailed requirements analysis and specification documentation;
Risk 03: Unrealistic schedules and budgets;
Risk 04: Inadequate knowledge and skills;
Risk 05: Absence of quality architectural and design documents;
Risk 06: Absence of a complete and detailed software development plan;
Risk 07: Lack of senior management commitment to the project;
Risk 08: Lack of effective project management methodology;
Risk 09: Developer gold plating;
Risk 10: Continuous requirement changes;
Risk 11: Introduction of new technology;
Risk 12: Failure to utilize a phased delivery approach;
Risk 13: Inadequate technical leadership; and
Risk 14: Harmful competitive actions.

### Software Project Controls

From the existing literature on risk management, the researchers listed eighteen controls that are considered important for reducing the risks identified; these controls are:

Control 01: Developing and adhering to a software development plan;
Control 02: Combining internal evaluations by external reviews;
Control 03: Involving management during the entire project lifecycle;
Control 04: Involving users during the entire project lifecycle;
Control 05: Ensuring there is a steering committee in place;
Control 06: Assigning responsibilities to team members;
Control 07: Developing contingency plans to cope with staffing problems;
Control 08: Including formal and periodic risk assessment;
Control 09: Dividing the project into controllable portions;
Control 10: Utilizing change control board and exercising quality change control practices;
Control 11: Utilizing automated version control tools;
Control 12: Ensuring that quality deliverables are produced and accepting nothing less;
Control 13: Implementing and following a communication plan;
Control 14: Educating users on the impact of changes during the project;
Control 15: Assessing cost and scheduling the impact of each change to requirements and specifications;
Control 16: Stabilizing requirements and specifications as early as possible;
Control 17: Avoiding having too many new functions on software projects; and
Control 18: Reviewing progress to date and setting objectives for the next phase.

### Empirical Strategy

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 identifying the risks that are involved in a software project in Jordanian companies, ranking the risks due to their importance and occurrence frequency, and identifying the activities performed by project managers to control the risks that are identified. Data collection was achieved through a structured questionnaire. Fourteen risk factors and eighteen controls were presented to respondents. The method of sample selection referred to as "snowball" and regular sampling was used. This procedure is appropriate when members of homogeneous groups (such as IT project managers) are difficult to locate. Forty project managers coming from specific organizations, mainly IT and finance participated in this study. A combination of rank ordering and chi-square technique ($x^2$) has been used to analyze the collected data.

Respondents were presented various questions, which used Likert-type scales. For presentation purposes in this paper and for effectiveness, the more extreme categories were combined in a way such that a five-point scale has been reduced to a three-point scale as the following: for choices being headed "completely unimportant," "not very important," "important," "very important," and "extremely important"; a category called "not that important" was created by combining the two ratings "completely unimportant" and "not very important." Similarly, a category called "very important" combined the two ratings "very important" and "extremely important." Similarly, five frequency categories were re-scaled into three sub-categories for presentation purposes. "Hardly ever" combined the two ratings "never" and "seldom." "Sometimes" was unchanged, while "most of the time," combined the two ratings "frequently" and "always."

## Importance of Risk Factors

All respondents indicated that the risk of "failure to fully complete detailed requirements analysis and specification documentation" was the highest risk factor and very important. In fact, the risk factors from risk numbers 2, 13, 11, 10, 9, 3, 7, and 5 were identified as very important, while the risk numbers 9, 12, 4, 6 , 1, and 11, in descending means were identified as important; aggregating the responses resulted in the following ranking of the importance of the listed risks (in order of importance):
Risk 02, Risk 13, Risk 11, Risk 14, Risk 09, Risk 03, Risk 07, Risk 05, Risk 08, Risk 12, Risk 04, Risk 06, Risk 01, and Risk 10.

**Table 1. Mean Score for Each Risk Factor**

| Risk | Mean | Std. Deviation |
|---|---|---|
| R02 | 3.95 | 1.131 |
| R13 | 3.87 | 1.114 |
| R11 | 3.65 | 0.662 |
| R14 | 3.57 | 0.549 |
| R09 | 3.45 | 0.959 |
| R03 | 3.38 | 1.030 |
| R07 | 3.15 | 1.442 |
| R05 | 3.00 | 1.340 |
| R08 | 2.98 | 1.050 |
| R12 | 2.97 | 1.209 |
| R04 | 2.90 | 1.374 |
| R06 | 2.90 | 1.317 |
| R01 | 2.75 | 1.080 |
| R10 | 2.58 | 0.984 |

The results in Table 1 show that most of the risks are very important or important. The overall ranking of importance of each risk factor for the three categories of project managers' experience is shown in Table 2.

**Table 2. The Overall Risk Ranking of each Risk Factor**

| Risk factors | Overall ranking | Experience 2-5 years | Experience 6-10 years | Experience >10 years |
|---|---|---|---|---|
| Unclear or misunderstand scope and objectives. | 1 | 14 | 3 | 14 |
| Failure to fully complete detailed requirements analysis and specification documentation. | 2 | 1 | 1 | 3 |
| Unrealistic schedules and budgets. | 3 | 3 | 10 | 6 |
| Inadequate knowledge and skills. | 4 | 7 | 13 | 12 |
| Absence of quality architectural and design documents. | 5 | 8 | 9 | 11 |
| Absence of a complete and detailed software development plan. | 6 | 13 | 8 | 10 |
| Lack of senior management commitment to the project. | 7 | 11 | 7 | 7 |
| Lack of effective project management methodology. | 8 | 9 | 12 | 9 |
| Developer god plating. | 9 | 5 | 6 | 5 |
| Continuous requirement changes. | 10 | 12 | 14 | 13 |
| Introduction of new technology. | 11 | 6 | 5 | 1 |
| Failure to utilize a phased delivery approach. | 12 | 10 | 11 | 8 |
| Inadequate technical leadership. | 13 | 2 | 2 | 2 |
| Harmful competitive actions. | 14 | 4 | 4 | 4 |

The results reveal that most of risks are very important or important.

## Frequency of Occurrence of Controls

Table 3 shows the mean and the standard deviation for each control factor. The results show that most of the controls are used most of the time. The three exceptions were control 04, control 06, and control 10.

**Table 3. The Mean Score for Each Control Factor**

| | *N* | *Mean* | *Std. Deviation* |
|---|---|---|---|
| **C18** | 40 | 2.62 | 0.586 |
| **C17** | 40 | 2.60 | 0.545 |
| **C15** | 40 | 2.55 | 0.597 |
| **C08** | 40 | 2.23 | 0.800 |
| **C09** | 40 | 2.20 | 0.853 |
| **C16** | 40 | 2.17 | 0.445 |
| **C05** | 40 | 2.12 | 0.463 |
| **C13** | 40 | 2.10 | 0.744 |
| **C14** | 40 | 2.10 | 0.810 |
| **C02** | 40 | 2.08 | 0.572 |
| **C03** | 40 | 2.05 | 0.677 |
| **C01** | 40 | 2.05 | 0.783 |
| **C11** | 40 | 2.03 | 0.768 |
| **C12** | 40 | 2.03 | 0.768 |
| **C07** | 40 | 2.03 | 0.832 |
| **C04** | 40 | 1.75 | 0.439 |
| **C06** | 40 | 1.73 | 0.506 |
| **C10** | 40 | 1.55 | 0.504 |
| **Valid N (listwise)** | 40 | | |

The overall ranking of importance of each control factor for the three categories of project managers' experience is shown in Table 4. Table 4 shows that the controls 02, 08, 09, 03, 07, 16, 01, 15, 17, and 18 are the most frequently used by the least experienced (2–5 years) project managers, whereas the controls 13, 05, 12, 11, 14, 06, 04, and 10 are used sometimes by them. Also the controls 15, 18, 17, 08, 14, 13, 16, 05, 11, 09, 12, 07 are the most frequently used by the experienced (6–10 years) project managers, whereas the controls 02, 01, 03, 04, 06, and 10 are used sometimes by them. Also the controls 18, 17, 15, 09, 02, 05, 16, 08, 03, 14, 12, 01, and 11 are the most frequently used by the most experienced (10 years and above) project managers, whereas the controls 13, 6, 4, 7, and 10 are used sometimes by them.

**Table 4. Overall Control Factor Ranking**

| *Controls factors* | *Overall ranking* | *Experience 2-5 years* | *Experience 6-10 years* | *Experience >10 years* |
|---|---|---|---|---|
| Developing and adhering a software development plan. | 1 | 4 | 14 | 12 |
| Combining internal evaluations by external reviews. | 2 | 10 | 13 | 5 |
| Involving management during the entire project lifecycle. | 3 | 7 | 15 | 9 |
| Involving users during the entire project lifecycle. | 4 | 17 | 16 | 16 |
| Ensuring there is a steering committee in place. | 5 | 12 | 8 | 6 |
| Assigning responsibilities to team members. | 6 | 16 | 17 | 15 |
| Developing contingency plans to cope with staffing problems. | 7 | 6 | 12 | 17 |
| Including formal and periodic risk assessment. | 8 | 9 | 4 | 8 |
| Dividing the project into controllable portions. | 9 | 8 | 10 | 4 |
| Utilizing change control board and exercise quality change control practices. | 10 | 18 | 18 | 18 |
| Utilizing automated version control tools. | 11 | 14 | 9 | 13 |
| Ensuring that quality deliverables is excellent and accepting nothing less. | 12 | 12 | 11 | 11 |
| Implementing and following a communication plan. | 13 | 11 | 6 | 14 |
| Educating users on the impact of changes during the project. | 14 | 15 | 5 | 10 |
| Assessing cost and scheduling the impact of each change to requirements 16 and specifications. | 15 | 3 | 1 | 3 |
| Stabilizing requirements and specifications as early as possible. | 16 | 5 | 7 | 7 |
| Avoiding having too many new functions on software projects. | 17 | 2 | 3 | 2 |

## Relationships between Risks and Control Variables

Spearman's correlation was performed on the data to determine whether there were significant relationships between control factors and risk factors. In order to determine the range of the effectiveness in mitigating the occurrence of each risk factor, chi-square was used to compare the controls to each one of the risk factors. The significant and insignificant relationships between risks and controls are not reported. We will clarify that relationship in the impact matrix discussion. The values of chi-square and values of correlation for each of the following risks are shown in the following tables. Table 5 shows that the significant value is less than the assumption value at the $\alpha = 0.05$ level of significance, so control 7 has an impact on risk 1 with chi-square; there is a positive relation between control 7 and risk 1, which means that whenever control 7 exceeds, risk 1 detracts.

**Table 5. Risk of 'Unclear or Misunderstand Scope and Objectives' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| 0.009 | 0.406 | 0.038 | 16.286 | **C07** |

Table 6 shows that the significant value is less than the assumption value at $\alpha = 0.05$ level of significance, so the controls 1, 5, 7, and 18 have an impact on risk 2 with Chi-square and there is a positive relation among controls 1, and 7 and risk 18, whereas there is a negative relation between control 5 and risk 2.

**Table 6. Risk of 'Failure to fully Complete Detailed Requirements Analysis and specification documentation' compared to controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| 0.010 | 0.403 | 0.019 | 18.708 | **C01** |
| 0.001 | -0.488 | 0.024 | 17.593 | **C05** |
| 0.000 | -0.528 | 0.003 | 23.562 | **C07** |
| - | -0.128 | 0.005 | 21.865 | **C13** |
| - | -0.160 | 0.003 | 23.596 | **C18** |

Through the analysis we did not find any relation with statistical significant between risk 3 and chi-square test, so we will disregard risk 3. Table 7 shows that the significant value is less than the assumption value at $\alpha = 0.05$ level of significance, so controls 9 and 18 have an impact on risk 4 with chi-square and there is a negative relation between control 18 and risk 4.

**Table 7. Risk of 'Inadequate Knowledge and Skills' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| - | -0.150 | 0.030 | 17.051 | **C09** |
| 0.001 | -0.487 | 0.010 | 18.6 | **C18** |

Table 8 shows that the significant value is less than the assumption value at $\alpha = 0.05$ level of significance, so the controls 1, 7, 13, and 15 have an impact on risk 5 with chi-square, and there is a positive relation among controls 7, 13, and 15 and risk 5.

**Table 8. Risk of 'Absence of Quality Architectural and Design Documents' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| - | 0.188 | 0.046 | 15.789 | **C01** |
| 0.011 | 0.576 | 0.042 | 16.036 | **C07** |
| 0.000 | 0.691 | 0.011 | 19.910 | **C13** |
| 0.023 | 0.359 | 0.000 | 20.40 | **C15** |

Table 9 shows that the significant value is less than the assumption value at the $\alpha = 0.05$ level of significance, so controls 7, 9, 10, 11, 12, 13, 16, 17, and 18 have an impact on risk 6 with chi-square and there is a positive relation among controls 7, 9, 10, 16, 17, and 18 and risk 6, whereas there is a negative relation between control 12 and risk 6.

**Table 9. Risk of 'Absence of a Complete and Detailed Software Development Plan' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| 0.035 | 0.335 | 0.000 | 28.251 | C07 |
| 0.003 | 0.458 | 0.000 | 30.880 | C09 |
| 0.004 | 0.442 | 0.001 | 19.461 | C10 |
| - | 0.044 | 0.034 | 16.615 | C11 |
| 0.037 | -0.331 | 0.023 | 17.741 | C12 |
| - | 0.017 | 0.014 | 19.103 | C13 |
| 0.002 | 0.478 | 0.028 | 17.177 | C16 |
| 0.024 | 0.357 | 0.016 | 18.752 | C17 |
| 0.003 | 0.458 | 0.012 | 19.565 | C18 |

Table 10 shows that the significant value is less than the assumption value at the α = 0.05 level of significance, so controls 9, 10, 11, and 14 have an impact on risk 7 with chi-square, and there is a positive relation between control 11 and risk 7, whereas there is a negative relation between control 9 and risk 7.

**Table 10. Risk of 'Lack of Senior Management Commitment to the Project' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| 0.039 | -0.327 | 0.030 | 17.059 | C09 |
| - | 0.135 | 0.003 | 16.131 | C10 |
| 0.001 | 0.686 | 0.015 | 18.935 | C11 |
| - | -0.097 | 0.008 | 20.834 | C14 |

Table 11 shows that the significant value is less than the assumption value at α = 0.05 level of significance, so controls 5, 7, 11, 13, 15, 16, 17, and 18 have an impact on risk 9 with chi-square, and there is a positive relation among controls 7, 11, 13, 16, 17, and 18 and risk 8.

**Table 11. Risk of 'Lack of Effective Project Management Methodology' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| - | 0.236 | 0.002 | 23.880 | C05 |
| 0.000 | 0.555 | 0.046 | 15.780 | C07 |
| 0.000 | 0.601 | 0.007 | 20.972 | C11 |
| 0.001 | 0.488 | 0.005 | 22.050 | C13 |
| - | 0.199 | 0.041 | 16.082 | C15 |
| 0.003 | 0.457 | 0.011 | 19.16 | C16 |
| 0.001 | 0.489 | 0.000 | 36.356 | C17 |
| 0.006 | 0.427 | 0.018 | 18.532 | C18 |

Table 12 shows that the significant value is less than the assumption value at the α = 0.05 level of significance, so controls 8, 10, 11, 15, 16, and 17 have an impact on risk 10 with chi-square, and there is a positive relation among controls 10, 15, 16, and 17 and risk 9.

**Table 12. Risk of 'Developer Gold Plating' Compared to Controls**

| *Sig.* | *Spearman Correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| - | -0.198 | 0.016 | 18.864 | C08 |
| 0.000 | 0.553 | 0.011 | 12.992 | C10 |
| - | 0.267 | 0.007 | 21.144 | C11 |
| 0.000 | 0.565 | 0.000 | 35.147 | C15 |
| 0.019 | 0.370 | 0.000 | 36.5 | C16 |
| 0.019 | 0.368 | 0.036 | 16.468 | C17 |

Table 13 shows that the significant value is less than the assumption value at $\alpha = 0.05$ level of significance, so controls 12, 15, and 16 have an impact on risk 10 with chi-square.

**Table 13. Risk of 'Continuous Requirement Changes' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| - | -0.202 | 0.008 | 20.584 | C12 |
| - | -0.221 | 0.026 | 17.454 | C15 |
| - | 0.146 | 0.017 | 18.672 | C16 |

Table 14 shows that the significant value is less than the assumption value at $\alpha = 0.05$ level of significance, so controls 1, 3, 9, 12, 13, 14, 16, and 18 have an impact on risk 15 with chi-square, and there is a positive relation among controls 1, 9, 13, 14, 16, and 18 and risk 11.

**Table 14. Risk of 'Introduction of New Technology' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| 0.019 | 0.370 | 0.018 | 11.863 | C01 |
| - | -0.283 | 0.033 | 10.508 | C03 |
| 0.015 | 0.380 | 0.004 | 15.192 | C09 |
| - | 0.280 | 0.045 | 9.759 | C12 |
| 0.000 | 0.542 | 0.008 | 13.813 | C13 |
| 0.000 | 0.602 | 0.000 | 21.970 | C14 |
| 0.021 | 0.363 | 0.011 | 13.047 | C16 |
| 0.001 | 0.514 | 0.001 | 18.519 | C18 |

Table 15 shows that the significant value is less than the assumption value at α = 0.05 level of significance, so controls 1, 3, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18 have an impact on risk 16 with chi-square and there is a positive relation among controls 1, 5, 8, 10, 12, 13, 14, 15, 16, 17, and 18 and risk 12.

**Table 15. Risk of 'Failure to Utilize a Phased Delivery approach' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| *0.004* | *0.444* | *0.000* | *31.1* | C01 |
| - | -0.053 | 0.022 | 17.863 | C03 |
| 0.000 | 0.570 | 0.001 | 26.243 | C05 |
| 0.002 | 0.484 | 0.004 | 22.857 | C08 |
| - | -0.068 | 0.005 | 21.974 | C09 |
| 0.000 | 0.540 | 0.006 | 14.495 | C10 |
| - | 0.040 | 0.020 | 18.218 | C11 |
| 0.000 | 0.583 | 0.002 | 25.079 | C12 |
| 0.027 | 0.351 | 0.005 | 22.208 | C13 |
| 0.000 | 0.621 | 0.001 | 27.053 | C14 |
| 0.041 | 0.325 | 0.002 | 24.369 | C15 |
| 0.028 | 0.347 | 0.034 | 16.673 | C16 |
| 0.002 | 0.477 | 0.026 | 17.430 | C17 |
| 0.000 | 0.645 | 0.003 | 22.981 | C18 |

Table 16 shows that the significant value is less than the assumption value at α = 0.05 level of significance, so controls 1, 5, 7, 10, 12, and 13 have an impact on risk 17 with chi-square and there is a positive relation among controls 5, 10, and 13 and risk 17, whereas there is a negative relation between control 7 and risk 13.

**Table 16. Risk of 'Inadequate Technical leadership' compared to controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| - | 0.069 | 0.028 | 17.219 | C01 |
| 0.000 | 0.554 | 0.038 | 16.326 | C05 |
| 0.034 | -0.336 | 0.000 | 29.623 | C07 |
| 0.012 | 0.394 | 0.005 | 14.913 | C10 |
| - | -0.133 | 0.025 | 17.568 | C12 |
| 0.000 | 0.567 | 0.015 | 19.047 | C13 |

Table 17 shows that the significant value is less than the assumption value at α = 0.05 level of significance, so controls 1, 7, 8, 9, 13, 17, and 18 have an impact on risk 18 with chi-square and, there is a positive relation among controls 1, 7, 8, 9, 13, 17, and 18 and risk 14.

**Table 17. Risk of 'Harmful Competitive Actions' Compared to Controls**

| *Sig.* | *Spearman correlation* | *Sig.* | *Chi- square value* | |
|---|---|---|---|---|
| 0.005 | 0.438 | 0.004 | 15.485 | C01 |
| 0.001 | 0.516 | 0.007 | 14.183 | C07 |
| 0.000 | 0.547 | 0.010 | 13.372 | C08 |
| 0.000 | 0.587 | 0.006 | 14.418 | C09 |
| 0.000 | 0.565 | 0.000 | 22.796 | C13 |
| 0.014 | 0.385 | 0.029 | 10.830 | C17 |
| 0.007 | 0.417 | 0.010 | 13.232 | C18 |

## Impact Matrix

The proposed model introduced in this paper depends on the impact matrix that represents the independent variables and the relations between controls and risks. Table 18 shows five states of relations between controls and risks: the first state (+), means that a relation is positive, such as control 7 (C7) effects positively on risk 1 (R1); the second state (-), means that a relation is negative, such as control 5 (C5) effects negatively on risk 2 (R2); the third state blank ( ), means that a relation is blank, such as control 1 (C1) does not effect risk 10 (R10); finally the state is (*), means that the control has effect on risk only without clearing the nature of relation (positive or negative or other), such as control 14 (C14) effects risk 7 (R7) without any direct impact (positive or negative or other).

## Conclusion

This paper presented a new technique to study the impact of different control factors and different risk factors on software project success or failure. Eleven of the fourteen risk factors were mitigated or reduced by the use of controls; thus, all controls impact risks 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14, expect control 3 and control 4. The impact matrix has illustrated the impact of the controls on the risk, and it has, also, illustrated the negative and the positive effect of any controls on the risk. Five of the controls used mitigated six or more risk factors. In future work, we intend to apply the results of this study to a real-world software project to verify the effectiveness of the new approach on software project success.

**Table 18. Impact Matrix**

| Risk Factors | Cnotrol Factors: C1 | | C2 | | C3 | | C4 | | C5 | | C6 | | C7 | | C8 | | C9 | | C10 | | C11 | | C12 | | C13 | | C14 | | C15 | | C16 | | C17 | | C18 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R | $\chi^2$ | R |
| R1 | | | | | | | | | | | | | † | + | | | | | | | | | | | | | | | | | | | | | | |
| R2 | † | + | | | | | | | † | - | | | † | + | | | | | | | | | | | † | | | | | | | | | | † | |
| R3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R4 | | | | | | | | | | | | | | | | | † | | | | | | | | | | | | | | | | | | † | - |
| R5 | † | | | | | | | | | | | | † | + | | | | | | | | | | | † | + | | | † | + | | | | | | |
| R6 | † | + | | | | | | | | | | | | | | | † | + | † | + | † | | † | + | † | | | | | | † | + | † | + | † | + |
| R7 | | | | | | | | | | | | | | | | | † | - | † | | † | + | | | | | † | | | | | | | | | |
| R8 | | | | | | | | | † | | | | † | + | | | | | | | † | + | | | † | + | | | † | | † | + | † | + | † | + |
| R9 | | | | | | | | | | | | | | | † | | | | † | + | † | | | | | | | | † | + | † | + | † | + | | |
| R10 | | | | | | | | | | | | | | | | | | | | | | | † | | | | | | † | | † | | | | | |
| R11 | † | + | | | † | | | | | | | | | | | | † | + | | | | | † | | † | + | † | + | | | † | + | | | † | + |
| R12 | † | + | | | † | | | | † | + | | | | | † | + | † | | † | + | † | | † | + | † | + | † | + | † | + | † | + | † | + | † | + |
| R13 | † | | | | | | | | † | + | | | † | - | | | | | † | + | | | † | | † | - | | | | | | | | | | |
| R14 | † | + | | | | | | | | | | | † | + | † | + | † | + | | | | | | | † | + | | | | | | | † | + | † | + |

## References


Flinn, S., & Stoyles, S. (2004). Human factors: Omnivore: risk management through bidirectional transparency. *Proceedings of the 2004 workshop on new security paradigms*, (pp. 97- 104).

Freimut, B., Hartkopf, S., Kaiser, P., Kontio, J., &Kobitzsch, W. (2001). An Industrial Case Study of Implementing Software Risk Management. *Communications of the ACM*, (pp. 277-286).

McNair, P. (2001). Controlling risk. *Communications of the ACM.* http://www.acm.org/ubiquity/views/p_mcnair_1.html.

Padayachee, K. (2002). An interpretive study of software risk management perspectives. *Proceedings of SAICSIT,* (pp. 118 –127).

Schawlbe K. (2006). Information technology project management, Thomson.

Taylor, H. (2005). The move to outsourced IT projects: Key risks from the provider perspective. *Communications of the ACM,* (pp. 149-154).

Teo, L., Ahn, G., & Zheng, Y. (2003). Dynamic access control: dynamic and risk-aware network access management. *Proceedings of the 8th ACM Symposium on Access Control Models and Technologies (SACMAT03),* ACM, June 2003, (pp.217-230).

Tom, A. , Seema, V. (2002). Controlling Software Project Risks. *Proceedings of SAICSIT 2002*, (pp. 128–140.)

Truta, T., Fotouhi, F., &Barth-Jones, D. (2003). Assessing global disclosure risk in masked Microdata. *Communications of the ACM*, (pp. 85-91).

Vaidyanathan, G. &Devaraj, S. (2003). A five-factor framework for analyzing online risks in e-businesses. Communications of the ACM, (pp. 354-360).

Wallace, L., & Keil, M. (2004). Software project risks and their effect on outcomes. *Communications of the ACM,* (pp. 68-73).