Risk Management in the Construction Phase of Building Projects in Taiwan

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Abstract

Project risk issues have seldom been addressed from the perspective of jobsite engineers. This study presents a novel approach for collecting risk management data in order to understand the realities of risk management in Taiwan. In this study, accumulation contributing ratio of risk and distance of controllability are utilized as the two proposed criteria to extract the consensus critical risks of practitioners. The data are analyzed from multiple points of view to explore the co-relationship among risk cause, risk strategy, risk result and project stage, and to clarify the risk mechanism and the realities of risk management. This analysis found that the risk is highest in the structure construction and finish work stages, and that schedule postpones and negotiation risk strategies are widely adopted by project managers in Taiwan for all risk results. Conclusions also included that contractors worries about the risk causes concerning natural phenomenon, and contract-related issues at the pre-construction stage which lead to schedule delay and cost overrun risk results.

Keywords: risk management; risk cause; risk strategy; project stage; risk result

1. Introduction

Many studies in risk management focused on management process (Akintoye and Macleod 1997; Isaac 1995; PMI 2004; Yeo 1995; Williams 1994; Ward 1999; Zhi 1995), contract relation (Baker et al. 1999; Hartman et al. 1997; Kangari 1995; Simon et al. 1996; Saito 1997; Sawada 2000) and risk analysis (Chapman 1998; Gong 1995; Ren 1994) in the past decade. Management process studies generally focus on developing reasonable processes for a risk management body of knowledge. PMI Standards Committee (2004) gathered and linked various management processes, and explained the required details in each process for producing rational results (PMI 2004). Chapman (1997) presented the six Ws for describing the risk in each management process. Many similar studies have attempted to analyze the questionnaire data to determine the merit and weakness of project risk management processes (Akintoye and Macleod 1997; Isaac 1995; Kangari 1995; Williams 1994; Ward 1999; Zhi 1995), including definition, focus, identification, structuring, ownership, estimation, evaluation, planning and management.

Studies of contract relationships typically concentrate on the allocation of responsibility among stakeholders in the contract to establish a reasonable relationship between them. Saito (1997) compared British, U.S. and Japanese procurement systems, and recommended establishing a new Japanese construction contract based on the concept of risk management, specifically to clarify the ambiguous responsibility allocation in the design-build procurement system frequently adopted in the Japanese construction industry. Sawada (2000) analyzed governmental construction contracts in Japan, and recommended that the Japanese government revise the scope of work in the contract, introduce third-party inspection and set up a contingency fee to clarify the risk allocation of stakeholders in public projects. Several other studies also attempted to explore proper application of risk strategies in the contract relationship for various project delivery systems (Hartman et al. 1997; Kangari 1995; Saito 1997).

Risk analysis studies have normally concentrated on developing a quantitative model and simulating risk results to forecast project schedule delay and cost overrun. Ren (1994) assessed the risk relationship between risk lifecycle and separate project risks to analyze the financial risks. Gong (1995) enhanced the PERT/PCM project scheduling technique by applying time-disturbance analysis to lower the prediction uncertainty caused by disregarding the effect of non-critical activities on project-duration estimation. Other
studies have attempted to develop more powerful and precise analysis methods to support user decisions (Ren 1994; Gong 1995).

Most works in management processes and contract relations have analyzed project risks qualitatively without specifying the entity and risk results. The main contribution of these studies has been to establish a risk management body of knowledge for all project stakeholders. Studies in risk analysis have concentrated on the quantitative analysis of activities concerning the client or contractor. The main objective of such studies is to determine each entity’s crucial activities, and to measure the probability of deviation between planning and consequence. Nevertheless, very few studies have discussed issues relating to project risk from the jobsite engineers’ point of view (Tsai et al. 2001a). Particularly in Taiwan, most risk management studies focus only on relationships between stakeholders and allocations of responsibility, and are merely qualitative discussions (Charoenngam and Yeh 1999; Wang and Chou 2003). When a project is run under the uncertainty of the construction environment, managing diverse situations from jobsite, which may lead to difficulties such as schedule delay and cost overrun, makes complexity of project delivery. As risk management in Taiwan is generally processed empirically at a jobsite, a theoretical algorithm is needed to analyze the reality of risk management by setting up risk strategies and quantitatively clarifying risks in the construction phase for jobsite risk management.

In order to improve the deficiency of risk management in Taiwan, there are two main purposes of this study. The first one is to present a new approach for collecting risk management data. The second one is to explore the co-relationship among risk cause, risk strategy, risk result and project stage, and to clarify the risk mechanism and the realities of risk management of building projects in Taiwan.

2. Investigation

Based on experience of helping project managers apply risk management methods, Isaac (1995) recommended using lengthier, but more specific descriptions, instead of short and abstract descriptions, making the likelihood and impact of risk easier to estimate.

This investigation adopted risk causes and categories from Tsai et al. (2001b), who brainstormed with 40 project managers to yield 650 clearly defined risk causes. The 105 risk categories (see Table 1.) and 247 risk causes are classified in abstraction description based on these 650 risk causes.

The quantitative and qualitative data relating to the 247 risk causes were gathered from 22 site managers in Taiwan with a questionnaire survey. Accumulation contributing ratio of risk and distance of controllability were utilized to extract the consensus critical risks of practitioners.

To understand the roots of project uncertainty, Chapman (1997) recommended addressing "the six Ws", i.e. the "who", "why", "what", "whichway", "wherewithal" and "when", for a project risk. The questionnaire survey applied "the six Ws" to gather the quantitative and qualitative data of the 247 risk causes from 22 building projects in the central region of Taiwan. These data were analyzed to search for co-relationships among risk causes, risk strategies, project stages and risk results.

The terms employed in the questionnaire are as follows.

1) Project risk: the exposure to the chance of occurrences of events adversely affecting project objectives as a consequence of uncertainty.

2) Risk cause: the underlying cause of risk result, categorized as "Safety problem", "Schedule delay", "Cost overrun", "Quality deficiency" and "Poor reputation".

3) Project stage: the construction phase was divided into four stages, "Pre-construction", "Structure work", "Finish work" and "Provisional acceptance".

4) Risk strategy: the risk strategies in the construction phase were classified as "Contingency fee", "Schedule postpone", "Negotiation", "Human resource" and "Contract-out".

5) Risk result: the result of the project risk, categorized as "Safety problems", "Schedule delay", "Cost overrun", "Quality deficiency" and "Poor reputation".

The questionnaires of this survey for gathering the basic data for 247 risk causes were processed and sent to 30 site managers, with 10–15 years experience of building construction, in the central region of Taiwan from August to September 2004. Twenty-two effective samples were received, with responses provided regarding the six basic descriptions of controllability, probability, impact, project stage, risk strategy, and risk result with occurrence for each individual risk cause.

2.1 Consideration of Quantitative Analysis

To select the important risk causes, the two-dimensional evaluation method is introduced to determine the risk cause. In the two-dimensional approach as depicted in Eq. (1), the value of "Risk" is determined as "Probability times Impact". Therefore, the farther the risk cause is from the cross-point of the two axes, the more critical the risk is for the project.

The probability in this investigation was determined using the relative frequency of problems occurring based on the experience of the respondents. The impact measures the weight of influence given to the project when the problem occurs.

\[
R_i = P_i \times I_i
\]

where

- \( R_i \): risk value of risk cause \( i \)
- \( P_i \): average probability of risk cause \( i \), \( 0 \leq P_i \leq 1 \)
- \( I_i \): average impact of risk cause \( i \), \( 0 \leq I_i \leq 1 \)
In this study, respondents have to answer the probability and impact of risk cause \(i\). The value of the probability and impact would be 0-1 to describe the result of risk causes occurrence. The probability and impact of risk causes always disruption with manager’s own experience and expertise. In order to gather a consensus, authors considered difference in different projects, used average probability to describe the occurrence of risk cause, to be the risk attributes. Therefore, this study calculated the average probability and impact values based on the answers of 22 respondents, but did not determine these values for individual projects. Furthermore, the analytical results were verified for every risk cause from the viewpoints of controllability, project stage, risk strategy and risk result.

3. Analysis

In this study, the collected data was analyzed with the five viewpoints to be stated below.

3.1 Two-Dimensional Evaluation using Pareto Diagram

To exclude the risk causes that did not significantly affect a project, the \(R_i\) values of risk causes obtained by Eq. (1) were arranged in descending order with Pareto analysis. As illustrated in Fig.1., the contributing ratio \((C_i)\) was measured in the ratio of \(R_i\) as an individual risk cause to the accumulation \(R_i\) as the entire risk causes by Eq. (2). The accumulation contributing ratio \((C_i)\), which is the ratio of the accumulation \(R_i\) in the descending order to the risk cause \(i\) and to the accumulation \(R_i\) of the entire causes, was obtained by Eq. (3).

\[
c_i = \frac{R_i}{\sum_{i=1}^{n} R_i}
\]

(2)

\[
c_i = \frac{\sum_{i=1}^{n} R_i}{\sum_{k=1}^{n} R_k}
\]

(3)

By Pareto diagram, an accumulation contributing ratio of 0.8 was taken as a maximum threshold, making a total of about 164 risk causes extracted from 247 risk causes. The risk causes concerning construction practice have the highest \(R_i\) values. These risk causes include, "Ha602. Workers not using safety belt and protective equipment” and

Table 1. Risk Categories (Tsai et al. 2001b)

| A. Natural phenomenon | B. Economic/Finance | C. Contract | C. Team/Human | G. Jobsite | Hc. Consultant (Designer) |
|-----------------------|--------------------|------------|--------------|----------|--------------------------|
| 1.A1-Earthquake       | 9.B1-Increased wages | 20.C1-Unequal contractual provisions | 57.F6-Faulty job field survey | 72.Gb5-Excessive demands from competition |
| 2.A2-Landslides       | 10.B2-Increased materials cost | 21.C2-Ambiguous provisions | 58.F7-Inadequate construction planning |
| 3.A3-Land settlement  | 11.B3-Exchange rate fluctuation | 22.C3-Terms not transparent | 59.F8-Inadequate procurement planning |
| 4.A4-Fire             | 12.B4-Higher tax & duty | 23.C4-Dispute among entities | 60.F9-Inadeq. coordination/related entity |
| 5.A5-Torrential rain  | 13.B5-Economic inflation | 24.C5-Unjust arbitrator | 61.Ga1-Incompetence in planning |
| 6.A6-Hurricane        | 14.B6-Economic deflation | 25.C6-Contractual content change | 62.Ga2-Inadequate construction planning |
| 7.A7-High gale        | 15.B7-Fluctuating interest rate | 26.C7-Insufficient insurance coverage | 63.Ga3-Incompetence in management |
| 8.A8-Rainfall         | 16.B8-Difficulty of financing | 27.C8-Defect warranty | 64.Ga4-Inadequate manpower |
|                      | 17.B9-Low market demand | 28.C9-Misjudged cost estimation | 65.Ga5-Faulty human resource allocation |
|                      | 18.B10-Strong Competitor | 29.D1-Change of laws | 66.Ga6-Frequent personnel mobility |
|                      | 19.B11-Plunge of land price | 30.D2-War/revolution/riot | 67.Ga7-Lack of the sense of responsibility |
|                      | 31.D3-Unstable policy | 32.D4-Recognition that takes time | 68.Gb1-Harsh working condition |
|                      | 33.D5-Connection-oriented society | 34.D6-Disagree restrictions | 69.Gb2-Deficit contracting |
|                      | 35.D7-Bribery/corruption | 36.D8-Strict equip./material restriction | 70.Gb3-Short lead-time |
|                      | 37.D9-Trade restrictions | 38.D10-Language barrier | 71.Gb4-ISO compliance |
|                      | 39.D11-State/private ownership mechanism | 40.D12-Rigid bureaucracy | 72.Gb5-Excessive demands from competition |
|                      | 41.D13.Lobby (legal/illegal) | 42.E1-Environment damage/pollution | 43.E2-Waste Disposal |
|                      | 44.E3-Burried cultural heritage | 45.E4-Accident-related loss | 46.E5-Difficult traffic to jobsite |
|                      | 47.E6-Restiction on work hour | 48.E7-Nearby subway/railway concern | 49.E8-Third party's objection |
|                      | 50.E9-Neighbours' complaints | 51.E10.Unpredictable underground conditions | 52.F1-Special ways of engineering |
|                      | 53.F2-New technology implementation | 54.F3-Too high quality standard | 55.F4-New materials |
|                      | 56.F5-Experimental difficulty | 57.F6-Faulty job field survey | 58.F7-Inadequate construction planning |
|                      | 59.F8-Inadequate procurement planning | 60.F9-Inadeq. coordination/related entity | 61.Ga1-Incompetence in planning |
|                      | 62.Ga2-Inadequate construction planning | 63.Ga3-Incompetence in management | 64.Ga4-Inadequate manpower |
|                      | 65.Ga5-Faulty human resource allocation | 66.Ga6-Frequent personnel mobility | 67.Ga7-Lack of the sense of responsibility |
|                      | 68.Gb1-Harsh working condition | 69.Gb2-Deficit contracting | 70.Gb3-Short lead-time |
|                      | 71.Gb4-ISO compliance | 72.Gb5-Excessive demands from competition | 73.Gc1-Monopolized bidding |
|                      | 74.Gc2-Labor Union | 75.Gc3-Patient-related dispute | 76.Gc4-Inappropriate competition |
|                      | 77.Ha1-Lack of technical workers | 78.Ha2-Low job quality | 79.Ha3-Low working morale |
|                      | 80.Ha4-Drawing incomprehension | 81.Ha5-Communication problem | 82.Ha6-Low safety awareness |
|                      | 83.Hb1-Financial problem/Bankruptcy | 84.Hb2-Local jobsite particularity | 85.Hb3-Incompetent technical skills |
|                      | 86.Hb4-Coordination among subcontractors | 87.Hb5-Multi-tasking | 88.Hb6-Lack of mobilization |
|                      | 89.Hc1-Constructability | 90.Hc2-Vague drawing specification | 91.Hc3-Complete construction scope |
|                      | 92.Hc4-Incompetent supervision skills | 93.Hc5-Frequent design change | 94.Hc6-Fair stance |
|                      | 95.Hc7-Incompetent jobsite personnel | 96.Hc8-Two slow decision making | 97.Hd1-Feasibility study |
|                      | 98.Hd2-Unreasonable demand | 99.Hd3-Reference by subcontractors | 100.Hd4-Late payment |
|                      | 101.Hd5-Coordination through governmental agents or neighbour nearby | 102.Hd6-Trust in consultant | 103.Hd7-Ability of jobsite personnel |
|                      | 104.Hd8-Financial problem/Bankruptcy | 105.Hd9-Defect warranty/maintenance | 106.Hf1-Defect warranty/maintenance |

To exclude the risk causes that did not significantly affect a project, the \(R_i\) values of risk causes obtained by Eq. (1) were arranged in descending order with Pareto diagram, an accumulation contributing ratio of 0.8 was taken as a maximum threshold, making a total of about 164 risk causes extracted from 247 risk causes. The risk causes concerning construction practice have the highest \(R_i\) values. These risk causes include, "Ha602. Workers not using safety belt and protective equipment” and...
"Hc501. Too many engineering change and too slow instruction fail project amount to be confirmed" of "H. Partners", "C101. Contract schedule is too short" of "C. Contract", "E105. Pollution on the roads" of "E. Safety/Environment", "Gb201. Subcontract is issued by improper tendering" and "Gc101. Usually collusive tendering" of "G. Team/Human".

Conversely, this method excluded risk causes that arise only or mostly in special projects. Such risk causes include "E802. Illegal party in the nearby of jobsite", "Ga303. No way to collect the information about project" and "D11. Regulation of nationalization/privatisation".

3.2 Distance of controllability

The degrees of uncertainty and the resulting risk are not wholly exogenous. They are relative to the ability of the manager to frame and resolve complex problems (Yeo 1995). As controllability of risk cause at the jobsite is a subjective judgment by the personal experience or preference of the site manager, risk causes with big difference in the evaluations of respondents and without a constant consensus need to be excluded. The distance $D_i$ of controllability of a risk cause was introduced and evaluated by Eq. (4). This results of this analysis extracted about 40% of the risk causes, the risk causes with distances over 0.2, indicating a large amount of disagreement existing over the judgments by the project managers. As shown in Fig.3., the distance of "F802. Wrong material" of "F. Construction" is 0.11. By contrast, the distance of "E504. Rush-hour large vehicle traffic restriction" of "E Safety/Environment" is 0.74, while the distance of "Hc205. Design being out-of-spec; different specification interpretation" of "H. Partners" is around 0.2.

The risk causes that contractor should face everyday usually have a constant consensus, as indicated in "F707. Inappropriate construction sequence by insufficient considerations", "F712. Lift equipment is chosen wrongly" and "F803. Timing of issuing subcontract is wrong" of "F Construction".

$$D_i = \sqrt{(P_i - P_{i2})^2 + (I_i - I_{i2})^2} < 0.2$$

where $P_i$: average probability of risk cause $i$ in "controllable" $P_{i2}$: average probability of risk cause $i$ in "uncontrollable" $I_i$: average impact of risk cause $i$ in "controllable" $I_{i2}$: average impact of risk cause $i$ in "uncontrollable"

In order to gather high consensus and strong effect on the project, considered difference in the controllability of risk cause was existed but the probability and impact of risk cause should not be disruption with controllable and uncontrollable. The distance $D_i$ of controllability of a risk cause was introduced and evaluated by Equation (4). In this study, the threshold value was set 0.2; the risk causes with distances of controllability over 0.2 (indicating a large disagreement among the project managers over the judgment) were excluded, that would be 40% risk causes or 97 risk causes in 247 risk causes. As shown in Fig.3., a comparison of the distribution of these 97 risk causes with the distribution of all 247 risk causes indicates that the average probability and the average impact concentrate on [0.2, 0.6] for 97 risk causes regarded as "controllable" and "uncontrollable", rather than the distribution being scattered from 0 to 1 for all 247 risk causes. Therefore, reliable answers can be extracted from subjective data of investigation using the "accumulation contributing ratio" and "distance" approaches simultaneously.

4. Risk Strategy and Risk Result

The 97 risk causes were analyzed from the viewpoints of risk strategy and risk result to clarify the current state of risk management. The relationship between risk strategies and risk results can be addressed as the site managers should consider certain risk strategies to avoid a risk result from the occurrence of particular risk cause.
Fig. 4. illustrates the relationship between risk strategy and risk result as measured from respondents' answers. The figure shows that the "Schedule postpone" and "Negotiation" risk strategies are widely adopted for all risk results. These results are very different from those of risk management in Japanese construction companies. As a convention in business in Japan, a company's reputation and its future business with clients depend on projects being completed on schedule. The "Schedule postpone" risk strategies is rarely adopted because of the fundamental requirement of keeping the contracts strictly on schedule in Japan (Tsai et al. 2001b). However, due to the lacks of contractual documentation and the significance of human relations, contractors in Taiwan opt for risk strategies of "Schedule postpone" and "Negotiation", causing managers to lose control of projects. This finding helps explain why most construction companies take a passive attitude to adopting the risk strategy of "Using human resources" to improve knowledge and ability in their risk management. However, since all project risks can be reflected on the cost in a certain degree (Isaac 1995), most risk causes are linked to the risk result of "Cost overrun". The risk strategies of "Negotiation" and "Contract out" are usually applied for uncontrollable risk causes, while the risk strategies of "Using human resources" and "Negotiation" are applied for controllable risk causes.

4.1 Risk of Project Stage

From the viewpoint of project risk changing in time, the risk in project stage can be measured by Eq. (6) and the risk ranking \( R_{ij} \) of each risk cause appearing at a given stage of the project was evaluated by Eq. (5). According to Fig. 5., most activities relate to construction, and the risk is highest in the "Structure construction" and "Finish work" stages. The risk evaluation is also reflected on the conditions of the client, designer, subcontractors and jobsite, while the risk is less clear in the "Pre-construction" stage than in the "Provisional acceptance" stage.

\[
R_{ij} = P_i \times I_i \times N_j \\
\sum_{i=1}^{N_i} R_i \\
N_j \\
r_j
\]

where

- \( P_i \): average probability of risk cause \( i \)
- \( I_i \): average impact of risk cause \( i \)
- \( R_i \): risk of risk cause \( i \) in stage \( j \)
- \( N_j \): number of respondents for risk cause \( i \) at stage \( j \)
- \( N_i \): number of respondents for risk cause \( i \)
- \( r_j \): risk of project stage \( j \)

4.2 Ranking Analysis

The risk ranking \( R_{ij} \) of each risk cause appearing at a given stage of the project was evaluated by Eq. (5). Table 2. lists the \( R_{ij} \) ranking of risk cause at each of the four project stages, which are defined as "Pre-construction", "Structure work", "Finish work" and "Provisional acceptance". The black mark represents the first 10 of ranking of risk causes at every stage; the dark gray mark represents ranks 11–20; the light gray mark represents ranks 21–30, and the white mark represents risk causes ranking lower than 30. The ranking also indicates the relationship between...
The five risk results are defined as "Safety problem", "Schedule delay", "Cost overrun", "Quality deficiency" and "Poor reputation". The black mark represents the top 10 risk causes for every risk result; the dark gray mark represents ranks 11–20; the light gray mark represents ranks 21 to 30, and the white mark represents ranks below the top 30. The contractor worries about the risk causes concerning "A. Natural phenomenon", "B. Economic/Finance" and "C. Contract" for the "Schedule delay" and "Cost overrun" risk results. The most significant risk cause is "C. Contract" for both the "Schedule delay" and "Cost overrun" risk results. The contractor worries about the risk causes concerning "A. Natural phenomenon", "B. Economic/Finance" and "C. Contract" for the "Schedule delay" and "Cost overrun" risk results. The contractor worries about the risk causes concerning "A. Natural phenomenon", "B. Economic/Finance" and "C. Contract" for the "Schedule delay" and "Cost overrun" risk results. The contractor worries about the risk causes concerning "A. Natural phenomenon", "B. Economic/Finance" and "C. Contract" for the "Schedule delay" and "Cost overrun" risk results

By revising $N_{ij}$ of Eq. (5) as the number of respondents for risk cause $i$ to risk result $j$, the same approach can be applied to evaluate the risk ranking of a risk cause concerning the risk result. Table 3. lists the risk ranking of each risk cause to every risk result.
and "Hd701. Incompetent jobsite supervisors" for "Poor reputation". The analytical results reveal that the project managers of jobsites expect a contract without biases, and that the representatives of the designer and the client have to handle mutual disputes fairly.

5. Conclusions

The fundamental project risk data were examined and analyzed in terms of risk strategy risk result and project stage in this study. Additionally, the realities of risk management in Taiwan were clarified according to the analytical results. Additionally, the ranking of risk causes at each stage and risk result were explored and the most important risk causes extracted for constructing decision-making support systems in the future.

This study achieved the following four aims.
1) The fundamental data concerning the project risk in the construction phase of the building project were collected and analyzed.
2) The important risk causes of project were extracted using two proposed criteria, the accumulation contributing ratio and the distance.

3) Most construction companies lack of contractual documentation and the significance of human relations, contractors in Taiwan, thus were widely adopted the risk strategy of "Schedule postpone" and "Negotiation" risk strategies (as shown in Fig.4.). However, that would cause managers to lose control of projects. Risk ranking of each risk cause appearing at a given stage of the project was shown in Table 2 and 3. The risk categories of the "G. Team/Human" and "H. Partners" of the project was shown in Table 2 and 3. The risk categories were both important at the "Structure work" stage and "Finish work". This finding helps explain why most construction companies take a passive attitude to adopting the risk strategy of "Using human resources" to improve knowledge and ability in their risk management.

The following approaches are suggested for future study:
1) A reliable database recording risk attributes like probability, impact, cost, project phase, risk strategy...
and risk result should be constructed from jobsite surveys of many construction projects.

2) The decision making support system should be based on a reliable database, enabling jobsite engineers to undertake risk management rationally.

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