Delay-based Reliability Analysis on Construction Projects

Shahryar Sorooshian

Faculty of Technology, University Malaysia Pahang, 26300, Malaysia
sorooshian@gmail.com

Abstract: The construction industry has a crucial role in the overall development of any economy; however it has its own drawbacks and difficulties that should be well studied in order to improve the efficiency of this industry. Delays, which are an inseparable part of any project, are an important issue in construction projects that are responsible for huge losses in capital investments and slow-moving progress of this industry. This study tries to investigate delay-based reliability of building construction projects. In order to achieve this goal the related literature is studied and the most common problems in this filed are found. Then, the questionnaire based on the literature and expert's recommendation is designed to analyze operations risk and industry reliability based on the delay sources. A multi-expert approach group decision making analysis of this research ranks the dominance of controllable factor on the project delays. Finally, based on risk value of delay factors, this research verifies the industry reliability.
[Sorooshian S. **Delay-based Reliability Analysis on Construction Projects.** *Life Sci J* 2014;11(3s):104-113]. (ISSN:1097-8135). http://www.lifesciencesite.com. 16

Keywords: Delay factors, Risk assessment value (RAV), Risk priority number (RPN), Construction industry

1. Introduction

The roots of construction industry can be traced back to the times when human beings tried to build their own shelters in the ancient times. The construction industry is regarded as a vivid indicator of the economy conditions in each country. The considerable impact of this industry on the overall health of the economy makes it an interesting and crucial area of interest for researchers, economists, and policy-makers alike. The current research aims to present an analysis on the causes of failure of the construction projects. A construction projects, similar to any other project, is expected to be completed in a certain time that is specified ahead of starting the physical task of the project during the early phases. A construction project involves a considerable amount of funding that goes to staff, machinery and the capital investment therefore any delay in the completion time will result in huge losses. The delays can impact other parties involved in the construction projects. Some of the main effects of delays can be named as time overrun, cost overrun, disputes between different parties, settlements, lawsuits, and total abandonment (Aibinu and Jagboro,2002; Sambasivan ,2007).

Generally, the aim of project Management is to facilitate the projects to reach the predefined goals of with employing knowledge, skills, tools and techniques to achieve project objectives (Saladis and Kerzner, 2011). In order to be able to prevent delays or decrease them, project manager have to discover the main causes of these delays and also find the proper strategies to deal with them and reduce their effects. According to Lindenbaum (2004), the delays of the construction projects can be categorized in three basic groups as follows.

(1) justifiable and unjustifiable
(2) Compensable and non-compensable
(3) Simultaneous

The available literature and studies that have been performed all around the world indicate that the drawbacks associated with financing of the project, clients, contractors and designer firms are among the most important ones. While, some issues and problems that could be problematic in nature including a multicultural environment, multinational work force, involvement of various parties and participants in a project and employing foreigner designers are not considered as significant drawbacks. Most of the above-mentioned issues are consistent with the study of Assaf et al (2006) where it was emphasized that the undesired condition of delay happens because there are constant hindrance in decision makings and owner approvals, setbacks in attaining work permits and lack of synchronization and harmony between different parties of construction projects. Another difficulty in construction projects is that in some case the top-ranked managerial staffs are not committed to the project completely that in turn results in the failure of external environment, actions, human-related and project-related factors (Chan et al, 2004).

It has been extensively reported in the literature and the existing surveys that proper performance of the construction industry is vital for the overall development of the economy. Therefore, it is necessary to establish comprehensive understandings of the causes of delays in this industry in order to be able to empower construction industry to reduce

delays through managing the available sources (Norzima et al, 2011). It could only be achieved when all the crucial factors that are involved in delaying the construction projects could be identified. The parties that are responsible for these causes should also be recognized so that the reasons of delays could be traced in different stages of the project and within any of the involved parties.

The delays in projects are happened as a result of malfunctions in the employed project management strategies. The critical issue of project delays in the construction industry is not limited to a certain economy or country and generally happens in all economies globally. There has been a growing interest among researchers and experts in better understanding of the roots and causes of the failures in construction projects. Moreover, it is essential for the project managers to have a comprehensive understanding of the project setbacks. Beside the famous move through an enlarged employ of project organizational structures and project-based work techniques, there is an associated increased potential for failure and misapplication (Pinto and Mantel, 1990; Abdullah, 2010).

Delay factors are categorized into nine basic groups based on their similarities and differences based on the views of experts. Any given cause of delay in construction projects can put into one of these nine groups that are project-related, client-related, consultant-related, design team-related, contractor related, material, labor, plant/equipment, and external factors. Moreover, the main effects of these delays can be categorized in six groups; Time overrun, Cost overrun, Disputes, Arbitration, Litigation, and total abandonment (Salleh, 2009; Sambasivan, 2007). First objective of this study is mainly focused on identifying the main causes of delays and understanding their effects on the completion time of the whole project, based on risk-based analysis. The other objective of this study is to apply the obtained findings of this research on a real-world construction industry and measure the reliability of these projects.

2. Delay Sources

Though there exist some exceptions, contractors do not fail due to poor construction and most of them provide an acceptable building. That may be mainly because they have to obey the strict and detailed specifications of the designs provided by designers in advance and regular inspections are performed as a routine. Therefore, the questions remains that “if they are not failing because of poor construction, why they fail?“ The main reasons of faulty constructions in project construction are categorized as internal and external causes.

The external causes cannot be controlled by the project teams and are inclusive of unfavorable weather circumstances, unpredictable site situations, the sudden fluctuations of market and radical regulatory changes. The sources of internal causes are happen because of malfunction of any of the parties that have a role in the project that includes the designer, the client, the contractor firm and other parties that provide material, labor or services (Meng, 2007).

Delays are a common practice in all aspects of industry and the building construction is not excluded. This challenge-prone construction industry requires high ability of problem tackling. When construction is considered, delay is described as the additional time that a project takes to completed compared to the original due date that has been set ahead of construction. The delay could be compensated or otherwise.

The sources of delays were tested by Baldwin et al (1971) and it was noticed that the construction projects face huge financial losses when any type of delay occurs. A comprehensive survey was carried out in 2006 by Assaf et al, and the sources of delay in construction industry were systematically investigated. The significance of the impact of these delays was investigated through interviewing various participants from different sections of this industry including 15 owner, 19 consultant and 23 contractors. Seventy sources of delay were identified by the authors (Baldwin,1971; Kumaraswamy and Chan, 1998).

The research by Assaf et al (2006) also introduced seventy sources of delay where they were categorized into nine basic groups. These groups were ranked based on their rate of occurrences, their level of impacts and their significance according to owners, contractors and consultants (Al-Khalil, 1995). The so called different classes of delay sources are as follows:

1. Material- The delays that are material-related are put in this category. The problems could be ranged from material changes, damages, shortages and deliveries to materials malfunction.
2. Labour- lack of labours, unskilled labours, and the race and nationality of the labours;
3. Equipment- Any delay associated with breakdown, malfunction or unavailability of the equipment in addition to the operator-related issues is categorized in this group.
4. Financing- The delays related to the late payments from owners or financial problems of contractors or other parties involved in the project are ranked in this group.
5. Environment-climatic circumstances, social and cultural issues, geological situations;

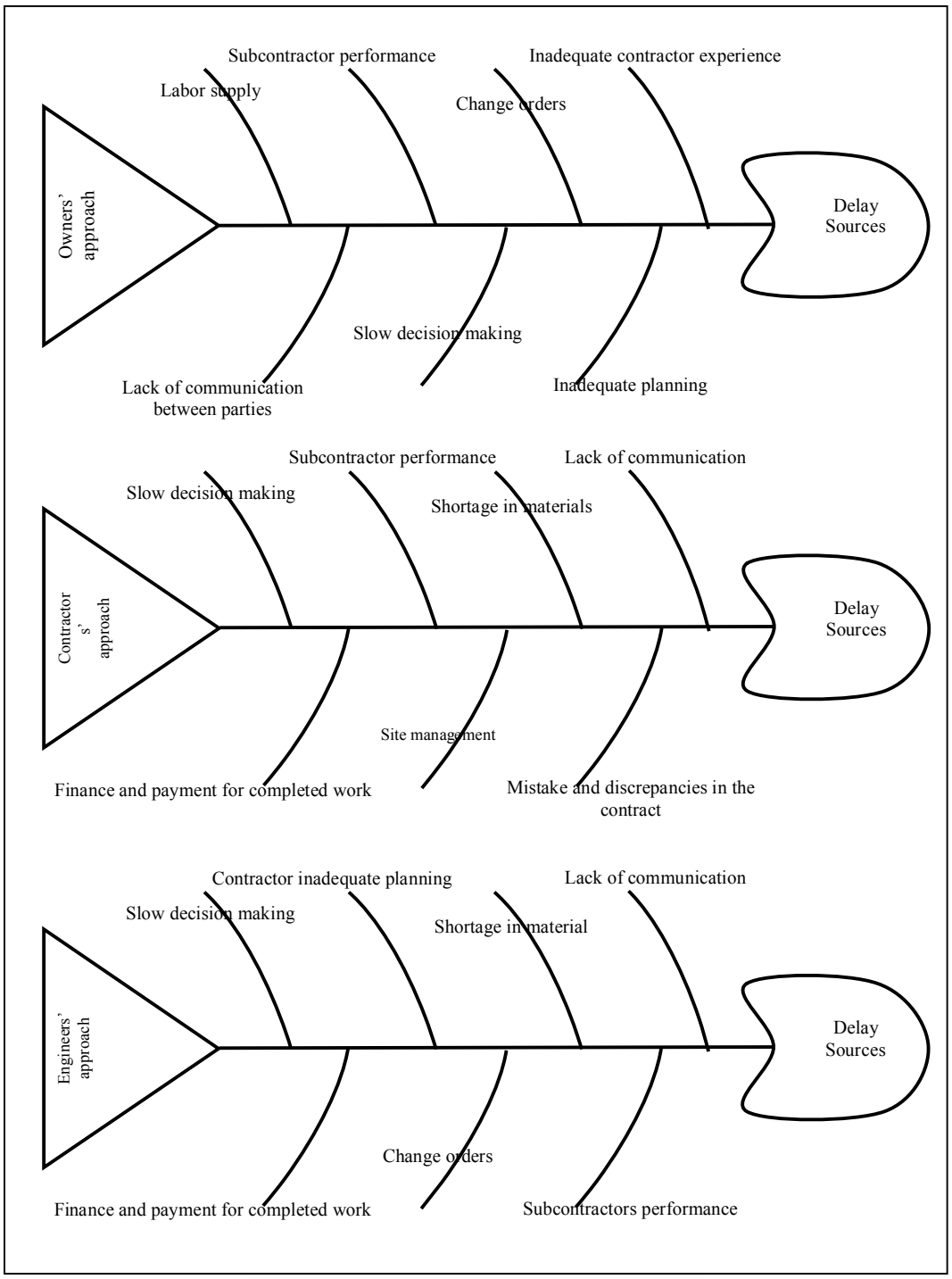

Figure 1. Delay sources of construction projects

6. Order changes- The delays that are associated with any modifications in the project by the owners due to the changes in scopes of the projects or other issues.

7. Government relations-delay related to permits, labour visa requirements, and government bureaucratic procedures;

8. Contractual relationship- The delays that are related to the problems arise from contracts among various parties of the projects lies in this group. The parties have different and sometimes conflicting interests that could cause delays in the project.

9. Scheduling and controlling techniques – poor planning and scheduling practices, lack of

management expertise in project control, and poor record keeping and maintenance.

Some delays in construction projects could be directly related to the level of the mentioned malfunctions that could in turn result in shutting many offices down in the during this period of time, unprepared businesses run the risk of missing the due dates to respond to a validly served payment claim and thereby open themselves to important commercial exposure (During, 2011).

The failure of construction projects are not always the same; then only risk management techniques could be employed to find a possible solution. The above mentioned failures which are explained about a construction building in this study are categorized by owners, engineers, contractors in relation with the most significant factors of delay. Salleh (2006) listed the most significant causes of building construction delays. These causes are as it is shown in figure 1.

3. Material and Methods

This study is going to estimate the Risk Priority Number (RPN) and Risk Assessment Value (RAV) for each of the seven significant identified causes of delay in the industry of building construction.

3.1. Scope of study

A five-floor residential building construction located in Iran is considered as the case study. According to the official reports of the Iranian authorities (the planning and economic department of the Office of Statistics and Information Technology of Iran), the construction of five-floor buildings has seen a greater increase in growth when it is compared to that of four-floor buildings or smaller ones (Affairs ,2010). This is mainly associated with the population boom of the country in the recent years and the critical need for more houses and the lack of land in metropolitan areas. People are willing to destroy their old-fashioned one-floor houses and replace them with more modern five-floor or higher apartments.

In the course of construction project managers, projects engineers, owners, third parties, designers including architects and engineers, and construction project managers are involved all together (Callahan et al, 1992). In addition, a temporary endeavor undertaken is responsible for producing a distinctive project in each construction project (Sambasivan, 2007). The basic project parties are as follows:

1. Owner: the most crucial role belongs to this part since it is responsible for setting the project requirements and the required functions and services. Moreover, owners are in charge of financial support of the project. Owners either pay themselves or attract external findings, governmental or private, for the project.

2. Contractor: The companies or individuals that are assigned with construction tasks through legal agreements are referred to as contractors. This group are responsible to carry out the tasks regarding the various conditions that have been discussed with the owners in advance. The contractors are generally private firms that carry out the construction based on the designs, conditions and specifications given to them by the project teams.

3. Engineer: This is a third part in the construction projects who provides an applicable design for a specific project based on the needs and requirements of the owners while making sure that the project is practical. In some of the construction projects, the designer is also assigned as the supervisor during the course of construction. The project team is generally including a private consultant, which could be a firm or individual, and various governmental departments, usually form the ministry of developments.

Generally the task is performed by a project manager while a construction design engineer, construction engineer or project architecture carries out the task of supervising. Project management strategies that are extensively employed in different types of projects are also utilized in construction projects and therefore construction project management has seen huge improvements in the recent years. All parties involved in this industry including owners, contractors and consultants have a common goal which is to finish a project with the predefined budget in the desired time while maintaining the highest possible quality measures and maintaining safety qualifications at all times for avoiding casualties.

In order to clearly identify the sample population this study investigate building construction projects with five floors that faced delay in order to rank the causes of delays for specified critical delay factors by assessing RPN and RAV for each group, which are relevant to the research in Iran-Shiraz city, are included: owners, engineers and contractors.

3.2. Research tool development and data collection

The list of causes of delay factors which are identified by Salleh (2009). A five-point scale questionnaire based on Salleh (2009) work was developed. A content validity of the data collection tool was test in a pilot survey among 3 owners, 3 contractors and 3 engineers. The primary aim of the pilot survey is to verify the completeness of the survey questionnaire in capturing the factors. The results of pilot survey shows all the respondents believed that the questionnaire is sufficient to capture and rank the causes of delays. Hence, it is not necessary to make any modification on the data

collection tool. To find the causes of failures in construction projects, the collected causes from literature were distributed between research participants and asked them to give the point between 1-5 to Severity (S), Occurrence (O) and Detection (D) of each of these three factors for each cause, the higher number representing the higher seriousness or risk. A random sample from each group selected and needed data gathered by using questioners. It was decided to use a personal administered questionnaire as the data collection instrument, as it produces quick results; and any doubts in the questions could be clarified on the spot. The simple random sampling technique was used in this research. Due to time and cost constraints built into the research, the chance to connect with a large sample was low; therefore, data collection process continued until gathering a minimum number of 30 completed questioners for each groups of respondents. This is assumed enough as a representative of the entire normal population.

3.3. Research analysis method

Risk Priority Number (RPN) is a way to analyze the associated risks with potential problems that are identified during a Failure Mode and Effects Analysis. The three main variant of RPN are severity, occurrence and detection hence, as the following equation (Eq (1)) Shows, RPN is a function of these three variants:

Severity (S) - Severity shows how severe the next user (customer) or end user would perceive the failures effect, and it is a numerical subjective that estimate this factor.

Occurrence (O) – Occurrence is a numerical subject estimate the likelihood of that the cause, this term sometimes also called likelihood instead of occurrence.

Detection (D) - It is a numerical subjective estimate of the effectiveness of the controls to prevent or distinguish the cause or failure mode before the failure reaches the customer. This study assumes that the cause has occurred. Detection is sometimes termed effectiveness.

$$RPN = f(S, O, D) \quad \text{Eq (1)}$$

The amount of RPN is calculated by multiplying three numbers. Following equation (Eq (2)) from operation research shows the RPN formula.

RPN= S*O*D Eq (2)

RPN is one of the main fundamentals of risk management which is widely used. For decays, some researchers tried to modify the RPN term; for example Sankar and his colleague (2001) used RPN and introduced Risk Priority Ranking method that utilized a ranking scale to represent the increasing risk of Severity, occurrence and detection combinations. Also, Wang and his/her colleagues (2009) used 'fuzzy' means to weigh the fuzzy ratings for Severity, occurrence and detection, and introduced Fuzzy Risk Priority Numbers for prioritizing failure modes.

Author followed the latest develops of RPN and found that recently a new term of RAV (risk assessment value) is developed in USA; University of Tennessee (Karthik,2010). RAV is based on the definition of RPN, to study reliability of systems. Karthik and his colleagues (Karthik,2010; Sawhney et al, 2010) have introduced RAV and they define it as "the ratio of the risk profile of lean system failure and the effectiveness of lean to detect and manage the failure.". Karthik et al (2010) explained that "RAV is proposed in order to emphasis the ability to detect and control the failures. As a result RAV emphasizes on designing systems utilizing continuous improvement tools to detect and manage the potential system failures". Compare with RPN, RAV places more emphasis to increase the system's ability to detect and manage failures. It is defined, RAV is a ratio of multiple Severity value and Occurrence value divided by value of Detection (Karthik,2010; Sawhney et al, 2010), as it is shown in Eq (3).

RAV= (S*O)/D Eq (3)

3. Results

The averages of received data from owners are presented in Table 1, which means for each issue the presented number in table is the average of all owners' response. Therefore, the obtained operations research RPN can be referred to all owners.

Table 1. RPN results from owners' point of view

Critical delay factors	Severity(S)	Occurrence(O)	Detection(D)	RPN
Lack of communication between parties	2.63	3.26	2.89	24.85
Slow decision making	2.94	2.63	2.31	17.96
Inadequate planning	2.73	2.52	2.84	19.65
Change orders	2.47	2.57	2.57	16.45
Inadequate contractor experience	3.05	2.47	2.68	20.26
Labor supply	2.47	2.36	2.42	14.18
Subcontractor performance	2.68	2.63	2.63	18.58

As it is shown in Table 1 the most important and critical causes of delay in construction projects is "Lack of communication between parties", with the highest operations RPN (24.85) and the lowest operations RPN is belongs to "Labor supply" which is 14.18.

The average of received data from contractors are presented in Table 2, which means for each issue the presented number in table is the average of all contractors response. Therefore, the obtained operations research RPN can be referred to all contractors.

Table 2. RPN results from contractors' point of view

Critical delay factors	Severity(S)	Occurrence(O)	Detection(D)	RPN
Slow decision making	2.09	2.72	2.63	15.03
Finance and payment for completed work	2.18	2.81	2.90	17.88
Subcontractor performance	2.54	2.90	3.00	22.21
Shortage in materials	2.72	3.18	2.90	25.24
Site management	2.27	2.54	2.36	13.67
Mistake and discrepancies in the contract	3.09	2.90	3.09	27.79
Lack of communication	2.00	2.90	3.27	19.04

Table 2 shows the most important factor in delaying construction projects in contractors' point of view is "Mistake and discrepancies in the contract" with the highest received operations research RPN from contractors (27.79). the second significant causes in this section is "Shortage in materials" with operations research RPN of 25.24 and the lowest operations RPN is 13.67 for "Site management", which means site management in contractors' opinion has the lowest priority to face a project with delay.

The average of received data from engineers are presented in Table 3, which means for each issue the presented number in table is the average of all contractors response. Therefore, the obtained operations RPN can be referred to all owners.

Table 3. RPN results from engineers' point of view

Critical delay factors	Severity(S)	Occurrence(O)	Detection(D)	RPN
Lack of communication	2.46	3.06	2.66	20.17
Slow decision making	2.6	2.73	2.66	18.95
Change orders	2.13	2.53	3.33	18.01
Contractor inadequate planning	1.86	2.66	3.60	17.92
Finance and payment for completed work	1.46	2.66	3.80	14.86
Subcontractors performance	2.26	3.13	3.00	21.30
Shortage in material	2.53	2.53	2.66	17.11

Table 3 shows the most important factor in delaying construction projects in contractors' point of view is "Subcontractors performance" with the highest received operations RPN from engineers (21.30). The second significant causes in this section is "Lack of communication" with operations research RPN of 20.17, and the lowest operations RPN is 14.86 for "Finance and payment for completed work", which means Finance and payment for completed work in engineers' opinion has the lowest priority to face a project with delay.

Based upon mentioned analysis, the most important factors that cause delay in construction projects are: Lack of communication between parties, Mistake and discrepancies in the contract and Subcontractors performance. In the following section the factors that can help to avoid delays are discussed. To conclude RPN analysis of this study are as follows:

1. The most important causes of delay from owners point of view is "lack of communication between different involved parties in project".
2. The third group which are asked for the causes of delay are engineers. Engineers believe that the most important factors which are make the projects facing delay are "Subcontractors performance" and "Lack of communication".
3. From point of view of contractor these causes are "Mistake and discrepancies in the contract" and "Shortage in materials".

Calculated RPN showed a deeper understanding of the construction project's management, but RAV

as a novel term improves the value of our research; and brings more contribution to the body of knowledge. Table 4 presents the data and resulted RAV for engineers approach, owners approach, and contractors approach.

Table 4. Multi-approach RAVs

	Delay sources	RAV
owners' point of view	Lack of communication between parties	2.96
	Slow decision making	3.34
	Inadequate planning	2.42
	Change orders	2.47
	Inadequate contractor experience	2.81
	Labour supply	2.40
	Subcontractor performance	2.68
contractors' point of view	Slow decision making	2.16
	Finance and payment for completed work	2.11
	Subcontractor performance	2.45
	Shortage in materials	2.98
	Site management	2.44
	Mistake and discrepancies in the contract	2.90
	Lack of communication	1.77
engineers' point of view	Lack of communication	2.82
	Slow decision making	2.73
	Change orders	1.61
	Contractor inadequate planning	1.37
	Finance and payment for completed work	1.02
	Subcontractors performance	2.35
	Shortage in material	2.40

RAV analysis presents that the average RAV from owners' approach is 2.72; from contractors' approach is 2.40; and from engineers' approach is 2.04. Minimum possible value for RAV is 0.2 (for severity=1, occurrence =1, and detection=5) and maximum value can be 25 (for severity=5, occurrence=5, and detection=1). Figure 2, 3 and 4 are presenting calculated RPN and RAV from different approaches of this study.

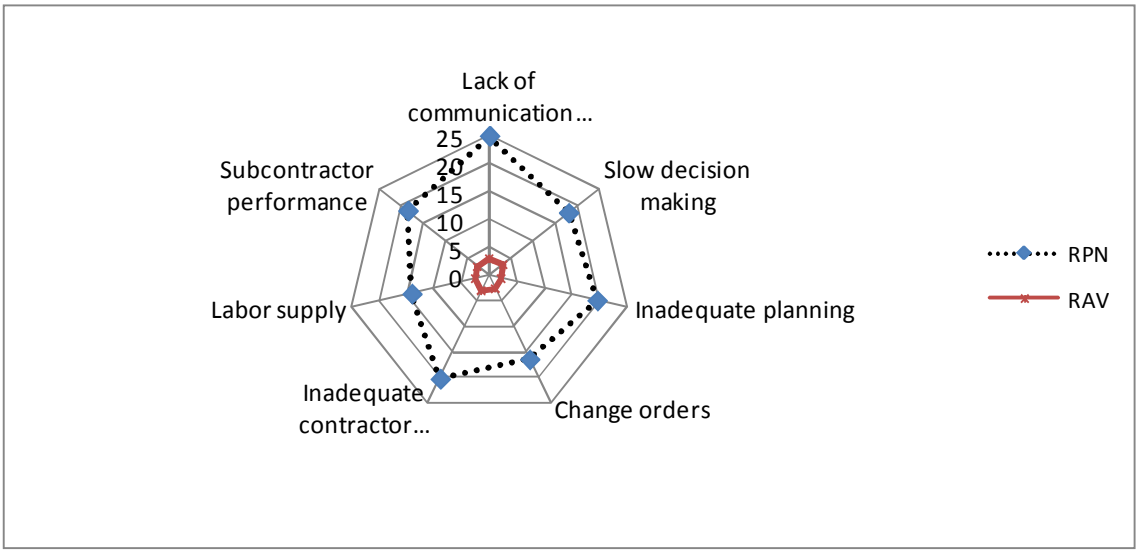

Figure 2. RPN and RAV from owners point of view

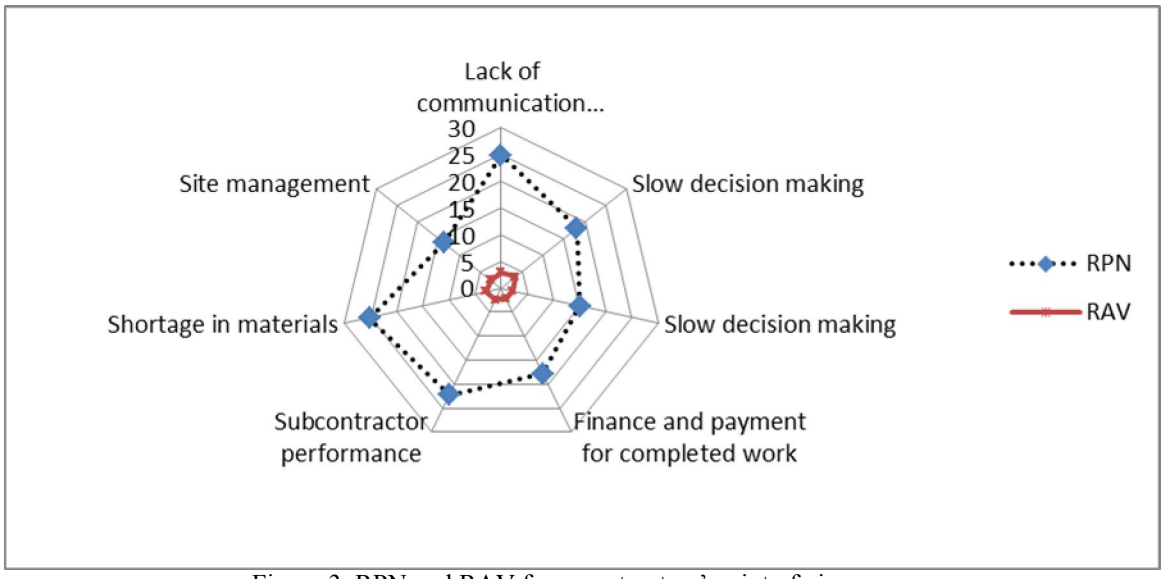

Figure 3. RPN and RAV from contractors' point of view

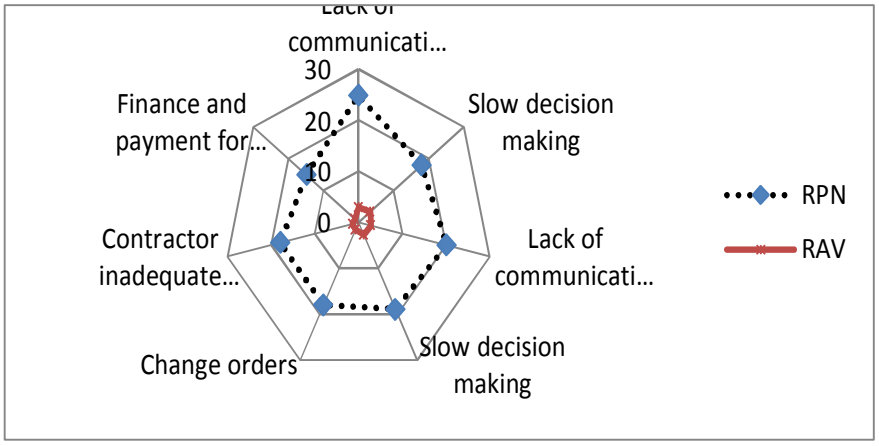

Figure 4. RPN and RAV from engineers' point of view

4. Discussions

This study investigates the improvement factors to avoid delay. The research concluded that all the main parties including owners, engineers and contractors are generally in the same league when it comes to categorizing the delay sources. It is interesting that despite their sometimes conflicting interests, their opinions on the causes of delays are close. The most useful improvement to avoid delays that are achieved in this study are as follows:

- Work Measurement
- Planning and Scheduling
- Supervision

Based on the reviewed literature, this study is one of the first attempts to valid RAV term for industry reliability analysis. The RAV scales is the component of the equation that is not directly, easily, immediately or consistently impacted by lean practitioners. Resulted values prioritize the delay sources based on their ability to be detected and be controlled by the system as Maria discusses (Andersen, 2012). Based on Maria's discussion

(Andersen, 2012) and referring to the resulted RAVs, managers of Iranian construction industry should develop/maintain lean tool(s) to detect and/or control the delay sources, especially those with higher RAV. Any improvements of the listed components are typically a key factor of the system's ability to detect a lean system failure and subsequently design and apply controls that would manage such delays. Generally, RAV greatly aligned with addressing system's reliability (Karthik, 2010; Sawhney et al, 2010). Moderately small numbers of resulted RAVs represent that the reliability of the studied system (Iran construction industry) from all tested approaches, are moderately acceptable.

To conclude, this study takes the conditions in each category that deviate from the ideal and prioritizes them based on the risk to the lean system as explained by severity, occurrence, and detection. Result of this study can be a guideline for advisors and decision makers of contrition projects of Iran; and a benchmark for other countries. The ability to perform similar analysis in a practical manner will enhance the delay risks and the reliability of the construction project's lean system and the probability that the construction industry will sustain. According to the all boundaries and limitations of this research, definitely more studies and researches will be required to fill in all the gaps that in this field of knowledge. This research evaluated and analyzed only causes of delays in building construction projects, future studies and literatures can be done for the other countries or regions to investigate the causes of delays in projects were used in this study. Scholars may use effect analysis approach (Sorooshian et al, 2010) to test findings of this study. It would make sense if further studies discuss how the risk factors will be integrated in schedule analysis; and what would be the effect of common cause failure modes; also to analyze the interrelationship between delay risks.

Acknowledgements:

This study is supported by University Malaysia Pahang research grant (RUD 130375).

Corresponding Author:
Dr. Shahryar Sorooshian
Faculty of technology, University Malaysia Pahang, Malaysia
E-mail: sorooshian@gmail.com

References

1. Aibinu, A. and G. Jagboro, The effects of construction delays on project delivery in Nigerian construction industry. International Journal of Project Management, 2002;20(8): p. 593-599.
2. Sambasivan, M.Y.W., Soon, Causes and effects of delays in Malaysian construction industry. International Journal of Project Management, 2007;25(5): p. 517-526.
3. Saladis, F.P. and H. Kerzner, Bringing the PMBOK guide to life: a companion for the practicing project manager: Wiley;2011.
4. Lindenbaum, W.H. and S.P. No, Time extensions and waiver of liquidated damages; 2004.
5. Assaf, S.A. and S. Al-Hejji, Causes of delay in large construction projects. International Journal of Project Management, 2006;24(4): p. 349-357.
6. Chan, A.P.C., D. Scott, and A.P.L. Chan, Factors affecting the success of a construction project. Journal of Construction Engineering and Management, 2004;130: p. 153.
7. Norzima. Z, Sorooshian. S, Chow K.W, Effective project management, Lambert Academic Publishing, Germany;2011.
8. Pinto, J.K. and S.J. Mantel Jr, The causes of project failure. Engineering Management, IEEE Transactions on, 1990;37(4): p. 269-276.
9. Abdullah, A.A., Literature mapping: A bird's eye view on classification of factors influencing project success. Afr. J. Bus. Manage, 2010;4(19): p. 4174-4182.
10. Salleh, R., Critical success factors of project management for Brunei construction projects: improving project performance;2009.
11. Meng, X., The effect of relationship management on project performance in construction. International Journal of Project Management; 2011.
12. Baldwin, J.R., et al., Causes of delay in the construction industry. Journal of the Construction Engrg. Division, 1971;97(2): p. 177-187.
13. Kumaraswamy, M.M. and D.W.M. Chan, Contributors to construction delays. Construction Management & Economics, 1998;16(1): p. 17-29.
14. Al-Khalil, M. and M. Al-Hazmi, Causes of delay in large building construction projects. Journal of Management in Engineering, 1995;11: p. 45.
15. During, O.F.P.H., Construction and development; 2011.
16. Affairs, D.o.P.a.E., Office of Statistics and Information Technology,2010.
17. Callahan, M.T., D.G. Quackenbush, and J.E. Rowings, Construction project scheduling; 1992.

18. Sankar, N.R.; Prabhu, B.S., Modified approach for prioritization of failures in a system failure mode and effects analysis. International Journal of Quality & Reliability Management. 2001;18(3), 324-35 .
19. Wang,Y.M.; Chin,K.S., Poon,G.K.; Yang,J.B, Risk evaluation in failure mode and effects analysis using fuzzy weighted geometric mean. Journal of Expert Systems with Applications. 2009;36(2), 195-207.
20. Karthik, S. A Modified FMEA Approach to Enhance Reliability of Lean Systems. Master's Thesis, University of Tennessee. USA ;2010,
21. Sawhney, R Karthik, S. Sonntag, C. Rao. P Rao. V, Capizzi, C., A modified FMEA approach to enhance reliability of lean systems. International Journal of Quality & Reliability Management. 2010;27(7), 832-855.
22. Andersen, M.B., Improvement of Failure Mode and Effects Analysis , Master Thesis, University of Business Intelligence. USA; 2012.
23. Sorooshian. S, Norzima. Z, Yusof. I, Rosnah. M.Y, Effect analysis on strategy implementation drivers, World Applied Sciences Journal, 2010;11(10):1255-1261.

2/8/2014