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Development of a Risk Assessment Model for Oman Construction Industry

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Graphical abstract

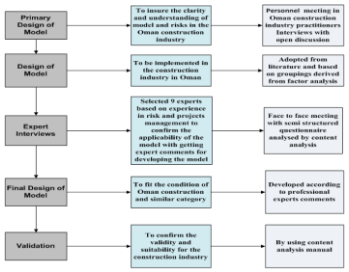

Figure 1: Risk Assessment Model Development methodology

Abstract

Oman as one of the Arabian Gulf countries which have invested billions of dollars in the construction industries, infrastructural services and real estate, but it is clearly identified that risk assessment was not applied for once on these awarded contracts. Lack of knowledge and awareness of risk management or assessment procedures in the construction industry in Oman caused additional cost and time delay in most of the awarded construction projects. This paper aimed at developing a model for risk assessment in the Oman construction industry to save huge amounts of millions of money wasted due to this problem. A field survey of semi-structured questionnaire with face-to-face interviews was carried out in the Oman construction industry including public, contractors and consultants. The research approach relies on data collected from primary and secondary sources. Combination of quantitative and qualitative data analysis was used in analysing the data for the Model development. The risk factors in the Oman construction industry varies from one category to another, the risk factors in government category are more than the consultant category and contractor's category. Overall, the Oman construction industry has no very high risk factors, which means it has good opportunities for investment. It is expected that the output of this research will have a good and beneficial contribution to save time and money for both public and private sectors in Oman due to expected awareness and improvements in the risk assessment procedures.

Keywords: Risk Assessment; construction industry; risk factors; Oman

1.0 INTRODUCTION

Construction industry is known for years to be fragmented in nature and every construction project is bound to have conflicts or disputes caused by high risk and the level of complexity of the project [1] model development under goes five main stages: which include identifying constructability design phase, identifying the degree of importance of the constructability principles, formulating a framework for measuring the level of constructability principles and design constructability, collecting historical project data, and applying ANN to assess design constructability [2].The objective of performing risk assessment in construction projects is to guaranty identification of risks and analysing their probability and impact effects at the project inception, in order to minimize the consequences effects of risks. Smith [3] discussed on the basic qualitative risk assessment techniques in order to understanding risks and their possible impact by using steps of identification, assessment, ranking, sorting, classifying, allocating ownership and judging the possibility and effectiveness of potential risks. The target of risk assessment process is to understand and measure the probability of occurrence and the possible effects on the project outcome, Office of Government Commerce [4] & Carr and Tah [5] discussed further on the issue of risk assessment procedure and technical aspects of the risk identified from this study. On the other hand, Lamit [6] developed a model on system life cycle sequence which can be used to identify walkability behavior in minimizing risk in construction industries.

2.0 RISK ASSESSMENT

Construction problems are common occurrences that hold back projects to run smoothly [7]. Keil [8] highlighted some level of which construction industry continues to see frequent financial claims on projects over the past twenty years. Generally, quite often, project owners try to avoid or minimize their financial risk by transferring more contractual risk on to the contractor. Transferring risk to contractor is quite common procedure in Oman construction projects especially by using lump sum contract. Mulholland and Christian [9], and Taroun *et al.* [10] confirmed that there was a lack of an accepted method of risk assessment and management among professionals in the construction industry compared to some other professions. It can

be seen that both researchers in 1999 and in 2011 still agreed on the lack of an accepted risk assessment model in construction projects to suit all practitioners in the industry despite more than ten years period between them.

Previous researchers; Fang *et al*. [11], Choi *et al*. [12], Lam *et al*. [13] Li and Zou [14] and Lamit *et al*. [15] developed different risk assessment models to solve precise difficulties such as tendering, quality, projects phases, environmental walkability etc. Valipour *et al*. [16] developed a risk allocation problem in public private partnership (PPP) which affects the timeline, cost and quality of the project. In the risk assessment procedure, there is no common risk assessment model that can be used for all types of risks yet. This study will introduce a common model for identifying different types of risks in construction industry projects. Taroun *et al*. [10] concluded that construction projects risk modelling is a developing and on-going process, and there is lack of comprehensive framework that would assist in measuring impacts of risk on specific project objectives, such as, time, cost and quality.

According to preliminary interviews conducted in this study with construction practitioners in Oman, it is assured that risk assessment is not applied at all or not applied properly at most of construction firms in Oman. Lack of knowledge and awareness of risk management or assessment procedures in the construction industry in Oman caused additional cost and time delay in most of the construction projects. Abu Bakar *et al*. [17] and Mehdi *et al*. [18] pointed out the main reasons for not implementing risk management procedures properly in Oman are:

i. Lack of understanding and awareness of risk management procedures
ii. Lack of awareness of computing resources and assistance
iii. Lack of top management support especially with smaller firms
iv. Lack of an accepted risk assessment model in the construction industry in Oman.

Which serve as the major cause of litigations, loss of time, additional cost, and dissatisfaction of stakeholders. Therefore, there is a distress need for this study in order to develop a model in the risk assessment procedure to fit the situation and conditions of construction projects at the firms and establishments in the Sultanate of Oman.

Bridges [19] indicated that the process used in risk assessment to qualify the significance of a project by identifying and analysing uncertainties and constraints in terms of the likelihood that an occurrence will happen and the probable consequences. In addition, they argued that risk assessments would work well whether the project is private or public. The quality processes that a risk assessment will generate can definitely assist in mitigating project cost associated with identified and unidentified risk.

The typical qualitative risk assessment process was explained by Smith [3] usually includes a brief description of the risk, the expected stages of the project when risk may occur, the parts of the project that could be affected, the causes that influence it to occur, the relationship with other risks, and the probability of its occurring and how it could affect the project. The risk assessment was also discussed by Karimi [20] he stated that it includes certain measures carried out either qualitatively or quantitatively, to estimate the value of the importance level of each risk factor to the project outcome, in order to make the evaluation of the risk of the possible factors causing failure or success to the project.

Researchers such as Bender [21], Chapman [22], U.S department of defence [23] and Bridges [19] classified risk assessment procedure in phases of identifying, analysing, and evaluating. Others such as Project Management Institute [24] and Office of Government commerce [25] classified risk assessment as one phase after identification in the risk management process and mainly concerned with analysing and evaluating the risks through the risk management cycle process. In this research a model is developed based on the first concept of risk assessment including risk identification, analysing, and evaluating.

The risk assessment in construction projects has been applied differently from project to another by using various models of risk assessment to evaluate the risk in certain activities of the projects. Many researchers have proposed various types of risk assessment models for precise activities in the construction projects assessment. The use of software programs in project management and assessment such as Program Evaluation and Review Technique (PERT) or Critical Path Method (CPM) have allowed practitioners to apply scheduling of time, allocation of resource, and management of cost to be carried out more efficiently in less time and more detail. Therefore, the planning and execution of the project can be done more accurately.

2.1 Risk Assessment Models

Fang [26] applied risk assessment model on tendering, Jannadi [27] used a Risk Assessor Model (RAM) to identify higher risks of major construction activities. Zayed [28] Used AHP in developing the R index model for highway projects and Choi [29] used system model for construction projects dividing any project into four phases. Lam [13], Zou [30], Eom [31], Shapira [32] & Li [14] used an Analytic Hierarchy Process (AHP) models based on factor weights.

The model of risk assessment for Oman construction industry will serve as a supplementary tool for risk assessment on different construction projects in Oman and can be useful for other establishments in the same category especially in the Arabian Gulf Countries which are having similar construction industry to the Sultanate of Oman.

The research used a questionnaire to evaluate the risk perception in the construction industry in the Sultanate of Oman. The questionnaire contain (42) key risk factors associated with construction projects. These risk factors are gathered from three primary sources: a literature review El-Sayegh [33], Zayed [28], Zou [30], Dikmen [34], Lam [13], Motawa [35], Jannadi [27], Baloi [36] & Mulholland [9] the primary open interviews with expert in construction projects and open pilot study questionnaire. The outcome of the literature review, exploratory interviews was (33) risk factors and pilot questionnaire has contributed significantly by adding (9) risk factors in preparing the final draft of the distributed questionnaire.

2.2 Model Development Method

The development of the model was based mainly on triangulation analysis of the composition of the literature review, questionnaire responses, and interviews outcome data collected. The design and development of the model was carried out in five phases as shown in Figure 1.

i. Plan to design the model in a way to fit the construction projects in Oman.

ii. Designing the model after intensive literature review and discussion with professionals in the projects management and risk management,

iii. The designed model presented to experts in the project risk management for comments on applicability and implementation to suit the construction industry in the Sultanate of Oman.

iv. After receiving the comments, the draft of the developed model was amended and became ready for distribution and validity checking.

Finally, interviews were performed with nine experts' mostly international expert with experience of more than 20 years on project management and risk management for validation of the model.

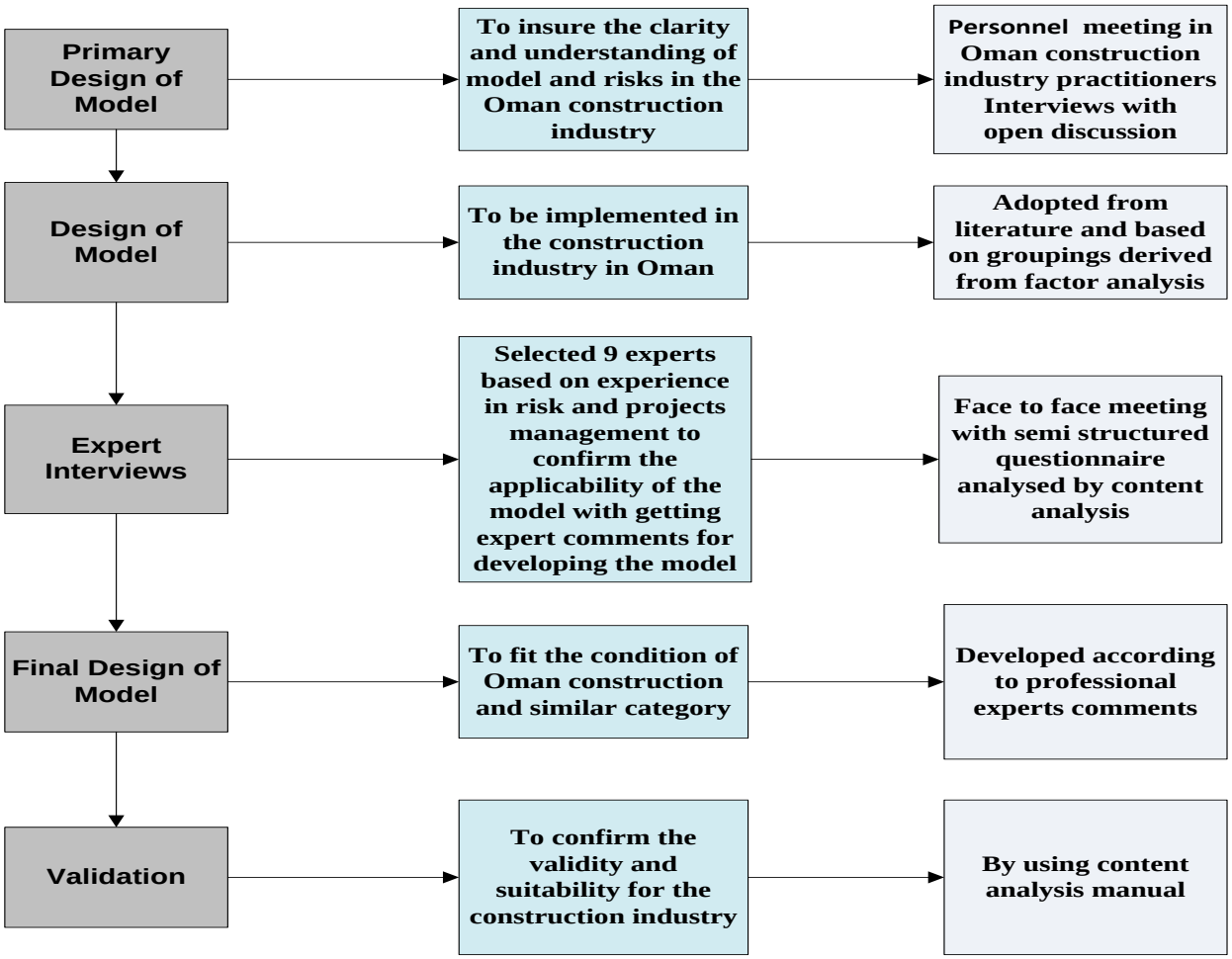

Figure 1 Risk assessment model development methodology

The questions were sent to nine experts selected based on their background experience on risk management and project management, positions in the organisation, and type of work they are responsible for. All experts are having more than twenty years' experience in project management and currently on job, three experts selected from the public sector, three from consultants sector, and three from the contractors sector. Five experts were having international experiences in project management especially in the Arabian Gulf Countries and Middle East in general. Before the meeting was held, the meeting took about one hour with each expert using the model for discussion and how it can be used. The model was checked by experts in the field of construction projects in Oman for applicability and validation. The checking process involved face-to-face interviews and questions were answered for applicability and validation. The Interview discussions were based on semi-structured questionnaire.

The questionnaire focused on the importance of how useful, suitable and applicable is the developed model with 9 professionals, selected according to their experience in the field of risk and project management, each expert have a wide experience in the construction industry for not less than twenty years and they are still currently in the same field. Five of the experts are expatriates with vast experience in risks in the construction before working in Oman especially in the Arabian Gulf Countries. The outcome of the exploratory discussion interviews has resulted in some changes to the model to fit more into the construction industry in the Sultanate of Oman.

The model was adopted from literature review resources: Cooper *et al*. [37], Zavadskas [38] & Zhang and Yang [39]. Figure 2 shows the initial design of the model (stage-1), which

was introduced to the experts and practitioners for understanding and clarification. The diagram then improved and developed more according to comments and discussion with experts and practitioners.

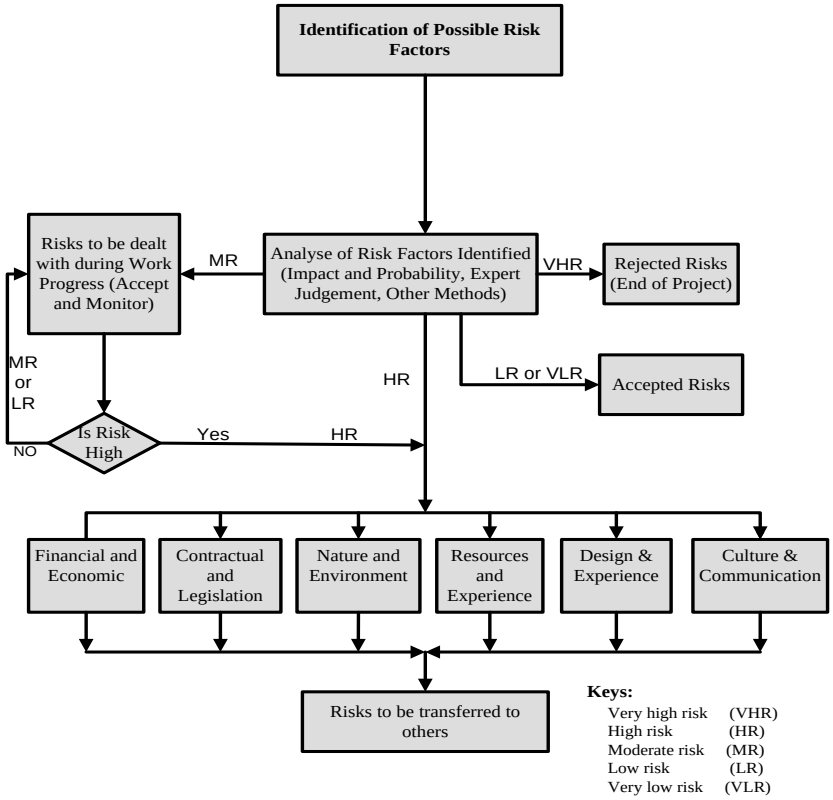

Figure 2 Risk assessment model–stage 1

The second stage of the developed model is shown in Figure 3 with changes in dealing with Very High Risk (VHR) category by adding mitigation to the process in order to reduce the risk category to a lower grade to be treated accordingly. The change here is due to most expert explained that even with VHR, the project will not be rejected unless trial for mitigation failed to reduce the category of the risk to a lower category that can be dealt with.

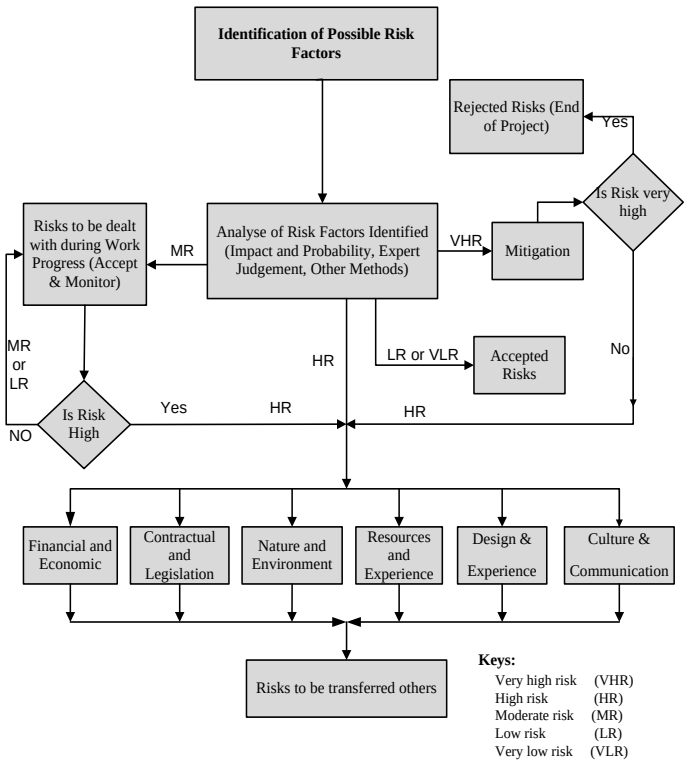

Figure 3 Risk assessment model–stage 2

Figure 4 (Stage-3) shows the results of the model in final design after development adopted from literature review and comments from experts of the construction industry in Oman. The final changes is dealing with the VHR after mitigation to a lower category of risk, and using the risk components resulted from the PCA analysis. In this model, the groups or components could be changed to any components selected by experts or any other process to suit the uniqueness of the project, size and capability of organisation, and conditions of the construction industry. The changes in Figure 3 to Figure 4 is for treating the mitigated VHR to the correct category by re-evaluating the risk after mitigation and implementing the components derived from the PCA into the model.

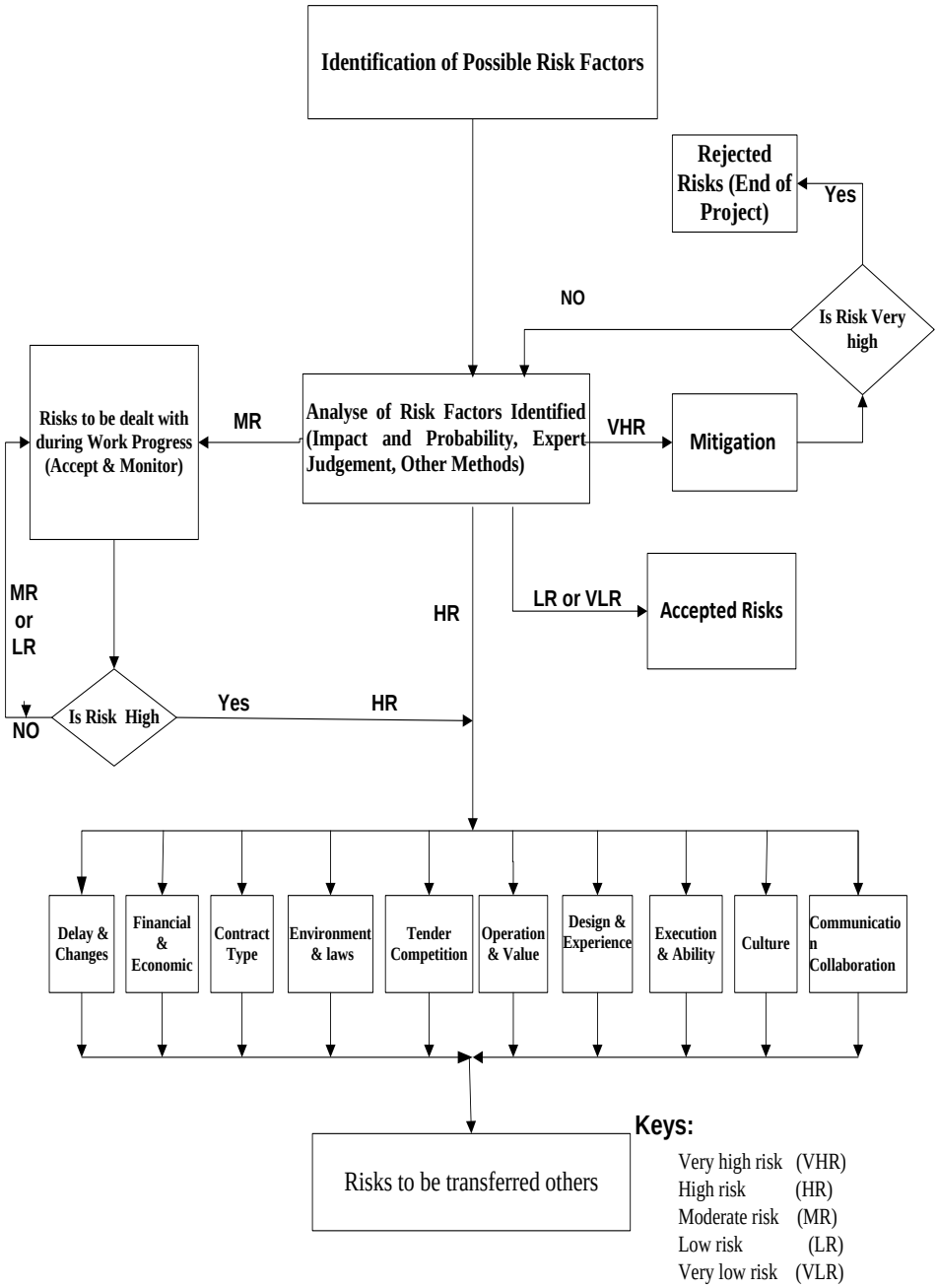

Figure 4 Risk assessment model–stage 3

3.0 RESULTS AND FINDINGS

The findings of the data collected were displayed in table's format in order to make the analyses easier to understand. Statistical interpretations were used to focus and indicate how responses varied and distributed. The analysis of data collected from questionnaires and interviews was used to assess the present situation of risk assessment experiences at the construction industry in Oman. The analysis of data requires careful interpretation, which lead to the development of risk assessment model. Forty-two key risk factors were identified in the construction industry projects in the Sultanate of Oman. These factors were evaluated in the industry for their possibility and impact on the projects outcome in Oman. Some of the factors were considered critical risk factors required to deal with in mitigation process towards achieving the objectives of the project. The key risk factors were analyzed by exposing the most critical factors affecting the construction projects goals in Oman.

Table 1 shows the respondents from each category, the government sectors has 43 participants mainly from directors level and senior engineers, the contractors sector has 49 participants from excellent grade and international companies and the consultants sector had 38 participants mostly architects and quantity surveyors.

Table 1 Respondent category frequency

Valid Respondent Category	Frequency	Per cent	Valid per cent	Cumulative per cent
Government	43	33.1	33.1	33.1
Consultant	38	29.2	29.2	62.3
Contractor	49	37.7	37.7	100.0
Total	130	100.0	100.0	

According to the means ranking in Table 2, there is no critical factor classified with very high-risk impacts in the construction industry of the sultanate of Oman, only high risks and moderate risks that should be dealt with by taking some measures of risk response in the risk management process. In addition, there is no low risk or very low risk factors indicated from the list in Table 2, which means all risks outlined in the table should take into consideration with some measure in order to avoid or reduce the effects from risk impact to an acceptable level.

The outcome of the highest mean value of all risk factors in Table 2 is 3.84 to the project finance factor in the consultant category with a 77% possibility of occurrence and this was ranked in the high-risk zone, the lowest mean value of all risk factors as shown in Table 2 is 2.16 also in the consultant category with a 43% possibility of occurrence and this was considered as a lower moderate risk. Therefore, all risk factors mentioned in Table 2 were considered either moderate or high risk factors. Researchers such as Al Zubaidi and Al Otaibi [40], Creedy, *et al*. [41], Wang and Yuan [42], Abd-Karim *et al*. [43] and Zaimi *et al*. [44] all explained that most critical factors of construction industry are delay in payment, delay in approvals, cash flow difficulties, lack of financial resource, design and scope change, and price escalation which is similarly affecting Oman construction industry as shown in Table 2.

The table summarizes the mean values ratings for all categories of government (public), contractors, consultants, and the industry as a whole containing all categories along with their respective rankings of the forty-two risk factors according to the total sample from Oman construction industry.

3.1 Model Use Guidance Details

The developed risk assessment model is divided into seven steps; the steps are explained according to their sequence as follows:

i. Identification of Possible Risk Factors
ii. Analyzing identified risk factors
iii. Dividing risk factors into five classification:
   a) Very high risks (VHR)
   b) High risks (HR)
   c) Moderate risks (MR)
   d) Low risks (LR)
   e) Very low risks (VLR)
iv. Projects with very high risks should be mitigated to reduce their impact on the project to a lower level that can be dealt with according to their risk level then or if not the project to be rejected before any commitment.
v. Distributing high risks into the suitable groups such as communication collaboration, communication collaboration, contracts type, delay and changes, tender competition, environment and laws, culture, design, operation and value, finance and economic and execution and ability as shown in the model for transferring risks. Alternatively, the professionals in the analysis or mitigation process can decide risks to any other groups.
vi. Moderate Risks in the project could be accepted and dealt with during the project progress. In this level, all risks and their impact on project are to be monitored, if moderate risks is transfer to a higher level, then it should be treated according to their level and mitigated or transferred to others.
vii. Low risks and very low risks are accepted and are to be dealt with in the project. The developed model can be used for any project and anywhere with some changes to satisfy the uniqueness of the establishment and the project. The explanation procedure of using the model is listed below. Risks can be transferred to others by suitable measures such as commercial insurance, joint venture, subcontracting, sourcing out, self-insurance and other measures suitable to the establishment and the industry.

3.2 Validation of the Model

For the validation of the model a semi structured interviews were carried out in the Sultanate of Oman with nine experts having experience of more than 20 years in the field of the construction industry, five experts were having international experiences in project management especially in the Arabian Gulf Countries and Middle East in general. Two of the experts during the meeting were handling the responsibility of managing the risks in their projects (more than $500 million) at the Muscat International Airport.

The model introduced to the consultancy section in the projects directorate of the Ministry of Defence in Oman. The procedure of the model was discussed with them for implementing the model and agreed to apply it at some of their new projects. In addition, Daan's office one of the leading offices in quantity surveying consultancy in Oman asked for permission to use the model in their future projects.

Table 2 Comparison between construction industry categories by risk factors means

Construction Key Risk Factors	Construction Industry			Government		Contractor		Consultant	
	Importance No.	Mean	Std. Error	Mean	Importance No.	Mean	Importance No.	Mean	Importance No.
Project Financing	1	3.64	.085	3.72	1	3.41	4	3.84	1
Payment Delay to Contractor	2	3.56	.070	3.56	3	3.43	3	3.74	2
Late Approval (Award Letter, Design)	3	3.52	.083	3.23	8	3.67	1	3.63	3
Quality Achievement Failure	4	3.48	.085	3.67	2	3.37	5	3.42	5
Estimation Accuracy	5	3.46	.084	3.47	5	3.49	2	3.42	6
Market Fluctuation and Inflation	6	3.20	.087	3.23	7	3.22	6	3.13	9
Natural Disasters	7	3.11	.108	3.02	16	3.02	8	3.32	7
Fraud & Abuse	8	3.09	.097	3.09	14	2.78	15	3.50	4
Construction Changes (Variation Order)	9	3.04	.102	3.09	13	3.00	10	3.03	11
Consultant Ability& Experience	10	3.03	.105	2.98	17	3.12	7	2.97	12
Contractor/Subcontractor Capability	11	3.02	.101	2.91	18	3.00	9	3.16	8
Design Complexity	12	3.01	.115	3.51	4	2.94	11	2.53	28
Design & Build Contract	13	2.99	.111	3.16	10	2.80	14	3.05	10
Lump Sum Contract	14	2.98	.099	3.12	11	2.90	12	2.95	13
Packaging Contract	15	2.92	.099	3.23	6	2.67	20	2.89	15
Staffing Levels	16	2.88	.091	3.21	9	2.67	21	2.76	16
Meeting Time Target	17	2.80	.099	3.02	15	2.73	18	2.63	22
Clients Satisfaction	18	2.77	.093	2.84	19	2.76	16	2.71	19
Workplace Restrictions	19	2.76	.079	2.72	24	2.82	13	2.74	18
Procurement & Materials Delivery	20	2.76	.091	2.79	20	2.73	17	2.76	17
Climate and Weather Condition	21	2.68	.076	2.65	27	2.53	28	2.92	14
Tech.& Equipment Obsolete	22	2.67	.075	2.77	22	2.61	23	2.63	21
Manpower Satisfaction	23	2.62	.089	2.65	26	2.55	27	2.66	20
Scope Description (Clarity)	24	2.60	.104	3.09	12	2.45	36	2.24	38
Legislation & Regulation	25	2.59	.084	2.60	29	2.69	19	2.45	31
Tendering Competition to Contractor	26	2.57	.096	2.56	30	2.59	26	2.55	27
Commissioning & Operating	27	2.56	.067	2.79	21	2.59	24	2.26	37
Contractor Support to Project	28	2.56	.112	2.56	32	2.53	31	2.61	24
Tech.& Equipment Use	29	2.55	.082	2.72	25	2.39	38	2.55	25
Public Security and Safety	30	2.53	.085	2.47	37	2.61	22	2.50	30
Health, Safety and Environment (HSE)	31	2.52	.090	2.49	35	2.53	29	2.55	26
Clients Culture	32	2.48	.085	2.72	23	2.53	30	2.16	41
Owner Knowledge & Experience	33	2.48	.106	2.63	28	2.49	32	2.29	36
Contractor & Consultant Cooperation	34	2.45	.105	2.40	40	2.47	35	2.50	29
Lump Sum with Bill of Quantity	35	2.44	.085	2.51	34	2.47	34	2.32	35
Trust between Contractor & Clients	36	2.42	.103	2.44	38	2.24	41	2.61	23
Tendering Competition to Client	37	2.41	.097	2.42	39	2.59	25	2.16	42
Construction Industry Culture	38	2.40	.081	2.56	31	2.41	37	2.21	40
Ethical Dealings	39	2.39	.091	2.51	33	2.29	40	2.39	33
Contractors & Consultants Communications	40	2.38	.093	2.30	42	2.49	33	2.32	34
Value Engineering	41	2.35	.088	2.49	36	2.33	39	2.24	39
Contractor & Owner Cooperation	42	2.32	.101	2.33	41	2.24	42	2.42	32
Valid N (listwise)	(130)			(43)		(49)		(38)	

The validation process resulted in adding improvements to the model three times according to discussion with expert and their recommendation for the applicability of the model. The three changes of the model shown in the Figures 2, 3, and 4. The development of model in Figure 3 was the mitigation process added to the VHR then redirected to the risk according to its situation after mitigation. Lu and Yan [45] explained that most suitable assessment for ranking the relative importance of risk

factors depends on experience of the professionals due to uniqueness and nature of construction projects and lack of information. The uniqueness of the construction industry was considered thoroughly in this study by depending on field survey data through most findings of the research which includes the risk factors and ranking and finally validation.

Zhang and Wildemuth[46] pointed out that qualitative content analysis may be used to support the validity and reliability inference of written data by preparing the data and processing it through writing up the finding in a report. In addition, they further explained that content analysis is a technique for screening words and meaningful contents for extracting objectives of text. Kumar [47] indicated that questionnaire content data can be analysed manually or by using assistance of computer programs, the manual analysis is suitable if the number of respondents and data is reasonably small for calculating frequencies and simple calculations. Therefore, the use of manual content analysis preferred here due to the number of respondents expert for validations.

4.0 CONCLUSION

The output of this research have a good contribution to the effort of risk assessment practice in the construction industry in Oman and similar countries especially from Arabian Gulf Countries and will satisfy practitioners in the risk management and assessment process. This study provides a good understanding of the risk assessment procedure to the construction industry to assist Oman construction projects practitioners interested in assessing the market opportunities and risks. This research study considered as an attribute to raise the awareness within the construction management community that risk can be understood and properly managed. This could be through putting more attention to the strategic and appropriate procedure of risk management and risk assessment.

The model can be used as a supplementary tool for risk assessment on different construction projects to identify, evaluate, then rank risks into categories, and finally distribute them in risk groups for mitigation. The output of this research is having a good participation and beneficial contribution to awareness of risk assessment process and considered a proper solution to solve difficulties in applying risk assessment process at construction projects in the Sultanate of Oman.

The developed model solved the uniqueness situation of the project in construction industry, which has the following strengths:

i. Flexible to fit with any projects in various organisations
ii. More practical than theoretical
iii. Easy to implement

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