

## COST ESTIMATION PRACTICES PREVALENT IN CONSTRUCTION PROJECTS IN OMAN

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**ABSTRACT:** This paper reports findings of a study that captures cost estimation practices and techniques prevalent in the construction industry in Oman. It also identifies the success and risk factors that are encountered in the cost estimation process. Eighty structured questionnaires were distributed to some professionals working in construction projects, selected randomly from large and medium size enterprises across the Sultanate. A response rate of 56% was achieved. The results showed that the unit rate method, the use of historical data and benchmarking are the most common methods used for cost estimation. Success and risk factors as reported by respondents were analyzed and ranked accordingly. The main sources of risk were reported by respondents as "Unclear reading and understanding of specifications", "Lack of clear documents of the project scope of work", and "Unavailability of Resources". This study provides an insight understanding of revealed practices and techniques and globally share the findings with researchers and professionals.

**Keywords:** Construction management; Cost estimation; Techniques; Practices; Risk.

### تقدير تكلفة الممارسات في مشاريع البناء في عُمان

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**الملخص:** تقدم هذه الورقة البحثية تقارير عن نتائج دراسة للوقوف على تقدير تكلفة الممارسات والتقنيات السائدة في صناعة البناء في سلطنة عمان. كما انها تحدد أيضاً عوامل النجاح والمخاطر التي تتم مواجهتها في عملية تقدير التكلفة. قمت في هذه الدراسة بتوزيع ثمانين استبياناً مركباً على المهنيين العاملين في مشاريع البناء، حيث تم اختيارهم بشكل عشوائي من الشركات الكبيرة والمتوسطة الحجم في جميع أنحاء السلطنة. وكان معدل الاستجابة 56%. وأظهرت النتائج أن طريقة معدل الوحدة واستخدام البيانات التاريخية والقياس هي أكثر الطرق المستخدمة لتقدير التكلفة. و حللنا عوامل النجاح والمخاطر حسب إجابات المشاركين وصنفنا النتائج وفقاً لذلك. وأفاد المجيبون على الاستبيان أن مصادر الخطر الرئيسية هي نتيجة "قراءة وفهم غير واضح للمواصفات" و "عدم وجود مستندات واضحة لنطاق عمل المشروع" و "عدم توفر الموارد" كما توفر هذه الدراسة فهماً عميقاً للممارسات والتقنيات التي تم الكشف عنها ومشاركة النتائج عالمياً مع الباحثين والمهنيين.

**الكلمات المفتاحية:** إدارة الإنشاءات؛ تقدير التكلفة؛ التقنيات؛ الممارسات؛ المخاطر.

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## 1. INTRODUCTION

Construction project outcome is characterized in terms of time, cost and quality achieved. Project clients demand their projects be completed on time, within budgeted cost and at appropriate quality or specification. Project cost estimation is primarily concerned with the cost of material and human resources needed to design, construct and complete scheduled activities. In addition, the cost estimate should consider the running cost of the constructed facilities including use and maintenance. The accuracy of any construction cost estimate is measured by how well the estimated cost compares to the actual cost (Oberlender and Trost 2001; Toutounchian *et al.* 2018). Elfaki *et al.* (2014) analysed some proposals that used intelligent techniques for construction cost estimation. They collected and analysed data over a period of 10 years and suggested a methodology that can be used as a standard benchmark for construction cost estimation proposals. Lim *et al.* (2016) studied the factors influencing cost estimation in Queensland, Australia and its relevance to estimation accuracy. They found that many factors of cost uncertainty for large-scale projects are not relevant for the contractors of small-scale residential construction projects. Akintoye and Fitzgerald (2000) studied cost estimating practices in the UK and found that the contractors use the labour and material rates to calculate prices for individual items in the bills of quantities. They also found that the major causes of inaccuracy in cost estimating are: (1) lack of practical knowledge of the construction process by those responsible for the estimating function, (2) insufficient time to prepare cost estimates, (3) poor tender documentation, and (4) wide variability of subcontractors' prices.

Cost estimation techniques can be categorized into qualitative and quantitative techniques (Niazi *et al.* 2006). Qualitative techniques use past historical data and judgment to subjectively estimate the cost of a project (Project Management Institute 2008). In contrast, quantitative techniques not only rely on prior data and skilled knowledge, but can also analyze project designs, processes, and individual attributes to explore cost functions. Therefore, analytical models offer a reliable way to determine project costs with a reasonable accuracy (Artto *et al.* 2001; Chou *et al.* 2006; Touran and Asce 2003; Wang 2004). Saha (2010) proposed a full quantitative technique to predict the potential benefits of simulation-based alternatives over conventional methods. A case study by Marco *et al.* (2005), described the practicability and predictability of traditional estimates at completion based on early progress measurement by presenting empirical results from previous construction projects. In reference to project life cycle cost estimation, Nassar (2006) recommended a three-step approach which includes:

preparing background information like a system / service describing assumptions and constraint; communication and coordination considering cost and requirements analysis precedence to cost estimate preparation. The third step includes selection methods/models to collect, validate and adjust data estimate costs. Kim and Kim (2010) proposed a preliminary cost estimation model using case-based reasoning and genetic algorithm. They concluded that their model is more reliable than the conventional cost estimation methods. Kujala *et al.* (2014) found that the cost management functions are impacted by the size, complexity, uncertainty and uniqueness of projects. Sequeira and Lopes (2015) proposed a spreadsheet method for project cost development for budget allocation. They stated that their method provides a simplified decision tool for assessing the construction cost with high accuracy.

Olatunji and Sher (2014) compared the Building Information Modelling (BIM) techniques with the conventional cost estimation methods and concluded that estimators need to respond to the challenges that BIM poses to traditional estimating practices. To enhance performance of BIM, a recent study by Heigermoser *et al.* (2019) proposed linking BIM to lean construction as a construction management tool in attempt to increase productivity and reduce construction waste.

Wu *et al.* (2014) examined the cost estimating practices and procedures in the UK and analyzed the impact of using BIM. They identified a number of challenges in terms of information exchange, model quality and UK standards. In addition, they developed a methodology to evaluate the ability of the existing BIM technology to support the UK quantity surveying practices. Several case studies in relation to the accuracy of project budgeting are reported in literature. Oyedele (2015) evaluated the construction cost estimation methods in Nigeria and recommended an improved procedure to achieve a quality estimate. Aibinu and Pasco (2008) examined the accuracy of pre-tender building cost estimates in Australia, by investigating 56 projects and surveying 102 firms. Their work showed that estimation in the construction industry in Australia is significantly affected by project size.

In small projects, cost is usually over-estimated by a large amount rather than underestimated. Moreover, accuracy of estimation has not improved over time, which implies that lack of experience plays a small role in biased cost estimation. Al-Mohsin and Al-Nuaimi (2013) developed a model to estimate the construction cost of villas in Oman at the conceptual design stage and after the preliminary design stage. They found that their model gives good correlation between the selected variables and the actual cost with  $R^2 = 0.79$  in the case of conceptual estimate and  $R^2$

0.601 for preliminary estimate. Kiziltas *et al.* (2009) emphasized the importance of obtaining and referring to historical databases in order to reduce estimator's errors. Popovic (2004) stated that implementing data mining techniques provides a number of solutions towards improving cost estimation process in construction projects. They found that the best practice is to arrange the data in a manner per type of work and incorporate it into various contract documents. On the other hand, Hwang (2009) proposed two dynamic regression models for the prediction of the construction cost index. Yu *et al.* (2006) used Web Based Intelligent Cost Estimator (WICE) and achieved a higher accuracy estimate compared to existing conceptual estimation systems. Jonny and Lichtenberg (2016) developed a new method utilizing a successive principle, to achieve a reliable and unbiased cost in infrastructure projects in Norway and Denmark. Recently, Juszczak (2017) proposed an approach based on the concept of nonparametric cost estimation with the use of artificial neural networks.

A number of studies have utilized Probabilistic Estimation Method (PEM) to establish possible ranges of project costs, helping relevant personnel to apply PEM to assess project risks (Chou *et al.* 2009; Yang 2008). The applications include a statistical framework for cost estimation in construction projects in 5 states in the USA Swei *et al.* (2017). Also, Monte Carlo simulation (MCS) has been applied to examine numerous project risk analyses regarding cost estimates (Chou 2011). Rather than estimating project costs, several researchers used an economical approach to determine life-cycle costs of infrastructure construction projects (Herbold 2000; Salem *et al.* 2003; Tighe 2001; Heralova 2017). The results included a decision-making process regarding pavement and rehabilitation scenarios selection. A deterministic life-cycle cost model was developed in which end-user specify the values of input parameters (Salem *et al.* 2003). Albalushi *et al.* (2013) blamed the absence of value engineering for cost and time overruns in projects in Oman.

Very little information was found in the literature about actual practices or procedures used for estimating cost of construction projects in Oman. The aim of this study was two folds; exploring practices and techniques prevalent in construction projects in Oman, and comparing them with worldwide practices and linking the results of analysis to actual cost and time spent on the project.

## 2. RESEARCH METHODOLOGY

In order to achieve the specified objectives, a framework was required to conduct the study. The overall framework that this research followed included the following elements:

- Identifying cost estimate practices, methods, techniques, tools and factors of project development phases worldwide.
- Identifying cost estimate practices, methods, techniques, tools and factors of project development phases in the Sultanate of Oman.
- Discussing and comparing the practices, methods, techniques, tools and factors in use in the Sultanate of Oman with those around the world.
- Identifying and comparing findings, and analysis of results, linking them to final cost estimate and the ending of the project.
- Linking the best cost estimate practices and techniques and providing recommendations for the same to be implemented in the Sultanate of Oman for future projects.

Generally, the nature of each project is an important element as it may determine when to use what practice and method or tools and to those particular practices and methods should be implemented.

Upon establishment of the research framework, data needed to address the research target had to be collected. Initially key points were generated and checked by the research team and then a series of interviews were scheduled and conducted with various personnel in both public and private sector organizations. During the interview, the subject responses were expanded upon and further suggestions and comments were noted. The information collected from these small organizations proved to be insightful. After interviewing the smaller organizations, other larger organizations were interviewed to confirm the information previously collected.

The use of a survey assisted in collecting the data needed to address the research target. Surveying is a powerful technique in establishing real-world practices. Once appropriate contacts were identified, they were electronically forwarded a copy of the survey. This work was followed by a pilot survey via a questionnaire conducted on 10 professionals working directly in the field of estimating construction cost and responsible for project biddings. As a result, some modifications were carried out on the questionnaire to eliminate ambiguities, potential misunderstanding or linguistic issues. The revised questionnaire was then distributed by hand to 80 professionals selected from different organizations across the whole industry ensuring that no more than one person per organization is allowed to participate. A total of 45 completed responses were received, giving a response rate of 56%. The use of a structured-questionnaire survey served as the main tool in collecting the data needed to address the research target. The responses were stored and statistically analyzed using Statistical Package for Social Sciences (SPSS) software. The respondents included clients, consultants and contractors.

### 3. ANALYSIS OF DATA AND DISCUSSION OF RESULTS

The data collected from interviews, recent literature review and the detailed survey responses, assisted in identifying the practices, methods and techniques used in project cost estimation in Oman. Based on this data, a comprehensive listing of both the effective and ineffective practices used by organizations was generated. This listing subsequently led to development of risk and critical factors influencing cost estimation. The practices, methods and factors were matched to the similarities found in the literature. Finally, a comparison of current cost estimate practices prevalent in Oman could be made with those used around the world.

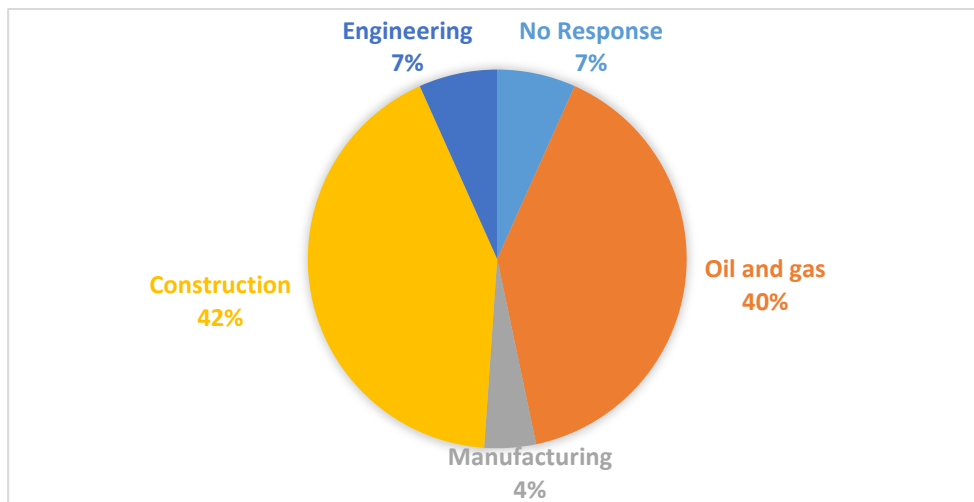
The first part of the questionnaire identified general information about the organizations that participated in filling out the survey. The information was categorized, analyzed and the result are shown in Table 1. Three distinct categories were used to differentiate between the respondent sectors, namely: public sector (26.67%) private sector (62.22%) and mixed sector (11.11%). The respondents were mixed sector (11.11%). The respondents were categorized as client, consultant or contractor. It was found that the majority of the organizations surveyed (mainly

Consultants and Contractors) belong to the private sector. The respondents operating in the public sector mainly comprise the clients.

The organizations were further identified by their primary field of operation as shown in Fig. 1. It can be deduced that the majority of the organizations interviewed have operated in the fields of construction, and oil and gas. Coincidentally, both fields happen to comprise the largest business sectors in Oman's economy according to the Ministry of Economy, Sultanate of Oman (Statistical Year Book 2011). In addition, the respondents from manufacturing and engineering fields were also identified. Table 2 shows the average value of projects which have been completed in the period 2009 – 2014. It was found that most of the completed projects were valued over 10 million Omani Riyals (one Omani Riyal = 2.59 USD) (the majority of these projects were issued by clients and involved contractor participation). The successful completion of high value projects suggests that these organizations have an efficient cost estimating process and construction performance. Table 3 presents the range of variations between the estimated and the actual costs of projects in the case of cost overruns. The cost overruns were grouped into five categories based on the value percentage. The data obtained showed that 51.1% of respondents claimed that the variations were minor,

**Table 1.** Organizations by sector.

Categories	Client	Consultant	Contractor	Total	%
No Response	0	0	0	0	0
Public sector	12	0	0	12	26.7
Private sector	0	14	14	28	62.2
Mixed sector	3	1	1	5	11.1
Total	15	15	15	45	100



**Figure 1.** Organization field of business by category.

ranging between 0% - 10%. This is considered to be an optimistic outcome as it suggests that the projects were estimated accurately. About 35.5% of the respondents claimed presence of variations between 10% - 30%, indicating cost overrun and inefficient project cost estimation.

### 3.1 Practice and Methodology for Project Cost Estimation

The second part of the survey collected information on various practices of cost estimation. When asked if the organizations have a dedicated cost estimation department, 78% of the respondents stated that they do (Fig. 2). They further elaborated on this, describing the structure of the stated department. There exists a department head under whom a number of experienced personnel who carry out relevant data analysis and cost estimation. Pricing information is regularly reviewed, updated and an open environment of communication exists, thereby allowing estimators to enhance their knowledge and gain experience. About 18% of the respondents reported that they did not have a dedicated cost estimation department. It is clear that clients give less importance to a dedicated department, which may lead to a poor project cost estimation process.

When asked about the existence of standard operating procedures, 80% of the respondents replied

in the affirmative (Fig. 3). Not surprisingly, 66% of the remaining 20% that responded in the negative were clients. It should be noted that there would be an added benefit of producing a manual of standard estimating practices to be used by all clients, consultants and contractors. With such a guide, the estimators would be able to perform estimates in less time since many of their questions could be addressed simply by referring to the manual. The benefits would substantially exceed the cost of capital investment of regular updates of the manual.

Approximately 53.3% of the respondents claimed that top management has direct involvement in the preparation of the cost estimation process (Table 4). About 20% are indirectly involved like advising to those personnel preparing the costing and about 22% of top management are involved at the last stage of preparation of cost estimation process. Top management involvement is important since the decisions made at all stages of the cost estimation process will often determine the way in which the project is carried out. It is also important that while estimating and preparing the documents of the cost proposal, the requirements should be understood and the information be robust and clear. Top management involvement also provides confidence on the project cost estimate accuracy.

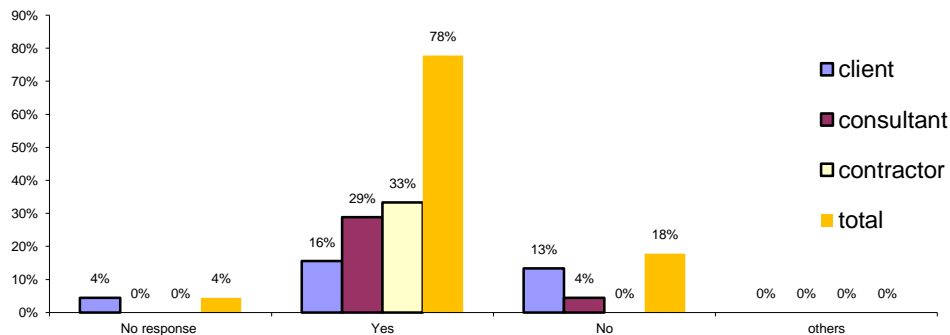


Figure 2. Organizations that have a Dedicated Cost Estimation Department.

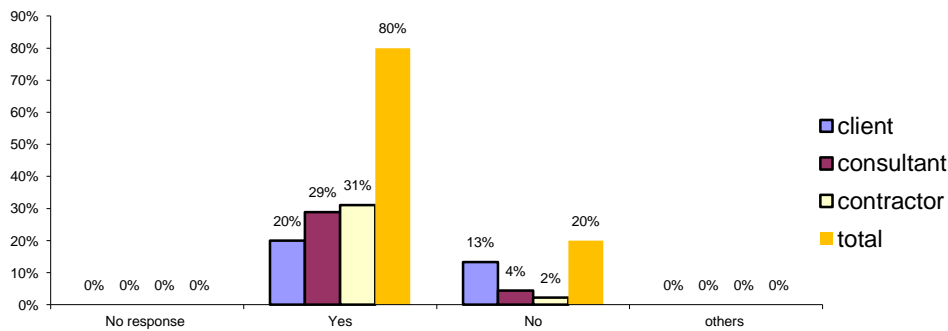


Figure 3. Status of Organizations that have Standard Operating Procedures for the Cost Estimation Department.

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### 3.2 Techniques for Project Cost Estimation

The third part of the survey collected information on the techniques of project cost estimation. First, the factors that determine the proper estimation technique to be used were sorted out (Table 5). About 62.2% of the respondents considered the following factors while preparing an effective estimate: (1) level of scope of work available, (2) size of the project, (3) time

constraints, and (4) availability of software. It was noticed, however, that contractors (70%) favored the level of scope of work available as a criterion while cost estimating.

Among all surveyed organizations, 77% reported that they use the unit rate method for estimating construction costs (Fig. 4). The use of Top-Down and Historical Data based techniques is of a second choice. Bench marking, Bottom-up and Expert-opinion were found to be the least used. 55% of the respondents justified the common use of the Unit Rate Method by claiming that it was the most accurate. This opinion was further justified by 31.1% of the respondents who claimed that it was the safest method to employ when the scope of work was unclear (Table 6). 55.5% of the respondents were in agreement that the historical bid based estimate was of second preference in Oman (Table 7). 40% of the respondents cited the following revision methodologies used in validating historical data: (1) revision according to the nature of the project, (2) revision as a market survey, and (3) revisions as a new process of the project (Table 8). 33.3% of the respondents favored the use of revisions according to the nature of the project.

53.3% of the respondents disagreed with the

**Table 2.** Average values of projects completed during the years (2009-2014) by category.

Categories	Total
No Response	4.44%
< R.O. 1 Million	11.11%
R.O. 1 Million - R.O. 5 Million	35.56%
R.O. 6 Million - R.O. 10 Million	6.67%
> R.O. 10 Million	42.22%

**Table 3.** Ranges of variations between the actual and estimated cost.

Categories	Total
No Response	2.22%
No Project Overrun	11.11%
0% - 10 %	51.1%
10% - 20%	20%
20% - 30%	15.56%
More than 30%	0

**Table 4.** Top management involvement in the estimation process.

Categories	Client	Consultant	Contractor	Total	%
No Response	1	0	0	1	2.22%
Direct Involvement	4	12	8	24	53.33%
Indirect Involvement	3	1	5	9	20%
Last Stage Involvement	6	2	2	10	22.2%
Others	1	0	0	1	2.22%
Total	15	15	15	45	100%

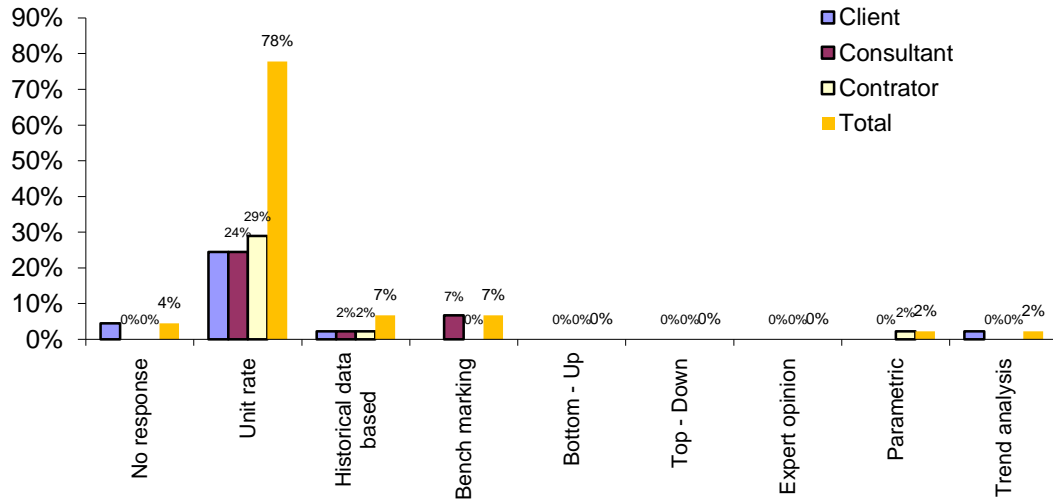


Figure 4. Commonly used cost estimation techniques.

Table 5. Criteria to be considered while cost estimating.

Categories	Client	Consultant	Contractor	Total	%
No Response	2	0	0	2	4.44%
Level of scope of work available	2	2	9	13	28.9%
Size of Project	2	0	0	2	4.44%
Time constraint	0	0	0	0	0
Availability of software	0	0	0	0	0
All of the above	9	13	6	28	62.22%
Total	15	15	15	45	100%

Table 6. Respondents reasoning for using rate method.

Categories	Client	Consultant	Contractor	Total	%
No Response	2	0	0	2	4.44%
Very Accurate Method	10	6	9	25	55.56%
Safest Method When Scope Of Work Is Unclear	3	5	6	14	31.11%
Most Recommended By Management	0	1	0	1	2.22%
Other Methods Are Risky	0	3	0	3	6.67%
Total	15	15	15	45	100%

Table 7. Is the historical bid- based estimate the most commonly used in Oman?

Categories	Client	Consultant	Contractor	Total	%
No Response	2	0	0	2	%
Agree	8	9	8	25	55.56%
Not Agree	5	6	6	17	37.78
Others	0	0	1	1	2.22%
Total	15	15	15	45	100%

opinion that benchmarking was a commonly used methodology in Oman (Table 9). Both Clients (53%) and Consultants (73%) strongly disagreed with the use of Benchmarking, as they believe that the method is highly inaccurate. They did however point out that it is the fastest method used in arriving at an estimate.

### 3.3 The use of Software for Project Cost Estimation

The use of software in the estimating process is beneficial in many ways. Software provides estimators with the tools that enable them to save time. Software assists estimators in calculating the total net cost of the project. In addition, it helps those who have to make decisions based on the estimator's report. It also

assists in implementing company procedures through standardization (Brook 2010). 48.8% of the respondents stated that they do not use any computer software for cost estimating, as opposed to 46.6% who said that they do (Table 10). 37.7% of the respondents stated that historical average prices are developed by the input of rates based on bid data (Table 11). 31% disagreed with the statement above. Around 49% of the respondents reported that software was not based on historical low bid cost data (Table 12). Historical cost databases are always considered when there is a requirement for readily available construction information. Historical cost databases serve as a guide during the early stages of project development.

**Table 8.** Revision methodology used in validating historical data.

Categories	Client	Consultant	Contractor	Total	%
No Response	2	0	0	2	4.44%
Revision According To Nature Of Project	5	5	5	15	33.33%
Revision As Market Survey	6	0	1	7	15.56%
Revision As New Process Of Project	0	1	2	3	6.67%
All Of The Above	2	9	7	18	40%
Total	15	15	15	45	100%

**Table 9.** Is benchmarking the most commonly used method in Oman?

Categories	Client	Consultant	Contractor	Total	%
No Response	0	0	3	3	6.67%
Agree	6	4	5	15	33.33%
Not agree	8	11	5	24	53.33%
Others	1	0	2	3	6.67%
Total	15	15	15	45	100%

**Table 10.** Organizations using software for cost estimation.

Categories	Contractor	Consultant	Client	Total	%
No Response	0	0	2	2	
Yes	7	8	6	21	46.6%
No	8	7	7	22	48.8%
Total	15	15	15	45	

**Table 11.** Rates updated in software based on bid data to develop average prices.

Categories	Client	Consultant	Contractor	Total	%
No Response	3	0	0	3	6.66%
Yes	4	8	5	17	37.7%
No	3	6	5	14	31%
Others	5	1	5	11	24.44%
Total	15	15	15	45	100%

**Table 12.** Software based on historical low bid cost data.

Categories	Client	Consultant	Contractor	Total
No Response	3	0	0	6.66%
Yes	2	6	0	17.77%
No	5	8	9	48.88%
Others	5	1	6	26.66%
Total	15	15	15	100%



There are various factors that play a role in interpreting cost databases as discussed earlier in the interpretation of the results. To name a few: (1) project size, (2) year being built, (3) inflation rate, (4) local market conditions, (5) complexity of the project, (7) procurement method, (8) site conditions. Modern historical database mining is all about better utilization and re-use of existing data. 48.9% of the respondents claimed that unit rate analysis was the basis for pricing rates (Table 13). This finding indicates that the rates used in the software are revised and analyzed according to the latest project scope of work available. 22.2% of the respondents claimed that pricing rates are based on the project process. In either case, pricing rates are not totally dependent on historical databases. 48.9% of the respondents claimed that it was the responsibility of project estimator to define the parameters and variables which serve as inputs for cost estimation software (Table 14). 17.8% of the respondents claimed that this responsibility falls on the project manager. The reason could attributed to the fact that such organizations do not have a dedicated

estimation department and no particular estimators are assigned specifically for creating project cost estimate. Most project managers are appointed to a project as a whole. Historical budgeting data offers valuable information on the success of past construction project, while current computer technology makes it easier to develop database oriented programs (Brook 2010). Although 53.3% of the organizations reported that they do not use OLAP (On-Line Analytical Processing) facility in their project cost estimate practice, studies have proven that using the OLAP environment can help in understanding the risk in the estimated cost and provide a means for forecasting more reliable construction cost estimates (Moon and Kown 2007). OLAP provides a secure, web-based workplace for people spread around the world, thereby allowing them to share information and make analysis. 35% of the respondents stated that they deal with uncertainty in the models and software very carefully as they realized that the uncertainties can cause the cost to fluctuate erroneously (Table 15).

**Table 13.** The basis for pricing rates.

Categories	Client	Consultant	Contractor	Total
No Response	4	0	2	6
Unit Rate Analysis	6	6	10	22
Fixed Standard Notes	1	5	1	7
Updating According To Project Process	4	4	2	10
Total	15	15	15	45

**Table 14.** Fixed parameters and variables which serve as input for cost estimation software.

Categories	Client	Consultant	Contractor	Total
No Response	4	0	0	4
Project Manager	2	4	2	8
Project Estimator	8	6	8	22
Software In charge	0	0	0	0
Others	1	5	5	11
Total	15	15	15	45

**Table 15.** Dealing with uncertainties in models and software.

Categories	Client	Consultant	Contractor	Total
No Response	4	0	1	5
Ignoring Them As They Have Minimal Effect	3	3	1	7
Dealing With Them Very Carefully As They Might Change The Cost	5	4	7	16
Considering Them As Unclear Output and Including Them In The Final Cost	2	2	1	5
Others	1	6	5	12
Total	15	15	15	45

### 3.4 Risk Factors in Project Estimation Process

This section of the survey explores the various risk factors encountered in project cost estimation. After having identified the factors influencing cost estimation during all project stages, they are categorized in order of risk. Then these risk factors were designated Likert scale values ranging from 4, reflecting the highest degree of risk, to 1 reflecting the lowest degree of risk. The responses for each factor were then added and divided by the total number of responses. In doing so, the mean values for each factor were obtained. The factors were then arranged in order of priority as per client, consultant and contractor (Tables 16-18). This is done to exercise a degree of control, thereby ensuring effective cost estimation for conventional construction projects.

According to the clients, an unclear reading and understanding of specifications scores the highest critical risk factor (3.667). Unavailability of resources comes as the second highest factor (3.200), followed by market fluctuation (3.066) (Table 16). Lack of experienced human resources contributes to committing mistakes during estimating process while changing in prices of raw materials, like cement and steel, results in an unreliable estimation.

Consultants reported that lack of clear documents of the project scope of work (3.667), followed closely by unavailability of resources (3.600) and an unclear reading and understanding of specifications (3.400), were the most critical risk factors in developing of an estimate (Table 17). As can be noticed, there is an agreement between clients and consultants on the main causes of risks while making estimates. Remedies to such problems include more time and revisions of scope work with consultation of local and international experts.

The contractors reported that the most critical factors as being an unclear reading and understanding of the specification (3.466), lack of clear documents of the project scope of work (3.4667) and lack of experienced project cost estimators (3.400) (Table 18). They also reported that the vague specifications and scope of work is the main cause of risk that leads to crude estimates. A study by El-Sayegh (2014), identified forty-two risk factors which cause time and cost overrun in UAE construction industry. Most of these factors are applicable to Oman construction industry due to similarity of the Gulf countries construction environment.

**Table 16.** Order of mean values of risk factors as per clients.

Risk Factors in the Project Estimation Process	Mean Values of Factors per Client	Priority
Unclear Reading and Understanding of Specifications	3.6667	1
Unavailability of Resources	3.2000	2
Market Fluctuation	3.0667	3
Lack of Experienced Project Cost Estimator's	3.0000	4
Lack of Clear Documents of the Project Scope of Work	2.8000	5
Lack of Project Planning and Monitoring	2.5333	6
Political Influence	2.5333	7
Aggressive Competition at Tendering Stage	2.4667	8
Urgency Emphasized by Owner while Issuing Tender	2.3333	9
Uniqueness Project Activities	2.2667	10

**Table 17.** Order of mean values of risk factors as per consultants.

Risk Factors in the Project Estimation Process	Mean Values of Factors per Consultant	Priority
Lack of Clear Documents of the Project Scope of Work	3.6667	1
Unavailability of Resources	3.6000	2
Unclear Reading and Understanding of Specifications	3.4000	3
Lack of Project Planning and Monitoring	3.1333	4
Market Fluctuation	2.9333	5
Lack of Experienced Project Cost Estimator's	2.8667	6
Aggressive Competition at Tendering Stage	2.7333	7
Urgency Emphasized by Owner while Issuing Tender	2.6000	8
Uniqueness Project Activities	1.8667	9
Political Influence	1.6667	10

### 3.5 Factors Critical to a Successful Project Cost Estimation

Twenty factors have been identified as being critical to achieve a successful cost estimate. Using the factors identified as driving variables, structured questions were made to explore their actual impact. The respondents were then asked to rate each of the factors in order of importance based on their cost estimation experience, by considering all types of projects they have been involved in. Likert scale with values ranging from 4, reflecting most critical, to 1, reflecting least critical, was used for evaluating the success of the project. The responses for each of the factors were then added and divided by the total

number of responses to result the mean values of each factor. Tables 19-21 show the factors' priorities as per the responses from the clients, consultants, and contractors respectively.

According to the clients, accuracy in taking quantities (4.066), availability of materials, skilled labour, equipment and time (4.066) and accuracy of data (3.933), were the most important factors to obtaining a successful cost estimate (Table 19). Again, accuracy in estimating the quantities requires reasonably high experience and involvement by estimator. Failure to control the cost of both human and materials leads to bad consequences on the overall estimated budget.

**Table 18.** Order of mean values of risk factors as per contractors.

Risk Factors in the Project Estimation Process	Mean values of factors per Contractor	Priority
Unclear Reading and Understanding of Specifications	3.4667	1
Lack of Clear Documents of the Project Scope of Work	3.4667	2
Lack of Experienced Project Cost Estimator's	3.4000	3
Market Fluctuation	3.2000	4
Unavailability of Resources	3.1333	5
Aggressive Competition at Tendering Stage	3.0000	6
Lack of Project Planning and Monitoring	2.9333	7
Urgency Emphasized by Owner while Issuing Tender	2.8000	8
Uniqueness Project Activities	2.4000	9
Political Influence	2.0000	10

**Table 19.** Mean values of critical factors to successful project cost estimation as per the clients.

Factors Critical to successful Project Cost Estimation	Mean /client	Priority
Accuracy in Taking Quantity	4.0667	1
Availability of Materials, Skilled Labor, Equipment and Time	4.0667	2
Availability and Accuracy of Data	3.9333	3
Top Management Involvement	3.8000	4
The Contractor / Consultant Work Load	3.8000	5
Collection of Quotations During the Estimation Process	3.7333	6
Wide Range of Options and Choices of Different Material	3.6667	7
Pre-bid Vendor Negotiation	3.6000	8
Involvement of Project Oriented Personnel in the Estimation Process	3.6000	9
Deviating from the Original Scope of Work	3.5333	10
Reliability of the Materials Quotations Provided by Suppliers	3.5333	11
Contractors keen on the job	3.4000	12
Clear Documentation of Projects	3.4000	13
Size and Value of the Project	3.3333	14
Level of Awareness of Competition in the Omani Market	3.3333	15
Timely Decision by the Owner/ His Staff	3.2667	16
Chances Of Improper Understanding of Client Requirement	3.2000	17
In-house Logistics	3.2000	18
Existence of Unit Rate Analysis	3.1429	19
Outsourcing Certain Services All Though Available In-House	2.9333	20

The consultants reported that accuracy in taking quantities (4.200), availability and accuracy of data (4.066) and deviation from the original scope of work (4.000) were the most important factors to reaching a successful cost estimate (Table 20).

Contractors reported that their interest in the job

(4.400), the involvement of project-oriented personnel of the estimation process (4.400) and clear documentation of projects (4.333) were the most important factors to obtaining a successful cost estimate (Table 21). The factors cited above fall in-line with the results of a study Liu and Zhu (2007)

**Table 20.** Mean values of critical factors to successful project cost estimation as per the consultants.

<b>Factors Critical to successful Project Cost Estimation</b>	<b>Mean Values of Factors per Consultant</b>	<b>Priority</b>
Accuracy In Taking Quantity	4.2000	1
Availability and Accuracy of Data	4.0667	2
Deviating from the Original Scope of Work	4.0000	3
Collection of Quotations During the Estimation Process	4.0000	4
In-house Logistics	3.9333	5
Availability of Materials, Skilled Labor, Equipment and Time	3.8000	6
Top Management Involvement	3.7333	7
Clear Documentation of Projects	3.6667	8
Pre-bid Vendor Negotiation	3.3333	9
Contractors keen on the job	3.2667	10
Existence of Unit Rate Analysis	3.2000	11
Outsourcing Certain Services All Though Available In-House	3.2000	12
Reliability of the Materials Quotations Provided by Suppliers	3.1333	13
Timely Decision by the Owner/ His Staff	3.0667	14
The Contractor / Consultant Work Load	3.0000	15
Level of Awareness of Competition in the Omani Market	2.8667	16
Wide Range of Options and Choices of Different Material	2.7692	17
Involvement of Project Oriented Personnel in the Estimation Process	2.7333	18
Chances Of Improper Understanding of Client Requirement	2.6667	19
Size and Value of the Project	2.2667	20

**Table 21.** Mean values of critical factors to successful project cost estimation per the contractors.

<b>Factors Critical to successful Project Cost Estimation</b>	<b>Mean Values of Factors per Contractor</b>	<b>Priority</b>
Contractors keen on the job	4.4000	1
Involvement of Project Oriented Personnel in the Estimation Process	4.4000	2
Clear Documentation of Projects	4.3333	3
Availability of Materials, Skilled Labor, Equipment and Time	4.3333	4
Accuracy Taking Quantity	4.2667	5
Collection of Quotations During the Estimation Process	4.2667	6
In-house Logistics	4.1333	7
Deviating from the Original Scope of Work	4.0000	8
Existence of Unit Rate Analysis	3.9333	9
Outsourcing Certain Services All Though Available In-House	3.8667	10
Pre-bid Vendor Negotiation	3.8667	11
Size and Value of the Project	3.8000	12
Level of Awareness of Competition in the Omani Market	3.8000	13
Wide Range of Options and Choices of Different Material	3.7333	14
Reliability of the Materials Quotations Provided by Suppliers	3.7333	15
The Contractor / Consultant Work Load	3.6000	16
Availability and Accuracy of Data	3.5333	17
Top Management Involvement	3.4000	18
Timely Decision by the Owner/ His Staff	3.4000	19
Chances Of Improper Understanding of Client Requirement	3.2667	20

mentioned in the literature review. The authors have shown that cost estimates may be improved by using phased cost factors. This was achieved by grouping influential factors into three: (1) input control factors, (2) behavioural control factors, and (3) output control factors. The responses obtained show that almost all the factors stated above have the same influence in the construction industry in Oman.

#### 4. CONCLUSION

This paper surveyed and assessed project management practices and techniques used in construction cost estimation across Oman. It also explored risk factors that contributed to unsuccessful cost estimation process in these projects. Inadequate or poor cost estimation has been identified as one of the major causes for project cost overruns in Oman. Although a number of high value projects have been successfully completed in Oman during the period 2009-2014, opinion amongst clients, consultants and contractors suggests that clients pay the least amount of attention to the cost estimate.

Feedback from face-to-face interviews and the literature review have helped to identify current best practices and techniques that can aid in achieving a successful project cost estimate. Also, identified are factors that can lead to risk and subsequent success or failure in the cost estimation process. As shown in Table 3, cost overrun in projects especially in the 20% – 30% range is prevalent amongst clients and consultants. Contractors, on the other hand, claim to have a maximum of only 10% cost overrun. The research results showed that:

- Around 35% of projects were completed with variation within the estimated budget in the range of 10%-30% (Table 2 and 3).
- The most commonly used cost estimation technique was the unit rate method (Fig. 4).
- Using a web-based software which updates unit rate price proved to be effective in reaching adequate cost estimate.
- Top management involvement provides confidence on the project cost estimate accuracy.
- Both clients and contractors believe that unclear understanding of specifications is the highest risk factor toward a cost overrun.
- Both clients and consultants consider accuracy in taking quantities is the most important factor that contributes to a successful estimation process.

It is recommended that clients need to invest further into the methods and procedures of cost estimation in order to have a better visualization of their projects. It is also recommended that future studies in cost estimation practices be carried out more precisely, as per cost estimate techniques matched to a sector. Research on each cost estimating method that examines the pros and cons of the method would be more effective. A distinction needs to be made whereby the techniques used in specific industry are not necessarily ported over to another industry and vice versa. Methodologies should be specific to the industry the company operates in.

#### CONFLICT OF INTEREST

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