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COST OVERRUN IN CONSTRUCTION PROJECTS IN DEVELOPING COUNTRIES, GAS-OIL INDUSTRY OF IRAN AS A CASE STUDY

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Abstract. Cost overrun in construction projects is a common issue affecting project performance, and Gas-Oil construction projects in Iran are no exception. This paper presents the results of a questionnaire conducted to identify and evaluate the relative importance of the significant factors contributing to the Gas-Oil construction industry of Iran as a case study for developing countries. The survey respondents included project owners, contractors and consultants involved in Iranian Gas-Oil construction projects. The results of the survey revealed that the main causes of cost overrun in this industry include inaccurate cost estimations, improper planning, frequent design changes, inadequate labour/skill availability, inflation of costs of machinery, labour, raw material and transportation prices. The first three factors are the project consultants' responsibility and the appointment of qualified consultants and personnel training are strongly recommended to alleviate cost overrun. The paper also reviews and compares findings of a set of similar researches in a number of developing countries.

Keywords: cost overrun, construction, developing countries, Iran, case study.

Introduction

Project success can be defined as meeting goals and objectives prescribed in the project plan (Ojo *et al.* 2011). Frimpong *et al.* (2003) describes a successful project as one that has accomplished its technical performance, maintained its schedule and remained within budgetary costs, besides considering the environmental conditions of the project site as well as the health and safety of project workers and local community. Because of the extensive use of sophisticated equipment, innovative construction methods, differences in the stakeholders' interests and restricted durations, construction projects are generally complex. This complexity, aligned with financial and engineering issues may consequently lead a project to suffer from time and cost escalations (overrun) or lack of quality. Cost overrun has been identified as the most serious effect among them all, especially in expensive projects with tight financial support. Project cost overrun is defined as the positive difference between the actual cost upon project completion and the agreed estimation of the project budget. Harisaweni (2007), a researcher in the field of cost and time issues in developing countries, reported that a construction project experiences cost overrun if it is completed in excess of the budget estimate which was included in the approved contract.

Cost overrun and delay have obvious effects on project performance and most certainly cause significant inconvenience to both clients and project owners (Ojo *et al.* 2011; Kazaz *et al.* 2012). The highest priority of project stakeholders is cost certainty, which is considered as a good and measurable indicator for project success and performance (Dey *et al.* 1996). Additionally, client satisfaction is an important determinant of contractor performance evaluation and comparison.

Developing countries are defined as nations which have not achieved a significant degree of industrialization relative to their population. These countries have, in most cases, a medium to low standard of living but they pursue becoming more advanced both economically and socially (Sullivan, Sheffrin 2003). Resulted from these endeavours towards advancement, construction companies are mushrooming in developing countries and therefore contractors need to initiate and maintain client satisfaction in order to remain competent in the industry (Torbica, Stroh 2001).

Developing countries are defined by the World Bank according to their Gross National Income (GNI) per capita per year. Countries with a GNI of US$ 11,905 and less are defined as developing (World Bank 2012). Delay and cost overrun are common phenomena in projects worldwide. However, these are especially severe in developing countries (Le-Hoai *et al.* 2008) because of economic difficulties which usually lead the construction projects in these countries to financial tightness. Addi-

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tionally, managing construction projects in developing countries has its special properties due to a range of issues spanning from political instability to unavailability of human resources and the rate and effect of inflation (Faniran *et al.* 2000). Considering these similarities, it would be fruitful to study a set of researches in this field for a number of developing countries and compare the main causes of cost and time escalation identified in them. There will be a deeper look into this in the literature review part of this paper.

A preliminary research in Iran showed that many petroleum construction projects suffer from cost overruns because many contractors lack managerial skills (Derakhshanalavijeh 2012). In 2006, the project manager of the Iranian Offshore Engineering Company (IOEC) announced that the offshore segments of the 9th and 10th phases of the South Pars gas field development plan had cost $70 million in excess of the contract's initial price. These two phases were planned to cost $374 million, but the escalation in the steel price, transportation costs, drilling rig costs and other expenditures resulted in the enormous amount of cost overrun. At the time of his statement, the 9th and 10th offshore phases were 67% completed and it had been decided that the contractor should pay for project's cost overrun (Derakhshanalavijeh 2012).

The emergence of these problems, evidenced with details of project cost issues in the Gas-Oil industry, reveals the necessity for further research about cost overruns within Iranian construction industry. As some of these problems occur as a result of ignorance of basic principles in project management, apperceiving project scope and project cost management plan seems necessary to mitigate problems of cost. This research is carried out to find the root causes of cost escalation in Gas-Oil projects in Iran. Additionally, it reviews a number of similar researches conducted in a number of developing countries aiming to find similar trends and to suggest solutions.

1. Literature review

Regardless of their type, location, size, and scope, time and cost can be considered and the main concepts of project management knowledge. Large construction projects, with their features of complexity and capital requirements, have attracted interest of many researchers who address major issues in cost and time management methods and suggest new techniques for controlling them in construction projects.

Table 1 compares the top ten ranked factors in a number of researches conducted formerly in Ghana, Kuwait, Pakistan, Vietnam and Nigeria. While the authors of these researches categorized all of the cost or time extension causes with their own grouping system, and didn't used a structured classification, it would be more practical to coordinate the causes signalled by them in an integrated categorizing system, similar to the one used for this research, with six categories: Owner flaws, Resource accessibility, Contractor/consultant flaws, Macroeconomic, Environment and external, as represented in Table 1.

In 2003 Frimpong *et al.* (2003) carried out a research about causes of delay and cost overrun in construction of groundwater projects in Ghana. Identifying 26 cost and time inducing factors, they distributed questionnaire to three groups of owners, consultants and contractors involved in construction projects. The results show that three groups of respondents-owners, consultants and contractors – have a good compromise on the top five factors. According to their research, owner and contractor/consultant flaws are the main causes of cost issues in groundwater projects in Ghana and no blame was pointed to macroeconomic or resourcing related issues (Frimpong *et al.* 2003).

With face-to-face interview of 450 randomly selected project owners from construction private sector in Kuwait, Koushki *et al.* (2005) identified main roots of delay and cost extension, identifying the first three causes of delay in construction projects in Kuwait as changing orders, owner's financial constraints and owners' lack of experience. Three main causes of cost increase were introduced as contractor-related problems, material related problems and owner's financial constraints. Recommendations from those researchers for minimizing time and cost overruns are providing adequate funds from owners, allocation of sufficient time and cost at the design phase and selection of competent consultants and reliable contractors to carry out the work. Compared to their fellow researchers in other developing countries, their research included the most extended real project data survey. Although this was the most remarkable point of the research, it is a regret their identified cost and time overrun causes were too generalized with the least possible details on each factor. According to the major categories, the results of the research are very similar to the one from Ghana, although as a result of economic stability in Kuwait, factors within macroeconomic category are not introduced effective for extending cost and time of projects.

Azhar *et al.* (2008) exploited a questionnaire survey in Pakistan categorizing a set of 44 factors in three groups of macroeconomic factors, management factors and business and regulatory environment related factors to examine their value in cost issues of construction projects. Regarding their findings, unstable cost of both manufactured and raw materials paralleled with inefficient lowest bidding method for selection of potential contractors are the main factors affecting cost of construction projects in Pakistan. Contractors, consultants and macroeconomic related items are blamed as the most important causes of cost extensions in Pakistan (Azhar *et al.* 2008). With limited number of questionnaire responses, the accuracy and trustworthy of results of their research is questionable.

In a similar research in Vietnam by Le-Hoai *et al.* (2008) the researchers introduce an opinion about developing countries that in these countries efforts have been

Table 1. Top ten ranked factors in some researches from developing countries with categories

	Causes									
Rank	1	2	3	4	5	6	7	8	9	10
Ghana (Frimpong *et al.* 2003)	Poor Contract Management	Material Procurement	Planning and Scheduling Deficiencies	Escalation of Material Prices	Contractor's financial difficulties	Monthly Payment difficul-ties	Cash flow during construction	Inflations	Bad weather	Deficiencies in cost estimates prepared
Category (by researcher)	Owner	Labor/ Material & Contractor	Consultant	External	Contractor	Owner	Owner	External	External	Consultant
Major Category	Owner Flaws	Resource Accesibility	Contractor/ Consul-tant Flaws	External	Contractor/ Consultant Flaws	Owner Flaws	Owner Flaws	Macro-Economic	Environment	Contractor/ Consultant Flaws
Kuwait (Koushki *et al.* 2005)	Change Orders	Financial Constraints	Owner's Lack of Experience	Materials	Contractor	Weather	Labour	–	–	–
Category (by researcher)	Consultant	Owner	Owner	Labour/ Material	Contractor	External	Labour/ Material	–	–	–
Major Category	Contractor/ Consultant Flaws	Owner Flaws	Owner Flaws	Resource Accessibility	Contractor/ Consultant Flaws	Environment	Resource Accessibility	–	–	–
Pakistan (Azhar *et al.* 2008)	Fluctuation of Costs of Raw Materials	Unstable Cost of Manufactured Materials	High Cost of Machineries	Lowest Bidding Procurement Method	Poor Project Management/ Poor Cost Control	Long Period Between Design and Time of Bidding	Wrong Method of Cost Estimation	Additional Work	Improper Planning	Inappropriate Government Policies
Category (by researcher)	Macro-Economic	Macro-Economic	Macro-Economic	Business and Regulatory Environment	Management	Business and Regulatory Environment	Business and Regulatory Environment	Management	Management	Business and Regulatory Environment
Major Category	Macro-Economic	Macro-Economic	Macro-Economic	External	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	External
Vietnam (Le-Hoai *et al.* 2008)	Poor Site Management	Poor Project Management Assistance	Financial Difficulties of Owner	Financial Difficulties of Contractor	Design Changes	Slow Payment of Completed work	Inaccurate Estimates	Obsolete or Unsuitable Construction Methods	Slow inspection of completed work	Mistakes during construction
Category (by researcher)	Contractor	Consultant	Owner	Contractor	Project	Owner	Consultant	Contractor	Consultant	Contractor
Major Category	Contractor/ Consul-tant Flaws	Contractor/ Consul-tant Flaws	Owner Flaws	Contractor/ Consul-tant Flaws	Contractor/ Consultant Flaws	Owner Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws
Nigeria (Ameh *et al.* 2010)	Economic Stability	Inadequate Production of Raw Materials	Government Policies	Inaccurate planning	Frequent Design Changes	Fraudulent Practices and Kick-backs	Cost of Materials	Fluctuations in the Prices of Materials	Lack of Contractor Experience	Incorrect Planning
Category (by researcher)	Environmental	Environmental	Environmental	Construction	Construction	Construction	Cost Estimating	Cost Estimating	Construction	Construction
Major Category	Macro-Economic	Resource Accessibility	Macro Economic	Contractor/ Consul-tant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Macro-Economic	Macro-Economic	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws
Iran (This research, 2012)	Inaccurate cost estimating	Improper planning	Frequent design changes/ design errors	Inadequate labor/skill availability	Inflation of machinery, raw material prices	Fluctuation of raw construction material prices	Inappropriate contract policies	Inadequate cost estimating approach	Lack of coordination between the design team and contractor	Inappropriate government policies
Category (by researcher)	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Resource Accessibility	Macro-Economic	Macro-Economic	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	Contractor/ Consultant Flaws	

spent on winning the contract rather than the contract itself which leads to sever budget and schedule problems. They recommend paying more attention to contractor selection stage and applying ISO standard in design stage. In their research, the key issues in construction cost and time are identified to be related to contractor/consultant flaws (Le-Hoai *et al.* 2008).

Ameh *et al.* (2010) mentioned this fact during their research about cost issues in telecommunication projects in Nigeria that in developing countries, where the currency change rate of money against major currencies like the US Dollar is declining fast, enough attention should be paid to the cost estimation stage to have a better estimation of the cost of imported materials. According to their research, many developing countries are politically unstable; they recommend preparing permission from law enforcement agencies to beef up on site security. As Ameh *et al.* (2010) expressed, the issue of corruption is a predominant factor affecting developing countries. Concluded from above, it becomes clear why the main cost issues identified in their research are related to macroeconomics and contractor/consultant flaws. They recommend contractors to make their stand on corruption known from the inception of the project to avoid kickbacks from the contractor as construction progresses (Ameh *et al.* 2010). The main difference of this current survey with what was done by Ameh *et al.* (2010) in Nigeria is their concentration on telecommunication projects, which have a totally different nature from construction projects.

The empirical and theoretical investigations performed by some researchers concern different aspects of project management in the gas, oil and refinery industry. Lang (1990) studied the effect of engineering, procurement and construction contracts (EPC) in managing costs within the oil industry but with a scattered outline, the author aimed to cover various aspects of project management, spanning from contracting issues to difficulties in resourcing, which have resulted in a lack of concentration in the whole paper. Dey *et al.* (1996) tried to develop a hierarchical planing model which enables decision makers to take vital decisions during the changing environment of the pipeline construction period. Extensive quantitative risk analysis was provided in the paper with limitted concentration on project cost management. Asrilhant *et al*. (2004, 2005) explored decision support and strategic project management in the gas and oil sector, concentrating on management process elements: context, content, internal business, external environment and learning and innovations perspectives. The data selected by those researchers, unfortunately, was scarce. Pongsakdi *et al.* (2006) addressed issues of uncertainty and the financial risk aspects in the planning of refinery operations. The major merit of the paper is detailed analysis of risk factors of Bangchak refinery as a case study.

There is also a major attention to cost related issues of construction projects in Iran. A substantial number of newspaper articles and interviews have been published targeting this field. In 2010 Mehdi Bazargan, the manager of strategic planning of oil ministry expressed that international sanctions against Iran have affected Gas-Oil project costs by causing difficulties for Iranian clients to reach essential equipments, resulting in higher prices for equipments as well as significant delays (Bazargan 2010). In 2011 the minister of oil introduced sanctions as the most serious causes of cost and time extensions (Petroleum University of Technology 2011). Quoting from one of the most important experts in Gas-Oil field in Iran, Akbar Torkan, since their commencement, sanctions have resulted to a fourth fold increase in the cost of these projects (PANA News 2013).

Focusing on financial management, other researchers tried to describe cost issues within the general construction industry of Iran, whereas most of them concentrated on time issues within Gas-Oil construction projects. A summary of some of them is outlined below.

Yadghar *et al.* (2006) introduced weakness in procurement and construction as the main reasons of delay in Gas-Oil projects. They also mentioned that procurement weights 45~75% of the total project and so logically the main reason of delay nests in the weakness of procurement phase.

Vafaiee *et al.* (2010) described the Gas-Oil industry of Iran as very confusing, due to "lots of non-pre planned contracts with too many contractors/suppliers in a great variety of project activities". They added that a lack of planning for managing project contractors has resulted in projects constantly being behind schedule, leading to many budget issues (Vafaiee *et al.* 2010). Concentrating on procurement management problems, they stated that most of the procurement oriented problems arise from inappropriately supplying goods and services required for project performance. Further they also noticed that none of the gas related construction projects in Iran have been completed within schedule, with an average delay of 60% and an average cost overrun of 20% (Vafaiee *et al.* 2010). To conduct the research a questionnaire was conveyed asking clients, consultants, contractors, management contractors and suppliers of gas projects to indicate their perception of the magnitude of thirty identified procurement-oriented problems.

Results from the Vafaiee *et al.* (2010) research, some problems such as political constraints and insufficient supportive legislation which force local banks to financially assist the gas industry, as well as excessive domestic inflation rates are strongly connected to government policies; therefore, the solution for these problems is beyond the stakeholders' range of action. However, as their research was limited to procurement management issues, the identified effective factors belong to this field only.

Dehghan *et al.* (2007) stated that project success is directly related to the definition and implementation of a sound integrated management system. On the other hand, they recognized that cost management is based on the idea that costs are not produced spontaneously but rather

as a result of managers' decisions, which are impacted by limited resources (Dehghan *et al.* 2007). The authors also stated that, given the multiplicity of contractors acting within the Iranian construction industry, there is intense competition for awarding contracts through the lowest bid method. The use of this method may lead contractors to include higher risk allowances in their bids. Therefore, contractors should firstly understand and acknowledge the costs and associated risks with sound accuracy and then control them during the construction phase in order to anticipate and mitigate cost overruns (Dehghan *et al.* 2007). As those authors described, cost control methods in Iran are not used accurately since at the lowest levels of work breakdown structure (WBS), the unit cost of resources and work is calculated on the basis of inaccurate estimations so that the total cost derived from the estimation phase is full of risks and uncertainties. Dehghan *et al.* (2007) aimed to generalize the results of their research to all the construction fields, while they are obviously completely different.

This current article reports a survey that aimed at inquiring, recording and documenting the invaluable experiences of experts and connoisseurs from Gas-Oil construction projects in Iran. Key differences between this research and other Iranian researches, which are concerned with cost and time issues within the construction industry, are the specific focus on the Gas-Oil industry and the use of an academic approach when pursuing research goals.

2. Data collection

In order to evaluate and analyze the causes of cost overrun in the Gas-Oil construction industry of Iran a questionnaire was developed with a three-step approach. Firstly, previous researches on time and cost overrun were used for reference in the pilot study. Secondly, a pilot was arranged with two construction project managers acting in the Iranian Gas-Oil industry. They clarified some of the issues that were more important from their point of view, concluding the identification of a total number of 51 factors that affect projects costs. To ensure greatest relevance and association with the Iranian construction industry, a pilot test was performed by way of a series of face-to-face interviews. Thirdly, three experts from construction projects in the Iranian Gas-Oil industry were involved in the critical review of the questionnaire design and structure. During the interviews, one of the authors together with an expert would cross-check and discusses each individual factor from the list of 51. The experts suggested adding of some more factors to the list and eliminating some of the issues that were not important or effective for cost increase. One of these experts suggested the classification approach, which was eventually adopted. By the end of this stage, the questionnaire was ready to be used. A total number of 44 factors were included and organized in the following six groups. However, the groups were not included in the questionnaire in order to prevent any bias or unwanted effect on the respondents' opinions:

- Owner flaws;
- Resource accessibility;
- Contractor/consultant flaws;
- Macroeconomic;
- Environment;
- External.

External factors are those which are not related to project parties' flaws, but they cannot be categorized within environment or macroeconomic group. Obstacles from government, inappropriate government policies and lack of construction cost data are examples of factors within this category.

The questionnaire was shared with personnel from the three principal construction parties (owner, consultant and contractor), who were asked to determine the ranks of both frequency of occurrence and severity of each factor listed in Appendix A (Table A.1).

A five point scale of 1 to 5 is adopted for evaluating the effect of each factor. These numerical values are assigned to the respondents' rating. In relation to the frequency of occurrence the following scale was used: 1– never; 2 – rarely; 3 – sometimes; 4 – often; 5 – always. In relation to severity of factor the following scale was used: 1 – no; 2 – little; 3 – moderate; 4 – very; 5 – extremely (Fig. 1).

Table 2. Number of questionnaires distributed and response rates

Respondent	Distributed	Received	Response Rate
Owners	40	16	40.00%
Consultants	80	37	46.25%
Contractors	60	25	41.67%

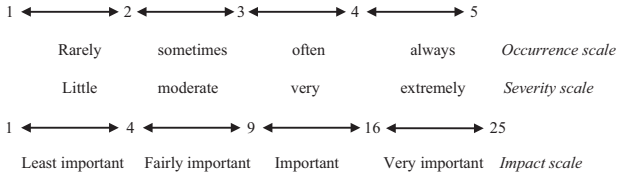

Fig. 1. Scale

Based on the respondents' rank, the mean values were calculated to show which causes had more effect on project performance. Whilst their project positions naturally differed, acting as project starter, planner or executor, respectively; the results were combined at the end, to show which factors or causes had more influence over Gas-Oil construction projects.

3. Data analysis

The responses to the questionnaires were processed by calculating their index value as a measure for identifying the factors that mostly contribute towards project

cost overrun. The index was also used to determine the various factors that demand the highest attention from the three perspectives under analysis, that of the owners, contractors and consultants. These factors would therefore be considered as identifiable problems to be solved.

Three types of indexes were considered:

- Frequency index: this index describes the occurrence frequency of a factor responsible for cost overruns. It is computed through the following formula:

$$F.I = \frac{\sum_0^4 a_i n_i}{N}, \quad (1)$$

where: a_i – constant expressing the weight assigned to each response(ranges from 0 for no occurrence to 4 for always); n_i – frequency of each response; N – total number of responses.

- Severity index: this index expresses the severity of a factor causing cost overruns. It is computed through the following formula:

$$S.I = \frac{\sum_0^4 a_i\ n_i}{N}, \quad (2)$$

where: a_i – constant expressing the weight assigned to each response (ranges from 0 for no severity to 4 for extremely severe); n_i and N as above.

- Importance index: this index expresses the overview of a factor based on both its frequency and severity. It is computed through the following formula:

$$IMP = F.I \times S.I. \quad (3)$$

- Spearman's Rank Correlation: this coefficient is used to show whether there is an agreement or disagreement among each pair of project parties. The formula for the Spearman correlation is as below (Keller 2008):

$$\rho = 1 - \frac{6\sum d_i^2}{n\left(n^2 - 1\right)}, \quad (4)$$

where: ρ is the Spearman's rank correlation; d_i is the difference between the ranks of each observation for the two variables and n is the number of ranked items.

The Spearman's rank correlation can vary from – 1 to 1 and he results can be interpreted as:

Close to –1 – Negative correlation.

Close to 0 – No linear correlation.

Close to 1 – Positive correlation.

The mean values of the responses and calculated answers obtained from the owners, contractors and consultants were classified from the lowest to the highest level, for the three indexes presented above. Index scales are graphically shown in Figure 1.

Appendix B (Tables B.1–B.3) shows the severity, frequency and impact indices for the 44 causes and their rankings as well as standard deviation for F.I and S.I, as obtained from the survey. It can be seen from these three tables that there is almost no difference in the overall ranking orders associated with occurrence and severity. This means that the more frequently a factor occurs, the greater the severity of its impact on the project budget. The deviation of the occurrence ranking order from the severity ranking order in each respondent group is small and can be neglected. Moreover, the first ten causes in the overall rankings evidence good agreement among the three parties inquired. However, a closer consensus can be seen between the consultants and overall.

4. Spearman's rank correlation

The Spearman's coefficient of rank correlation demonstrates whether there is an agreement or disagreement among each pair of parties. Table 3 illustrates the results of the Spearman coefficient calculation. The conclusion that can be inferred from these results is that there is a very good agreement among the three parties in ranking these causes regardless of the frequency, severity or importance index. The highest degree of agreement is between the owner-contractor pair, scoring 0.910 for severity, 0.848 for frequency and 0.940 for importance. Given the good agreement between the parties in their ranking of the factors causing cost overrun, all of the data could be used as a whole for further analysis.

5. Discussion on results

The results show that there are several important factors underlying the causes of cost overruns in the Gas-Oil construction industry of Iran. The five most important factors, agreed by the project owners, consultants and contractors are: inaccurate cost estimations; improper planning; frequent design changes or mistakes in design; inadequate labour/skill availability; inflation in the costs for machinery, labour, raw material and transportation prices.

Based on the answers to the questionnaire and on the result analysis performed in the above section, the

Table 3. Spearman's rank correlation results

	Severity index	Frequency index	Importance index
	Spearman rank correlation coefficient	Spearman rank correlation coefficient	Spearman rank correlation coefficient
Owners-contractors	0.910	0.848	0.940
Contractors-consultants	0.846	0.878	0.937
Owners-consultants	0.867	0.848	0.940

authors suggest the following set of solutions for cost overrun mitigation of construction projects in the Iranian Gas-Oil industry (see Table 4). These solutions are mainly suggested by the participants in the survey and some are suggested by the authors or come from previous surveys, as depicted in the table.

Comparing the results from the current research with those of previous ones from different developing countries, represented in Table 1, one may find a number of obvious differences, as well as similarities in the results. By grouping the information from Table 1 and the results from Tables B.1 to B.3, four major streams are obvious:

1. Items related to economic instability named as macroeconomic in major categorizing system: Inflation of machinery, labour, raw material and transportation prices (impact index (IMP) of 3.760, frequency index of (F.I) 1.709 and severity index (S.I) of 2.03, fluctuation of raw construction material prices (IMP = 3.227, F.I = 1.750, S.I = 1.844)). As it was mentioned earlier, researches from Pakistan and Nigeria have the most frequent items within this group. With unstable economic situation within the country and fluctuations in major currency exchange rates, just like other developing countries, Iran suffers from unexpected changes in prices. But while these causes might be identified as uncontrollable items, there are methods to mitigate their effects, as mentioned in Table 4.
2. Items related to resource accessibility: Inadequate labour/skill availability (IMP = 3.772, F.I = 1.811, S.I = 2.083). This item is the only candidate of this group ranked as effective for cost overruns in this research which is similar to other developing countries with no, or just one, resource accessibility related causes for cost/time overruns.
3. Items related to contractors and consultants flaws, or lack of knowledge and their communication is-

Table 4. Suggested solutions for the top ten problems identified

Suggested solutions	Problem
a. Select qualified cost/time estimators *b*. Regular training for cost estimators through meetings or related courses (Asrilhant *et al.* 2004) *c*. Use of models for relationships among project construction time, project cumulative sales, and cost (Chen 2011)	16th problem: Inaccurate cost estimation
a. Minimize project idle time b. Making scope, risk, team and communication perform well at the initiation and planning phase of the project (Chen *et al.* 2013)	17th problem: Improper planning
a. Selecting reputable and experienced consultants	18th problem: Frequent design changes/errors in design
b. Frequent cross check of design documents	
Set long term plans for training Iranian workers to learn welding, sealing and equipment installation techniques	1st problem: Inadequate labour/skill availability
a. Expedite orders of long delivery items as to reduce the impact of international growth in their price (Vafaiee *et al.* 2010) *b*. Prevent any delay in project schedule by accurate planning *c*. Use expert opinion and advise for estimating inflation rates	2nd problem: Inflation of machinery, labour, raw material and transportation prices
Analyzing Gas-Oil industry's risk factors comprehensively to make more realistic initial project budget (Dey *et al.* 1996; Ogunlana *et al.* 1993)	3rd problem: Prices fluctuation of raw construction materials
Consult with contract law experts before signing any contract	10th problem: Inappropriate contract policies
Consultants to select professional cost estimators to attain more accurate estimating	15th problem: Inadequate cost estimating approach
Designers and general contractors to cooperate in the project team to expedite project completion (Shahalizadeh, Farhadyar 2006)	20th problem: Lack of coordination between the design team and the general contractor
a. Select reputable and experienced contractors using the latest and most suitable construction methods *b*. Train contractors to increase their technical knowledge through regular courses	37th problem: Obsolete or inadequate construction methods
Investigate construction site conditions and activities to prevent delays and reworks (Shahalizadeh, Farhadyar 2006)	38th problem: Inadequate preconstruction study
a. Find competitive contractors by project owner *b*. Employ experienced and qualified technical staff *c*. Train fresh staff to increase their technical knowledge	40th problem: Errors during construction
Care on the selection of technology and the licensing agency at the project outset not to include countries politically in conflict with Iran (Vafaiee *et al.* 2010)	42nd problem: Inappropriate government policies

sues: Inaccurate cost estimation (IMP = 4.756, F.I = 2.162, S.I = 2.199), frequent design changes (IMP = 4.283, F.I = 2.061, S.I = 2.078), improper planning (IMP = 4.034, F.I = 2.123, S.I = 1.904), inadequate cost estimation (IMP = 3.184, F.I = 1.769, S.I = 1.798), lack of coordination between design team and general contractor (IMP = 4.001, F.I = 1.831, S.I = 2.086). This is obvious from Table 1 that in this research, as well as researches in other developing countries, majority of cost overrun causes are placed within this category. This means that consultants and contractors are the two project parties that should pay more attention to their activities, revise their methods of activity execution and extend their knowledge for their respective fields. Design and cost estimation are two main project activities that are done at the very first phases of a project. Any mistakes in these activities may eventually lead to extra cost allocation in the subsequent phases. Similarly mistakes during construction would result in wastes in material and resources.

4. External items are described as factors that are neither related to project parties, nor to environment or macroeconomic issues. Majority of these factors are related to government policies and regulations so their mitigation and resolving is within government authorities' hands. Respondents of this survey blame Iranian authorities in just one factor, inappropriate government policies that ranked 10th with IMP = 3.045. The situation is not different in other developing countries.

The authors of this research acknowledge that the results obtained from the ranking of each factor, differed substantially from the initial expectations. After the 2012 sanctions on Iranian external trade, it became prevalence to believe that the predominant problems in the construction industry were based on these limitations and on the unpredictable increase of the major currency exchange rates (mentioned as macroeconomic factors in Table A.1). However, the results of the survey revealed that although these factors can be important up to certain levels, they are ranked lower than the preventable factors such as contractor/consultant flaws or resource accessibility issues.

6. Relevance, limitations and future research

The approach used during this research was the best possible way of collecting data for a non-structured complex problem. Because the development of a mathematical model wouldn't be possible before having the picture of factors determining cost overruns. Besides, the characteristics of these issues don't allow considering other approaches, so the same procedure has been followed by former researchers worldwide (Emhjellen, Osmundsen 2001; Frimpong *et al.* 2003; Harisaweni 2007; Azhar *et al.* 2008; Le-Hoai *et al.* 2008; Ameh *et al.* 2010, etc.). The authors of this research tried to collect and treat the most relevant information from experienced trustable authorities to enhance accuracy in the output results. As there are no records of a similar research in the Gas-Oil field in Iran, this research has a considerable amount of contribution to understanding the reality of Gas-Oil construction industry management issues in Iran, mainly in the field of cost management. Similar approaches should be taken for treating problems such as delays, lack of environment concerns or experience and in other type of projects, rather that Gas-Oil. Similarly, future surveys could be performed to determine the effect on time and cost overruns brought about by the necessity of too many formal procedures prior to a project start, such as tender procedures, contract negotiation and governmental bureaucracy.

The next step after identifying the effective factors in cost overrun would be to use the results of this research to establish a framework, mathematical model or artificial intelligence model for predicting, identifying, reducing and mitigating cost overrun issues in construction projects for the Iranian Gas-Oil industry which shape the outline of the future researches of these authors. Considering similarity of the nature of cost issues in developing countries, depicted in discussion on results section, this research can also be used as a benchmark for further researches trying to clarify similar issues in developing countries.

It is suggested by the authors that the selected participants in the inquiry be addressed personally, in both the delivery of the questionnaires and when collecting the answers. Additionally, having undertaken the survey for this article, it is clear that some respondents prefer interviews to filling out questionnaires. The experience gained with this approach has assisted in recognizing the following main advantages: less time is needed waiting for the answers to the questionnaires as well as the collection of additional information during the interviews. This allowed for the composition of Table 3 above. The disadvantages are the higher survey costs due to transportation and time spent during interviews, which limited the number of inquiries and its geographical range in a large country as Iran.

Conclusions

This paper has attempted to investigate the main factors impacting the cost of Gas-Oil related construction projects in Iran as a sample of construction cost issues in developing countries. The factors were identified through interviews with Gas-Oil project managers as well as drawing on factors previously identified by researchers in the construction industry of various countries. They were then organized in the form of a questionnaire and distributed between respondents as well as active individuals working within construction projects for the gas-oil industry of Iran including project owners, consultants and contractors.

The findings of the paper could help the construction managers to gain better understanding about the problems influencing budget of large-scale construction projects. By taking care of these potential factors in their future projects, construction managers can take control of cost escalation in these projects not only in Iran, but in other developing countries.

Finally, it is worth mentioning that the research project, on which this article is based, has achieved all of its objectives and was used for the proposal of solutions for managing factors causing cost overruns, as summarized in Table 4.

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Appendix A

Table A.1. Cost overrun factors and categories

No.	Factor	Group
1	Inadequate labour/skill availability	Resource accessibility
2	Inflation of machinery, labour, raw material and transportation prices	Macroeconomic
3	Fluctuation of raw construction material prices	Macroeconomic
4	Waiting for materials/ Material procurement	Resource accessibility
5	High interest rates charged by bankers on contractor loans	Macroeconomic
6	Unstable cost of manufactured materials	Macroeconomic
7	Inadequate production of raw materials in the country	Resource accessibility
8	Inadequate duration of contract period	Contractor/Consultant
9	Inappropriate contractual procedure	Contractor/Consultant
10	Inappropriate contract policies	Contractor/Consultant
11	Inadequate quality /ambiguity of contract documents	Contractor/Consultant
12	Lowest bidding procurement method	Contractor/Consultant
13	Bureaucracy in bidding/tendering method	Contractor/Consultant
14	Lack of construction cost data	External
15	Inadequate cost estimating approach	Contractor/Consultant
16	Inaccurate cost estimating	Contractor/Consultant
17	Improper planning	Contractor/Consultant
18	Frequent design changes/ design errors	Contractor/Consultant
19	Long period between design and time of bidding/tendering	Contractor/Consultant
20	Lack of coordination between the design team and the general contractor	Consultant/Contractor
21	Scope changes occasioned by inadequate pre-contract study	Contractor/Consultant
22	Scope changes arising from redesign and extensive variation	Contractor/Consultant
23	Poor financial control on site	Contractor/Consultant
24	Poor relationship between management and labour	Contractor/Consultant
25	Breakdown of construction plant and equipment	External/Contractor
26	Unforeseen site conditions	Environment
27	Stealing and waste on site	External/Contractor
28	Social effects like disputes on site	External/Contractor
29	Adverse effect of weather/ Bad weather	External
30	Inadequate site investigation	Contractor/Consultant
31	Additional work	Contractor/Consultant
32	Fraudulent practices, kickbacks, corruption	Contractor/Consultant
33	Incompetent subcontractors	Contractor/Consultant
34	Lack of coordination between general contractor and subcontractors	Contractor/Consultant
35	Litigation	Contractor/Consultant
36	Work suspensions owing to conflicts	Contractor/Consultant
37	Obsolete or inadequate construction methods	Contractor/Consultant
38	Inadequate preconstruction study	Contractor/Consultant
39	Numerous construction activities going on at the same time	Owner flaws
40	Errors during construction	Contractor/Consultant
41	Domination of construction industry by foreign firms and aids	External
42	Inappropriate government policies	External
43	Obstacles from government	External
44	Financing and payment method for completed work	Owner flaws

Appendix B

Table B.1. Responses from owners, contractors and consultants, factors' severity index, mean values, standard deviation and ranking of the top ten overall factors

Factor No.	Overall		Owner			Consultant			Contractor		
	S.I	Rank	S.I	St. dev	Rank	S.I	St. dev	Rank	S.I	St. dev	Rank
8	2.139	1	2.077	0.760	2	2.273	0.786	2	2.067	0.704	2
11	2.135	2	2.000	0.816	3	2.273	0.786	2	2.133	0.743	1
38	2.134	3	2.154	0.689	1	2.182	0.751	3	2.067	0.704	2
42	2.100	4	2.077	0.760	2	2.091	0.701	4	2.133	0.743	1
20	2.086	5	2.077	0.954	2	2.182	0.874	3	2.000	0.845	3
1	2.083	6	2.000	0.816	3	2.182	0.874	3	2.067	0.926	2
18	2.078	7	2.077	0.494	2	2.091	0.539	4	2.067	0.799	2
9	2.078	8	2.077	0.760	2	2.091	0.831	4	2.067	0.704	2
37	2.056	9	2.077	0.760	2	2.091	0.831	4	2.000	0.756	3
10	2.044	10	2.000	0.707	3	2.000	0.632	5	2.133	0.640	1

Table B.2. Responses from owners, contractors and consultants, factors' severity index, mean values, standard deviation and ranking of the top ten overall factors

Factor No.	Overall		Owner			Consultant			Contractor		
	F.I	Rank	F.I	St. dev	Rank	F.I	St. dev	Rank	F.I	St. dev	Rank
16	2.162	1	2.154	0.801	1	2.000	0.775	4	2.333	0.617	1
17	2.123	5	2.077	0.760	3	2.091	0.701	2	2.200	0.862	2
18	2.061	11	2.000	1.080	10	2.182	0.874	3	2.000	0.756	11
8	1.927	4	2.000	1.080	3	2.182	0.982	1	1.600	1.056	5
20	1.831	15	1.692	1.109	5	2.000	0.894	4	1.800	0.941	4
1	1.811	6	1.615	1.044	6	1.818	1.168	5	2.000	0.980	3
15	1.769	11	1.615	1.044	6	2.091	0.831	2	1.600	0.986	5
3	1.750	8	1.615	1.121	6	1.636	1.206	6	2.000	0.845	3
2	1.709	9	1.692	0.751	5	1.636	0.809	6	1.800	0.775	4
40	1.602	30	1.769	1.013	4	1.636	1.206	6	1.400	1.183	7

Table B.3. Responses from owners, contractors and consultants, factors' severity index, mean values, standard deviation and ranking of the top ten overall factors

Factor No.	Overall		Owner		Consultant		Contractor	
	IMP.I	Rank	IMP.I	Rank	IMP.I	Rank	IMP.I	Rank
16	4.756	1	4.739	1	4.400	5	5.133	1
18	4.283	2	4.154	3	4.563	2	4.134	3
8	4.122	3	4.154	3	4.960	1	3.307	6
17	4.034	4	3.946	2	3.973	7	4.180	2
1	3.772	5	3.230	5	3.967	6	4.134	3
20	4.001	6	4.135	4	4.567	4	3.302	5
2	3.760	7	3.722	4	3.599	8	3.960	5
15	3.184	8	2.907	10	3.764	3	2.880	8
3	3.063	9	2.826	7	2.863	11	3.500	4
42	3.045	10	3.012	8	3.032	10	3.093	7

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