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-
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 (Derakhshanlavijeh 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 (Derakhshanlavijeh 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 use 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

| Rank | Category (by researcher) | Changing Orders | Flaws | Materials | Consultant/Flaws | Consultant/Flaws | Consultant/Flaws | Consultant/Flaws | Consultant/Flaws | Consultant/Flaws |
|------|-------------------------|-----------------|-------|-----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|      | Ghana (Frimpong et al. 2003) | Poor Contract Management | Material Procurement | Planning and Scheduling Deficiencies | Escalation of Material Prices | Contractor’s financial difficulties | Monthly Payment difficulties | Cash flow during construction | Inflations | Deficiencies in cost estimates prepared |
|      | Category (by researcher) | Owner | Labor/ Material & Contractor | External | Consultant | Contractor | Owner | Owner | External | External | Consultant |
|      | Major Category | Owner | Flaws | Resource Accessibility | Consultant/ 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 | Consultant | Weather | Labour | — | — | — |
|      | Category (by researcher) | Consultant | Owner | Owner | Labour/ Material | Consultant | External | Labour/ Material | — | — | — |
|      | Major Category | Consultant/ Flaws | Owner Flaws | Owner Flaws | Resource Accessibility | 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 | Consultant/ Consultant Flaws | Consultant/ Consultant Flaws | Consultant/ Consultant Flaws | Consultant/ Consultant Flaws | Consultant/ 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 | Consultant | Project | Owner | Consultant | Contractor | Consultant | Contractor |
|      | Major Category | Contractor/ Consultant Flaws | Contractor/ Consultant Flaws | Owner Flaws | Contractor/ Consultant Flaws | Contractor/ Consultant Flaws | Owner Flaws | Contractor/ Consultant Flaws | Contractor/ Consultant Flaws | Contractor/ Consultant Flaws | Contractor/ Consultant Flaws |
|      | Nigeria (Amele et al. 2010) | Economic Stability | Inadequate Production of Raw Materials | Government Policies | Inaccurate Planning | Frequent Design Changes | Fraudulent Practices and Kickbacks | Fluctuations in the Prices of Materials | Lack of Contractor Experience | Incorrect Planning |
|      | Category (by researcher) | Environmental | Environmental | Environmental | Construction | Construction | Cost Estimating | Cost Estimating | Construction | Construction |
|      | Major Category | Macro- Economic | Resource Accessibility | Macro Economic | Consultant/ Consultant Flaws | Consultant/ Consultant Flaws | Consultant/ Consultant Flaws | Macro- Economic | Consultant/ Consultant Flaws | Consultant/ Consultant Flaws | Consultant/ 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 | Resource Accessibility | Macro- Economic | Macro- Economic | Contractor/ Consultant Flaws | Contractor/ Consultant Flaws | 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 planning 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 limited 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 Mehd 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.

Vafaeie 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 (Vafaeie 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% (Vafaeie 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 Vafaeie 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 within this category. Obstacles 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).

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

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

![Fig. 1. Scale](image-url)
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:

\[ F.I = \frac{\sum a_i n_i}{N}, \]  

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:

\[ S.I = \frac{\sum a_i n_i}{N}, \]  

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:

\[ I.M.P = F.I \times S.I. \]  

\[ \rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}, \]  

where: \( \rho \) 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
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 |
|---------------------|---------|
| 1. Select qualified cost/time estimators | 16th problem: Inaccurate cost estimation |
| 2. Regular training for cost estimators through meetings or related courses (Asrilhant et al. 2004) | |
| 3. Use of models for relationships among project construction time, project cumulative sales, and cost (Chen 2011) | |
| a. Minimize project idle time | 17th problem: Improper planning |
| b. Making scope, risk, team and communication perform well at the initiation and planning phase of the project (Chen et al. 2013) | |
| 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) | 2nd problem: Inflation of machinery, labour, raw material and transportation prices |
| b. Prevent any delay in project schedule by accurate planning | |
| c. Use expert opinion and advise for estimating inflation rates | |
| 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 | 37th problem: Obsolete or inadequate construction methods |
| b. Train contractors to increase their technical knowledge through regular courses | |
| 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 | 40th problem: Errors during construction |
| b. Employ experienced and qualified technical staff | |
| c. Train fresh staff to increase their technical knowledge | |
| 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 |
issues: 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 trustworthy 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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### 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 S.I | Owner S.I | Consultant S.I | Contractor S.I |
|------------|-------------|-----------|----------------|----------------|
|            | Rank        | St. dev   | Rank           | St. dev        | Rank           | St. dev | Rank |
| 8          | 2.139       | 2.077     | 0.760          | 2.273          | 0.786          | 2.067   | 0.704 | 2 |
| 11         | 2.135       | 2.000     | 0.816          | 2.273          | 0.786          | 2.133   | 0.743 | 1 |
| 38         | 2.134       | 2.154     | 0.689          | 2.273          | 0.751          | 2.067   | 0.704 | 2 |
| 42         | 2.100       | 2.077     | 0.760          | 2.091          | 0.701          | 2.133   | 0.743 | 1 |
| 20         | 2.086       | 2.077     | 0.954          | 2.182          | 0.874          | 2.000   | 0.845 | 3 |
| 1          | 2.083       | 2.000     | 0.816          | 2.182          | 0.874          | 2.067   | 0.926 | 2 |
| 18         | 2.078       | 2.077     | 0.494          | 2.091          | 0.539          | 2.067   | 0.799 | 2 |
| 9          | 2.078       | 2.077     | 0.760          | 2.091          | 0.831          | 2.000   | 0.704 | 2 |
| 37         | 2.056       | 2.077     | 0.760          | 2.091          | 0.831          | 2.000   | 0.756 | 3 |
| 10         | 2.044       | 2.000     | 0.707          | 2.000          | 0.632          | 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 F.I | Owner F.I | Consultant F.I | Contractor F.I |
|------------|-------------|-----------|----------------|----------------|
|            | Rank        | St. dev   | Rank           | St. dev        | Rank           | St. dev | Rank |
| 16         | 2.162       | 2.154     | 0.801          | 2.000          | 0.775          | 2.333   | 0.617 | 1 |
| 17         | 2.123       | 2.077     | 0.760          | 2.091          | 0.701          | 2.200   | 0.862 | 2 |
| 18         | 2.061       | 2.000     | 1.080          | 2.182          | 0.874          | 2.000   | 0.756 | 11 |
| 8          | 1.927       | 2.000     | 1.080          | 2.182          | 0.982          | 1.600   | 1.056 | 5 |
| 20         | 1.831       | 1.692     | 1.109          | 2.000          | 0.894          | 1.800   | 0.941 | 4 |
| 1          | 1.811       | 1.615     | 1.044          | 1.818          | 1.168          | 2.000   | 0.980 | 3 |
| 15         | 1.769       | 1.615     | 1.044          | 2.091          | 0.831          | 1.600   | 0.986 | 5 |
| 3          | 1.750       | 1.615     | 1.121          | 1.636          | 1.206          | 2.000   | 0.845 | 3 |
| 2          | 1.709       | 1.692     | 0.751          | 1.636          | 0.809          | 1.800   | 0.775 | 4 |
| 40         | 1.602       | 1.769     | 1.013          | 1.636          | 1.206          | 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 IMP.I | Owner IMP.I | Consultant IMP.I | Contractor IMP.I |
|------------|---------------|-------------|------------------|------------------|
|            | Rank          | St. dev     | Rank             | St. dev          | Rank             | St. dev | Rank |
| 16         | 4.756         | 4.739       | 4.400            | 5.133            | 1                |
| 18         | 4.283         | 4.154       | 4.563            | 4.134            | 3                |
| 8          | 4.122         | 4.154       | 4.960            | 3.307            | 6                |
| 17         | 4.034         | 3.946       | 3.973            | 4.180            | 2                |
| 1          | 3.772         | 3.230       | 3.967            | 4.134            | 3                |
| 20         | 4.001         | 4.135       | 4.567            | 3.302            | 5                |
| 2          | 3.760         | 3.722       | 3.599            | 3.960            | 5                |
| 15         | 3.184         | 2.907       | 3.764            | 2.880            | 8                |
| 3          | 3.063         | 2.826       | 2.863            | 3.500            | 4                |
| 42         | 3.045         | 3.012       | 3.032            | 3.093            | 7                |
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