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Why Forecasted Initial Project Price is Lower in Developing Countries

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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ABSTRACT

With the increasing of international projects and involvement of foreign companies in execution of projects in developing countries, from one side and growing of domestic companies in developing countries, in the other side, the competition for absorbing the projects are becoming more and more serious.

Heavy Industrial construction projects due to their numbers worldwide, almost standardised procurement strategies and their monetary values are the most common projects falling in the competition for the bidders. Examples for these projects are Oil & Gas plants, Petrochemical, Power Plants, Water Treatment Plants, Mines and Urban Infrastructures. Either a Process related facility or a Non Process Infrastructure can fit in above mentioned category.

As a matter of fact, developing countries are more likely in need of the above facilities than the developed countries. Hence they become very interesting target for the Vendors and Contractors, both domestic and foreign.

This research will focus of bench marking the similar projects in both developing and developed countries, for their initial prices and also will discuss how prices change in project life cycle, what are the hidden costs of projects in developing countries; and also will explain the factors keeping the costs lower with domestic companies.

Results of this research will illuminate the facts about the initial prices of the projects for both clients and contractors, and will help them to realise the actual costs of the projects before making their final decision.

ACKNOWLEDGEMENTS

This thesis is part of a research project on an investigation into the initial prices of the construction projects. The research has been carried out by gathering data from projects completed in one of the Middle East countries (Iran), whilst working in Project and Construction Manager roles for both the contractor and client (in the course of my work experience there).

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1. INTRODUCTION

1.1 Objectives and Scope

This research program is an in-depth study into the facts route causing the initial prices of the projects to be lower in developing countries, and also describing the process for price fluctuations and variations during the project life cycle, by bench-marking a number of nominated projects in developing countries.

This research will address following questions and will clarify:

- Why initial price of projects in developing countries differ with similar projects in developed countries;
- What are the hidden costs of the projects in developing countries;
- How project price changes during the project life cycle;
- How a cost estimate is accomplished for projects in developing countries;
- What are the levels of safety requirements in developing countries;
- What are the factors making project costs lower in developing countries;
- What are some improvements to the cost estimating process;
- How to manage price changes during the project life cycle; and
- What are the front end loading level and costs in developing countries.

1.2 Background

There are several literature resources and references on general topics related to project costs and pricing methods, however this research will form a new approach to this field and will demonstrate a comparative perspective of initial prices of projects in developing and developed countries.

Being involved for over 24 years in industrial projects and interacting with local and international clients, contractors and consultants has provided a very good opportunity and platform to observe the various strategies in pricing and contracting of large scale projects and to analyse the impacts and outcomes of each approach.

Benchmarking of projects in developing countries by using data for an entire project or a part of a project and comparing with data of a similar project in a developed country will support this research to be practical and aim to enrich the results.

The information and data introduced in this research are based on projects that I was involved in (in the project management team). In some cases to avoid the complexity of comparison and in order to better focus on the logics and route cause analysis, only sections (or phases) of the project have been taken into consideration and certain unique indicators have been analysed for that particular part.

1.3 Significance

By having a sound knowledge in principles of project management and by applying this knowledge in the project's life cycle, a project manager will very soon understand the benefits of having a summarised and appropriately organised material in the proposed topic, to help him/her estimate and manage the costs of the project with greater accuracy and predictability level.

For both the client and tenderer groups, outcomes of this research will be a valuable reference to assist them in better understanding the differences and variations in pricing strategies and even cost estimating inputs applied in developing countries. This will enable them to have a more efficient planning process and effectively estimate projects budgets.

Applying the results of this research can greatly add value to tenderers to engage the 'best fit' projects for their organisation by increasing their tendering accuracy and competitiveness.

Clients and owners also will receive the benefits of using the results of this research, by having a holistic picture of the factors affecting the initial prices estimated by tenderers and so, avoiding the hidden costs of the project which may lead to variations and changes during the project life cycle.

1.4 Thesis Outline

This study report contains six chapters. Chapter 1 presents the objectives, scope and significance of the research. Chapter 2 gives an overview of the history and outlines the fundamental knowledge surrounding projects pricing practices and cost controlling in both developed and developing countries.

The methodology utilised in the research is described in Chapter 3. Chapter 4 provides the data and information associated with this research, including a discussion on the data and the challenges encountered. Chapter 5 gives a summary of research findings and Chapter 6 outlines recommendations for further research.

To achieve the objectives of this research, the following steps have been taken:

Literature Review

As the first stage of the research, a review of the literature relevant to project initial pricing in Iran and Australia was undertaken. The research explored the approaches used to determine the initial price of the projects in Iran. The research also considered the history of localisation of the contractors in Iran and outlined the social, cultural and economical factors involved in this process.

The research will explore the process of price changes in Iranian projects and the levels of acceptance from both client and contractor perspectives.

Data and Information Gathering

The majority of the research efforts have been made to source, collect and analyse the data and information from the projects.

Web based research has been conducted to find the resources providing the body of knowledge for project management and cost monitoring systems.

Also web-based networking has been used vastly in this research, to reach the project professionals across the globe, for their experiences and ideas.

Conclusion and Recommendations

The final stage of the thesis involves providing a summary of the conclusions drawn from the experimental works and outlining the recommendations for further research.

2. BACKGROUND and BODY of KNOWLEDGE

Major construction projects are primarily managed through three different models.

EPCM - EPCM is considered a relatively new structure and has primarily been practiced for the last 10 years in construction of Oil & Gas and Petrochemicals plants. EPCM means the company is contracted to provide engineering, procurement and construction management services. Sometimes the Construction and Management components of an EPCM contract are separated from each other and in these cases Management will cover all and every aspects of the project management on behalf of the owner. Other companies are contracted by the Owner to provide construction services and they are usually managed by the EPCM contractor on the Owner's behalf. Think professional services contracts, where the project is largely Owner managed and the cost risk and control is weighted towards the Owner. EPCM contracts vary from project to project and the range of services that is tendered in each project is never the same.

Advantages of EPCM contracts are as below:

- Lower Overall Cost
- Staff's Sense of Ownership
- More Control over Process
- Better for less defined projects with anticipated changes to scope of supply
- Less Legal Litigation (Identify issues early and remedy situation before larger problems arise)
- Owner's Financing Flexibility [1]

Before moving further to the other type of the contracts in major projects, it is vital to have better understanding of each component of E, P and CM.

Figure 1 – EPCM process flow diagram [1]

ENGINEERING

Every major project requires hours of engineering to move from initiation to production to a successful reclamation. A company offering EPCM services for a proposed project will start with a conceptual plant plan and conceptual design of the facilities. For many projects, a preliminary economic assessment and a pre-feasibility study will be required before the project can receive financial backing from a bank or other financial institute to proceed with a bankable feasibility study. Hours of engineering go into these studies, as they cover everything from the proposed plant layout to a detailed analysis of the plant design. The next step, a bankable feasibility study requires the company providing the EPCM for the project to design the facilities, process optimization and flow-sheets, plant expansions, piping and electrical layout, instrumentation and control engineering, and cost estimation. The engineering design teams must be able to execute the full range of design and specification of equipment within the project.

PROCUREMENT AND LOGISTICS

After the engineering phase of a project is completed, it is crucial for every project to develop a procurement strategy. Procurement is the link between the design and engineering and the installation or construction phases of a project. This often involves international purchasing and expediting, in addition to coordinating any required source inspections, and all logistics and travel functions that might be associated with the procurement of equipment and bulk materials that will be needed. Some other areas of procurement and logistics are recommending qualified bidders for construction projects, preparing and issuing RFP (request for proposal) packages, bid analysis, and purchase preparations and recommendations. If the company involved is also in charge of the overall management of the project, the next steps will be preparing and awarding the purchase orders, expediting suppliers' data submissions, and then inspecting equipment and material before making sure all freight documentation is correctly filled out so that there will be no delays. Depending on the size and scope of the project, the logistics and procurement segment of a project can be a daunting task. Now that the engineering part of the project is done, deadlines to project commencement must be met and there can be many delays or hurdles that must be overcome in order to keep the project on time.

Any company that offers procurement and logistic services must have good relationships with equipment suppliers and freight companies to ensure that equipment and materials will be delivered safely and on schedule. In addition, risk management of the overall project is high at this stage, so anyone working on the logistics phase of a project must have contingency plans ready.

CONSTRUCTION MANAGEMENT

Project management is the application of knowledge, skills, techniques, and tools to a broad range of activities to in order to meet the requirements of a particular development. Team building, risk, business, legal, and time management skills are essential to ensure a successful completion of any project. The EPCM project manager is accountable for the outcome of the project in terms of all deliverables, usually stated as performance, time, costs, and scope. It is the project manager that will ensure that the project is executed with due care and diligence and within the contractual definition of the required deliverables.

In many projects, the construction management and project management are done together. Many companies offer this service to their client. As they have been involved with the engineering and procurement and logistics, they are the logical choice to be in charge of the construction of the facilities, while overseeing the project management of the entire project. An EPCM company will offer construction management and supervision as part of their overall project management. Management and supervisory services range from initial preconstruction planning to construction and installation, to plant commissioning, start-up assistance and operational phase accompanied by contract management, cost control, and quality checks. A post implementation review is also part of the project management.

EPC is another strategy for contracting of major projects and is very popular in developing countries and has been applied to most of the recent projects in Iran. EPC means the company is contracted to provide engineering, procurement and construction services. Think Design & Construct style contracts, where the project is largely Contractor managed and the cost risk and control are weighted towards the Contractor and away from the Owner.

Advantages of EPC contracts are as below:

- One Stop Shopping "One point of Contact"
- "Hands off" approach to project
- Minimal Staffing Requirements
- Minimal Legal Risk
- Best for well defined projects with Detailed Engineering Complete before EPC Contractor selected (Minimal Unknowns) [1]

EPC and EPCM contracting are both very prevalent types of contracts within the construction industry. Dependent on the level of risk the Owner of a project is willing to accept, budget constraints, and the Owner's organization core competencies, will determine which method is best for their project. EPC contracting tends to be more expensive, to the Owner, due to the shift of project risk away from the Owner and to the EPC Contractor.

One of the highlighted characteristics of the huge projects in Iran (and in most of the developing countries) is that they are Government Owned projects; hence they may be affected with political as well as economical conditions.

From about 100 years ago, Iran started to use the foreign consultants and contractors to construct the Industrial and Non-Industrial infrastructure in the country. These generally were Buy-Back and Turn-Key, with a very limited contribution of local engineers and workers.

After the revolution in 1977, in respect of independency of the country, the government started to launch the Technology Transfer projects to the foreign companies urging them to utilise the certain numbers of local professionals and trades. Although this strategy had considerable effects in increasing the time and costs of delivery of the projects, on the other hand, ended up with training of the local resources and leveraging their knowledge and skills for delivery of the huge construction projects.

At present majority of the construction works in Iran are being performed successfully by domestic contractors. Nowadays domestic designers and consultants perform the substantial amount of the detail design works, using services of foreign-service suppliers for the concepts, patents and some specialised fields.

One of the models extensively used in Iran is EP + C. This model is the most common and success proven model for the delivery of the government owned major projects, using one or even multiple domestic contractors for construction portion of the project. This model has been used for more than 25 years in Iran with highly appreciated results in different economical conditions.

EP can be one domestic consultant company or a combination of the domestic and foreign consultants being responsible for the engineering portion of the project and procurement of the project material. Construction part of the project can be contracted to one main contractor or several companies. Distribution of works between several contractors may be based on their area of the expertise or geographical areas of the project site.

The advantage of EP+C model is the flexibility in selection of the contractor for the construction phase and also the time frame for execution. By having complete visibility of the progress of the design and procurement of the key and long lead equipment, the project owner which in most cases is the governmental company, decides on when to start the execution phase. In most cases due to the political conditions, some projects starts very early in construction. The risk of budget and time overrun in this case is considerably high, however considering the unstable economic and political conditions of the developing countries there are always good justifications for these overruns.

Generally, when using the EP+C model, the owner sets up a management team to take control of managing all aspects of the project using EP contractor as the consultant to them, however in most complex projects an external consultant can be engaged as Managing Contractor (MC) of the project which works on behalf of the owner from initiation to the commissioning stage and handover.

Regardless of what procurement strategy is taken in account for delivery of the projects, pricing used for tendering purposes starts with estimating the time and costs involved in delivery of the project.

ESTIMATING

Estimation of initial prices for projects is one of the major steps in either developing a project or alternatively in the bidding process (e.g. tendering). Further, this is the area and one of the most important aspects where both the owner and contractor are involved and interested in. There are two primary categories of project cost estimates in development phase: Project Planning Cost Estimates and Project Design Cost Estimates. Project Planning Cost Estimates are used for project justification, analysis of alternatives, approval, and for programming. Project Design Cost Estimates are used to summarize the cost of a project's contract items of work and will be part of the construction contract for the project [2].

Owners directly or through their delegated consultants must estimate the costs for the project in several stages. In the development phase, they need to identify the budget required for the whole project from study to delivery. This can be used for either investment evaluation purposes or for getting capital approvals and authorizing the funds required for moving forward. In the investment evaluation process, the estimated project costs are used in calculations related to the producing the business case for the project by introducing the financial objectives. Financial objectives are often expressed by measures such as internal rate of return (IRR). IRR and similar measures are based on the evaluation of the life cycle cost and revenue streams in a way that takes into account the time-value of money [3].

Oxford English Dictionary defines Estimating as: "To form an approximate notion of the amount, number, magnitude or position of anything, without actual enumeration or measurement".

There are three categories of estimates applied in projects:

- Time estimates are used in scheduling work, assigning resources and determining delivery dates.
- Cost estimates are used for budgeting.
- Cost and benefit estimates are used in cost/benefit analysis to determine the overall viability of a project.

Table (1) shows general idea when above mentioned estimates need to be conducted.

Project phase	**Estimates required**
Initiation	Time, cost and benefit estimates in project definition.
Planning	Time estimates in project schedule. Cost estimates in project budget. Cost and benefit estimates in business case.
Start of project stages	Time and cost estimates reconfirmed for the stage.

Table (1) – Estimates required in project phases

Level of accuracy in estimating is very important and increases during the life of the project as more knowledge is gained about the project. Inaccurate time estimates can result in inefficient use of resources and late delivery.

Inaccurate cost estimates can result in insufficient budget being allocated and lower price submitted in tenders by the contractors. For the owners, over-estimating will result excess budget being set aside for the project when it could be used for other projects, however for the contractors, this can lead to an in-competitive tender price and loosing the chance of winning a project.

If the cost or benefits estimates are inaccurate this can lead to incorrect decisions about proceeding with the project being made.

Different types of estimates reflect the range of accuracy expected from the estimate. Three types of project estimates are: [4]

- Order of magnitude: obtained in the initiation phase of a project for the whole project with a range of –25 to +75%.
- Budget estimate: an estimate derived during the planning phase for the whole project with a range of –10% to +25%
- Definitive estimate: an estimate derived at the start of each project stage for that stage with a range of –5% to +10%

At an early stage an employer will want to know the probable cost of his intended project. Usually no realistic figure is possible until a feasibility study of the project has been completed; before that only an ‘order of magnitude’ figure or ‘budget estimate’ can normally be quoted. Three main methods of producing this are as follows:

- by reference to the cost of similar projects;
- by sketch layout and component costing;
- by use of cost curves if available.

The first assumes a record is available of the cost of past projects undertaken by the employer's engineer, or perhaps costs taken from the technical press. The reference costs need to be accompanied by data, such as project size, project components and distinctive features, dates of construction, and whether the price includes land, legal and engineering costs.

Inflation factors may have to be applied to update the costs. By comparing the principal features of the proposed project with those for which past costs are available, a probable order of magnitude total cost may be derived.

The second method is the most reliable. Even before a feasibility study is undertaken it should be possible to sketch out the proposed project on some notional site if the actual site is not yet decided, so the layout and sizes of the various components required can be judged. The components can be roughly sized so that their possible cost can be estimated by comparison with price data held for similar structures. This procedure can also reveal costs for items which may otherwise have been overlooked.

The third method, using published cost curves, is considered to not be very reliable, because the data on which such curves are based is so frequently absent, and virtually every civil engineering project has certain unique features substantially affecting its cost. Hence costs expressed per unit of size or output can vary greatly; however, a cost curve can be used to show whether costs developed by the other methods seem realistic.

While any of the above methods will involve uncertainty, they can be useful in comparing different options for a scheme, provided uniform parameters are used. The final estimate of cost drawn up by the engineer should be based on current prices and include a substantial contingency sum. It need not include for possible future inflation of prices, because this is a matter for the employer's financial advisers to deal with, but the basis of the estimate should be clear.

The possible range of the cost should be shown; but whether the employer chooses to quote the highest or lowest estimate is up to him. Many of the major projects providing a major benefit would probably not have been built if the initial estimate quoted for it by the employer had not erred on the optimistic side [5].

An estimate is a qualified guess and every estimate is based on assumptions. An estimate assumption is a statement which has been considered to be true in deriving the estimate. These estimate assumptions need to be specified so that the basis of the estimate is known and validity of the assumptions can be assessed.

For example, a work effort estimate is usually based on a level of skill and expertise. If a lower level of skill and expertise is utilized, then it is likely that the task will require more effort.

Effort and Duration

In estimating it is essential to know whether the estimate is an effort or duration based estimate.

- **Effort** is the amount of work required to complete a task – used to estimate cost of resources.
- **Duration** is the time that elapses between the start and end of the task – used to estimate timeframe.

This takes account of the fact that people usually work on multiple tasks, in or outside of a project. Only if they can work on a task for 100% of their working time will effort equal duration. Normally they will work intermittently on the task and there may be time required to complete a task where no human activity is required.

For example, the estimate for painting a room may be 10 hours for two people (20 hours effort), over 3 days (duration) allowing for other tasks and for the drying time of the paint.

It is important to consider the costs related to the efforts required and also the duration of the completing the tasks in the project, to reach to more accurate estimates in time and cost.

Four commonly used estimating methods are discussed here.

Benchmarking

This method is also known as the Analogous or Top-down method.

It is applied to determine order of magnitude estimates in the initiation phase of the project. The method uses the actual durations, effort or costs from previous projects as a basis for estimating the effort or costs for the current project.

Following principles must be applied when using this method:

1. Identify a previous project or section of a previous project that is similar to the current project. The level of similarity should be identified very diligently, as this could be the basis of errors in the final estimates.

2. Assess the extent to which the current project is similar to the previous project – the comparison factor (e.g 1.5 if the current project is estimated to be 50% larger). Having clear determination of the similarities and all the factors involved in the new project may help to accurately assessing the comparison factor.

3. Compute the estimate for the current project based on the actual durations, effort or costs from the previous project and the comparison factor.

Benchmarking is one of the most common processes used for project pricing in Iran. If there is a reference to similar or almost similar project(s) which are currently progressing or have already been executed, then the easiest way seems to be to benchmark the new estimates against the existing ones.

This could be the most efficient way to produce a rough estimate of the approximate costs of the project, however also the most high risk way if that rough estimate was to be used for tendering and evaluation purposes, without applying the correct comparison factors.

Even to get a very rough estimate by the use of referencing to other projects, the following considerations have to be taken:

- Estimates must be based on the costs of a completed and delivered reference project, not a project in progress;
- Projects scope and specifications should match each other;
- Geographical context of the projects should match or proper adjusting factors must be applied;
- All historical information of the reference project and lessons learned should be reviewed and considered;
- Time factor between two projects: This may apply to the economical and political conditions, exchange rates of currencies, rates of services, wages, resource restrictions due to number of huge project being executed at the same time frame and prices for the material and transportation;
- Bill of quantities involved in both projects;

It becomes very likely that all or some of above conditions are not met and the project owner is misguided in his assumptions and expectations.

Parametric / Unit Rates Method

In this method, the project price is calculated by multiplying the unit rate for each item of the scope of work and supply by the quantity of that item.

This method is more accurate than Benchmarking, however still requires some attention.

- Project scope must be properly broken down to ensure all the activities and requirements of the scope are captured and priced;
- Quantities should be accurately surveyed. This is only applicable when all detail drawings are available and a detail and comprehensive bill of quantity is prepared;
- Unit rates for each item must be accurate. If the unit rates are based on benchmarking to other projects, all considerations mentioned for benchmarking should be applied;
- If using this method in the early stages of a project, before the design completed or even started, proper adjusting factors shall be considered;

The parametric method is also known as the object based method. It is used to obtain definitive estimates and to confirm bottom up estimates where possible.

If the amount of effort needed to carry out a particular activity for a particular object is known, and the number of objects is known, the effort required to perform the activity for all the objects can be determined.

The amount of effort for the single activity can be determined either from a standard, which has been established from previous experience, or by executing a sample activity if no standard exists.

Steps in deriving the estimate:

1. Identify an item to be estimated.
2. Estimate the number of items.
3. Estimate the effort per item.
4. Multiply effort per item by number of items to determine the total effort.

Generally the contractors for small projects or part of a project use this method to submit a budget price for the project and adjust their claims based on the facts, during the project. In these cases the client takes the risk of the cost increase.

Schedule of Rates of Resources

This method is based on the estimated time and the numbers of the resources required for the project and is used in maintenance, operation or very small construction projects with limited tasks and short time frame. Also this can be used for consultants and design portion of the projects during early study phase or even throughout the project life.

In some rare cases this method is used to refurbishments and repair works, where the scope of work cannot be quantified accurately.

Considerations to be applied for this method are:

- The numbers of the resources required to complete the task must be determined accurately;
- The skills and capacity of the allocated resources should match the nature of the task from quality and complexity perspectives;
- The rates for resources should be accurately calculated;

Bottom-up Method

The bottom-up method is considered to be the most accurate method for generating project estimates. It is used to determine budget or definitive estimates during the planning phase and at the start of each project stage.

The method uses the Work Breakdown Structure (WBS) developed during the planning stage of the project. Estimates are created for all tasks at the lowest level of the WBS and then these are accumulated to determine the estimates for the whole project.

This method is used when all the details for the activities are available and the work is properly broken down to the lowest measurable level. Hence this rarely can be used for the projects in development phase, as not all details are available at that stage.

When using this method, the costs for the activities in the lowest level of the work breakdown structure are estimated and summed up to produce the total price of the whole project. One or a combination of above mentioned methods can be used to determine the cost for each activity, however proper allocation of the indirect costs to the activities must be taken in consideration in each case. The consensus technique is usually used to obtain task estimates for the low level tasks on the WBS, because as well as producing reliable estimates it also builds active involvement, cooperation and commitment. Experts with the skills required to perform the work should be included in the estimating process.

One disadvantage of the bottom-up method is that it is much more time-consuming than other methods.

Estimating Techniques

No matter which estimating method is being used for a project, some technique will be required to perform the estimation correctly. There are several ways to conduct the estimates for activities and tasks, however three of them are more commonly used in the construction projects.

Weighted Average Estimates

Weighted average estimating is also known as sensitivity analysis estimating.

With this technique three estimates are obtained for each item rather than one. This provides a more accurate estimate than when only one estimate value is provided. The three estimates are known as the best case (O = Optimistic), worst case (P = Pessimistic) and most likely (M = Median).

These are then used in the following formula to determine the estimated effort:

Formula (1): Estimated effort = (O + 4M + P) / 6

$$\text{Estimated effort} = (O + 4M + P) / 6$$

Consensus Estimating

Steps in conducting a consensus estimating session are as below:

- A briefing is provided to the estimating team on the project.
- Each person is provided with a list of work components to estimate.
- Each person independently estimates O, M and P for each work component.
- The estimates are written up on the whiteboard.
- Each person discusses the basis and assumptions for their estimates.

- A revised set of estimates is produced.
- Averages for the O, M and P values are calculated.
- These averages are then used in the weighted averages formula to calculate the estimated effort.

Phase Ratios

Project phase ratios provide a means of generating a top-down order of magnitude duration estimate for a project, or they can be used as a sense check of bottom-up duration estimates of the time allocated to each project phase.

Phase ratio estimating uses an estimate for one phase of a project to derive the likely size of the other phases, and hence an overall estimate for the project. For example, if analysis takes 5 weeks, and this represents 10% of the project, then the project is likely to take 50 weeks.

The concept behind this method is that similar types of projects would normally spend the same percentage of time in each phase. The phase ratio technique is based on studies that average the proportion of time that a large sample of projects has spent on standard project phases. An example of initial set of project phase ratios is provided below. These may vary based on the nature of the projects and should be refined based on results from completed projects.

Phase ratios are not accurate enough to be used as budget or definitive estimates, hence they are mostly used by owners in identification and planning stage of the projects.

Project Phase	Phase Ratio
Initiation	5%
Planning	20%
Analysis	10%
Design	10%
Construction	20%
Testing	20%
Implementation	10%
Closure	5%

Table (2) – Project Phase Ratios (Example)

Applying Contingency to Estimates

Contingency can be applied to each project stage or to each task. It provides a buffer to absorb the impact of dealing with unforeseen issues or complexities in completing the task or stage.

The uncertainty of the estimate and the level of risk must be assessed prior to applying the contingency.

Also the length of time between when the estimate is produced and when the estimated task or stage is likely to be executed, must be taken in consideration to determine the best level of contingency required to be applied for each task or to the whole project. For example, if there are four sequential stages to a project, then there is more uncertainty about the last stage than the first and hence the contingency for the last stage should be greater.

An increase to the estimate must be applied as a contingency in line with the uncertainty, risk and the length of time to execution, determined as a percentage of the estimate.

Recommended Practices in Estimating

Although estimating is considered one of the most complex aspects of the project and involves various skills and expertise efforts to reach the most appropriate price estimation, presented below are some very common good practices which if followed, may leverage the level of accuracy in the project initial price estimation.

- Always obtain at least two estimates
- Involve the people who will be doing the work (or with the skills to do the work if resources have not yet been allocated) in the estimating process and the people who require the work done where possible.
- Use more than one estimating method
- Each estimate must be independently derived
- Review the estimates and rationalize the differences
- Document assumptions made
- Add contingency based on the level of uncertainty and risk
- Get agreement and commitment from the project team for their task estimates and also from the project sponsor for the overall project estimate
- Review and refine the estimates as the project proceeds based on progress

Estimates need to be verified and reviewed to check that they are realistic. Using more than one method of estimating and/or two or more independent estimators to produce estimates, then comparing these provides a very effective verification of the estimates. For example, “phase ratios” is a useful technique for checking estimates derived by other means. As tasks progress, updated estimates of effort, and time to complete the tasks must be regularly obtained from the resources performing the tasks. These are called “revised estimates” and should be used to keep project schedules continually up to date.

Common Mistakes in Price Estimation

Due to the time constraints for the tenders and also lack of knowledge or attention of the bidders, mistakes are most likely to occur during the pricing process. Some of these mistakes are initiated by ignorance of very small items and factors involved in a simple and single activity, however can result in huge variance between the estimated price and the actual costs to perform the particular task during the project, or even can affect other tasks in their costs. If the price for an activity is wrongly estimated and particularly when that specific item is a repetitive task during the project period, then the impact of that mistake can end up with serious losses for the project.

In most cases the indirect costs such as vehicles and transportation, administration, utility bills, computers, stationary and etc are considered as one single item in the cost estimates, usually calculated as a percentage and added to the project price. This is the area the most mistakes occur in different ways, as there are no detail references of cost allocation to the activities, so the weight factors of the activities are not reflected in the relevant indirect costs.

Any review and change to the direct portion of the price for a task, must involve the review and change in the indirect costs, as well.

As an example the administration costs for sending a fabricated steel part for coating may be taken in consideration as an indirect cost to the coating costs, however if the number of the parts exceed a certain amount which change the once off transportation to multiple transportations, then the administration efforts required will be different to the original estimates.

Project Execution Plan and Procurement Strategy

One of the most important reference documents to the price estimate is the Execution Plan and Procurement Strategy for the project. This is where all the steps of completion and strategies to procure the goods and services and the level of involvements of the activities are defined.

Although a contractor can always change his decision to how to procure the goods and services for the job as the project move forward, the costs for different strategies have to be assessed and consequences must be considered during the process of change. This is the same with the sequences of the activities need to be followed to complete a project.

For example if the pricing for the fabrication of steel structural works was based on an out-sourcing strategy and has been changed to in house fabrication, then all the direct and indirect factors affecting the cost have to be considered in the price of the steel structural works. Examples of direct costs are skilled resources, space, equipment, tools and etc, while indirect costs are logistics, statutory permits, legal requirements, quality accredits, safety, insurances, organisational growth and etc.

Generally, the domestic contractors in developing countries do not have accurate estimates of the costs of doing the works ‘in house’. In most cases even after the works are completed, they do not have an analysis on the costs and final product value. They are on the fixed mind-set that outsourcing always will cost more to them.

This is in contrast to the contractors operating in developed countries. These generally analyse what would be the benefits of outsourcing vs. executing in house, and based on the results of the analysis, they set the procurement strategies for each project.

In setting the procurement strategy for the project, regardless of where and by whom the project is going to be executed, two main aspects should be considered. Each project has its own characteristics and no two similar projects should have the exactly same strategy applicable for their procurement, hence each project must have its own analysis done based on the specific characteristic and conditions. Secondly, even in one single project the procurement strategy could be different between different disciplines. For example, although the supports for piping and electrical works in a large construction project, can be manufactured by the structural manufacturer; the installation of the piping and electrical supports can be considered in the piping and electrical installation scope, instead of having them installed by the steel structure installer.

The analysis on the benefits of different strategies, should be conducted by an expert group specialised in cost analysis, technical, scheduling and commercial/ legal aspects of the procurement, not only during the cost estimating process, but also during the project lifecycle, to ensure the anticipated outcomes are achieved.

Again, benchmarking of procurement strategy between the projects, is one of the main common errors happening in the cost estimating of the projects and one of the most seen driver for the changes to the project lifecycle costs, in developing countries. Sometimes even the large and experienced construction companies consider to follow the same strategy they have used for a project to execute a forecoming project, without considering the specific conditions and characteristics of the new project. Costs of outsourcing or doing in house may vary from one project to another being affected by geographic factor, time restrictions, seasonal and weather condition, availability of resources, rates of resources, insurance policies and coverage, project specific technical and quality requirements, statutory regulations and etc.

One of the other important items in the execution plan, which can affect the accuracy of the price estimation, is the level of quality controls and quality assurance systems in delivery of the projects.

Although in most cases the quality assurance systems are applied to the entire organisation of the companies, in some cases these can be tailored to fit the project specific requirement. This can have both positive and negative effects on the costs, but would be preferable if is determined during the initial price estimation, rather than being surprised during the project execution period. Most companies choose to implement the existing quality assurance system to all their projects, however this can create substantial differences to the time and cost estimated for the project between competitors and hence lead to either low pricing and significant losses due to non-compliance to the project delivery requirement or losing the tender competition due to higher price offered allowing for un- necessary quality assurance activities.

On the other hand, having an already established quality assurance system for projects is not only very helpful to ensure the quality of the works delivered, but also lowers the costs by to minimisation of the rejected works and re-works during the project execution. Having quality assurance system in place, also increase the efficiency of the resources and prevent the un-necessary reporting, documentation and hence honours the effective communications in the project.

With above explanation, we can see how the detail and accurate investigation and analysis are essential to determine the level and content of the quality assurance systems applied to the projects.

Quality control activities are costly and most of the time indirect and potentially invisible, but important enough to be identified during the cost estimating process of the projects. They also include some direct costs which are mostly related to the resources and tools used for conducting quality inspections during the execution phase. The indirect costs of quality control systems are the costs related to the establishment and maintaining of the quality control systems, training, advisory, documentation and all other office based activities, however the cost of the quality inspectors, inspection tools and test equipment and all other site based activities fall in direct costs of quality control. Both indirect and direct parts of quality control works can be outsourced with some considerations, however in most cases the companies prefer to manage the quality through their own quality management department and outsource the direct part of quality inspection and testing. A well defined project execution plan and procurement strategy will clearly determine the scope, boundaries and communication channels for these activities.

Performance and accuracy of the quality control systems is one of the key factors ensuring a smooth execution and the successful delivery process of the project. A well designed quality control and assurance system eliminate the risks of failures and costs overrun by monitoring all activities involved in the process of execution and preventing unexpected and over estimated defects and reworks, which by all means reduce the risks to the project schedule and project costs, as well as leveraging contractors' performance levels in clients post-execution evaluation process and hence increasing the chance of involvement of the contractor in further projects.

Although having a well established quality assurance system is very beneficial to the company to assure they deliver what they have planned to deliver, the quality control system should be reviewed and tailored for each project according to project specific requirements. The QA/QC systems are usually designed based on the national and / or international standards which are generally referenced in the project documents as the minimum requirements; however each project may have its specific quality requirements such as particular design criteria, specific tolerances and etc, which should be considered in determining the QA/QC systems for the projects. Non conformity of the company systems and processes with the project requirements may affect project time schedule and costs in both positive and negative ways. An over-expected QA/QC control will add extra costs and time to the project without adding any value to it. An under-expected control

system may cause shortfalls in delivered quality and incur high volume of re-works impacting the project schedule and cost, as well as lowering the companies' performance levels in clients' post-execution evaluation.

Therefore it's essential to have a deep awareness of the project requirements and a detail analysis on the best suiting QA/QC to ensure all project goals are achieved.

Project Execution Plan must address the detail of the project QA/QC system and process, as one of the key factors of delivery of the project.

In addition to the procurement strategy, the Procurement Management Plan, as part of the project execution plan, should contain all details on how the entire process of procurement will be managed during the project lifecycle. This may include the organisation charts, internal and external communication channels, list of preferred suppliers, vendors and subcontractors, documentation process, inspection plans and etc. Similar to the quality management plan, the procurement plan also will need to be reviewed and tailored for each project to ensure the specific requirements and conditions of the project is considered and the procurement plan is efficient and cost effective. Some companies have their quality assurance (QA) systems covering the procurement activities, as well as production. In this case, the review of the processes should be in a more integrated way to ensure every aspects of the project are covered intelligently.

A Project Communication Management Plan is also one of the fundamental aspects of the project execution plan which due to the project specific conditions and needs, can be quite different to the general communication plan determined for the company; So needs to be structured based on the internal and external stakeholders' charts and the level of their involvement in the execution of the project during the project lifecycle. The communication management plan determine all the tools and systems used for communication, name, roles and contact details of the internal and external stakeholders, the time and intervals of the regular meetings communications, reports, as well as the emergency response procedures and plans. Even it may contain the layout of the worksites and offices with emergency movement plans and assembly points. Examples of the communication tools and systems are phones, radio, emails, company online portal, minutes of meeting, letters, forms, templates for reports and etc. The communication charts show the direct and indirect reporting and communication channels between the stakeholders.

Most projects consist of a broad range of stakeholders all of whom may have varying interests and influence on the project. As such, it is important for project teams to determine the communication requirements of these stakeholders in order to more effectively communicate project information.

There are a number of methods for determining stakeholder communication requirements; however, it is imperative that they are completely understood in order to effectively manage their interest, expectations, and influence and ensure a successful project.

Once all stakeholders have been identified and communication requirements are established, the project team will maintain this information in the project's Stakeholder Register and use this, along with the project communication matrix as the basis for all communications. An example of Project Team Directory is shown in figure (2).

Communications planning involves planning for all the communications with project stakeholders. A useful tool is the reporting schedule. It can help you identify the frequency and types of information required by different stakeholders. Communication protocols include the:

- method of communication
- standards
- templates
- security
- ethics
- timeframes and reporting schedules
- who requires the information
- version control method

ole	Name	Title	Organization/ Department	Email	Phone
Project Sponsor	A. White	VP of Technology	IT	a.white@abc.com	(555) 555-1212
Program Manager	B. Brown	PMO Manager	PMO	b.brown@abc.com	(555) 555-1313
Project Manager	C. Black	Project Manager	PMO	c.black@abc.com	(555) 555-1414
Project Stakeholders	See Stakeholder Register	See Stakeholder Register	See Stakeholder Register	See Stakeholder Register	See Stakeholder Register
Customer	J. Doe XYZ Corp	Manager	IT	J.Doe@xyz.com	(615) 555-8121
Project Team					
Technical Lead					

Figure (2) – Project Team Directory (example)

Communication can often be difficult. There can be misunderstanding; one way communication; lack of verification; insufficient, inaccurate and inappropriate information. Also in some cases the information can be with held and / or inappropriate communication media may be used. Communication flow charts help to resolve part of these issues. An example of the Communication Flowcharts is shown in Figure (3).

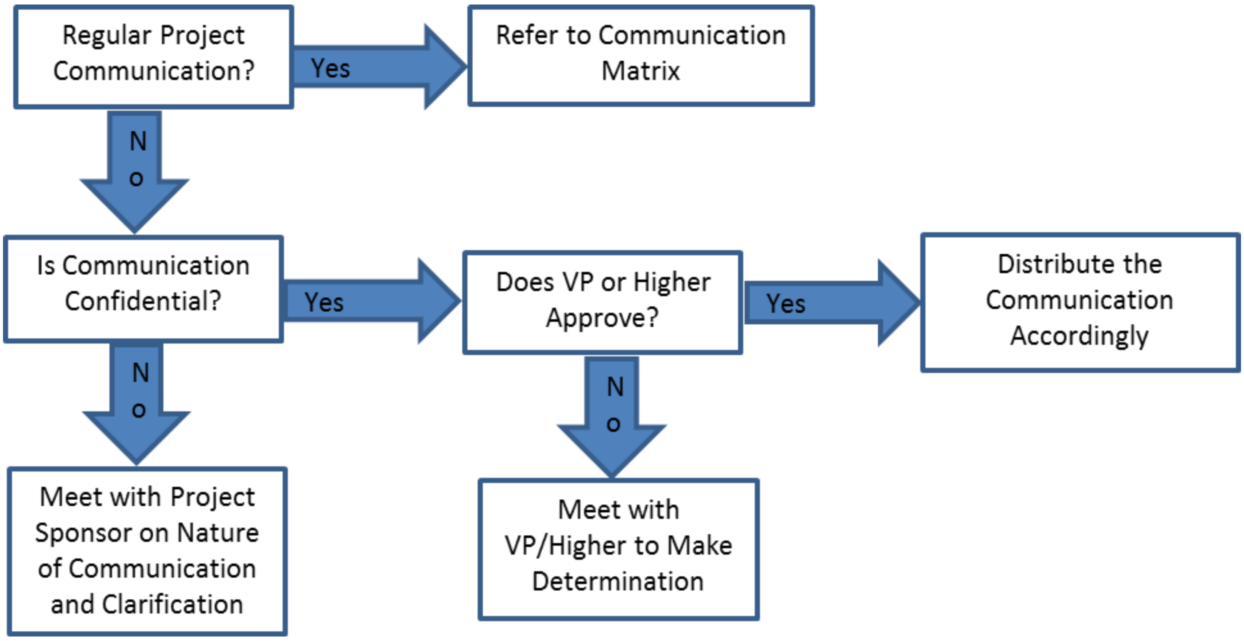

Figure (3) – Communication Flowchart (Example) – [6]

The Resource Management Plan is another aspect of the project execution plan, dealing with the human resource management strategies during the project. This covers the procedures and criteria for hiring the manpower, the span of the resources during the project lifecycle, the portion of local workforce engagement, training and skills improvement strategies, accommodation and logistics for personnel, fatigue management, working rosters and shift adjustments and etc. HR management plan, also define the rules an regulations for workplace harassment, unions relation, recruitment disputes and any workforce related subject in the project.

Due to its nature, dealing with people and communities, HR planning should be conducted very diligently considering all cultural characteristics of the local workforce, project duration, community needs and restrictions and etc.

Lack of awareness and knowledge about the location of the project, cultural characteristics of the locals, community expectations and restrictions, travelling and living facilities for the temporary project workforce, may lead to serious issues during the project execution phase, which in some cases can end up with huge impacts on project time and costs.

Project execution plan (PEP) shall also clearly explain how the workers and employee relationship matters and disputes will be addressed during the project and how the different union affairs will be managed. Also the working days and hours, shift and roster changes, leaves and etc must be included in Fatigue Management section of the project execution plan. Personnel logistics such as travel, accommodation, messing, transport and etc must also be included in the PEP.

Project Execution Plan must also contain the management plan for risks. Project Risk Management Plan should identify all risks involved in the project, as well as the controls and actions required to eliminate the risks or to control them. The first thing is needed is to generate a register for all potential risks to the project. This will include all types of the risks and depending to the size and complication level of the project, can be a short or a very comprehensive list.

Figure (4) – Risk Management Diagram

The risk register must be followed by a Risk Assessment conducted by project team and all key stakeholders having their input to the level of the controls and mitigation plan. Risk assessment generally is conducted through the stakeholders meetings and workshops.

Risk register and risk assessment report are live documents and must be maintained updated during the project execution. Figure (4) shows the loop for continuous risk management in an operational environment. Any new circumstances and any changes to the conditions during the project may either add (delete) some risks to (from) the list or change the existing risks in their level of severity, likelihood and / or consequences. Figure (5) shows a typical template for health and safety risk assessment register which can be used to register all other types of the risks, as well.

Health & Safety Risk Assessment Curtin University

Activity / Task / Location:	Date:
Developed by:	Approved By:

Hazard Identification		Risk Assessment			Control	Residual Risk Assessment				
Activity	Potential Hazards	Consequence	Likelihood	Risk Score	Risk Control Measures 1. Eliminate, eg: eliminate task, remove hazard 2. Substitute eg: replace with less hazardous process, material 3. Isolate eg: enclosures, restricted access; 4. Engineering eg: guarding, separation, redesign; 5. Administrative eg: Safe Work Procedure, training; 6. Personal Protective Equipment (PPE) eg: gloves, goggles	Consequence	Likelihood	Risk Score	Who is responsible to implement the changes	Date Finalised

Figure (5) – Health and Safety Risk Assessment [7]

The Risk Matrix are used to determine the level of the risks, based on the likelihood and the consequence of the risks. Figure (6) illustrates a typical risk matrix used generally in the industrial projects, however the metrics for consequences and likelihood could vary in some instances due to the special characteristics of a project and / or type of the activities involved and historical records of the incidents.

First Level RISK MATRIX for the Safety Management System HAZARD REGISTER

← Consequence →		← Likelihood Values →				
		(1) Rare	(2) Unlikely	(3) Moderate	(4) Likely	(5) Almost certain
	(1) Very Low Consequence	2	3	4	5	6
	(2) Low Consequence	3	4	5	6	7
	(3) High Consequence	4	5	6	7	8
	(4) Very High Consequence	5	6	7	8	9
	(5) Extreme Consequence	6	7	8	9	10

Overall Risk Table

	Extreme Risk, immediate action required by either Treating or Avoiding risk
	High Risk, CEO and Airport Safety Manager to consider for appropriate action
	Low Risk, is managed by routine procedures, and can be Accepted with no action

Consequence values	Likelihood values
Very Low – no injury, damage/disruption less than $[5,000]	Rare – The event may occur only in exceptional circumstances
Low - minor injury, damage/disruption less than $ [10,000]	Unlikely – The event could occur at some time (1 event in 10 years)
High – significant injury, damage/disruption less than $ [500,000]	Moderate – The event should occur at some time (1 event in 5 years)
Very High – serious injury, single fatality, damage/disruption less than $ [5,000,000]	Likely – The event will probably occur in most circumstances (1 event in 2 years)
Extreme – Multiple fatalities or permanent injury, damage/disruption above $[5,000,000] value	Almost certain – The event is expected to occur in most circumstances (1 or more times per annum)

Figure (6) – Risk Matrix [8]

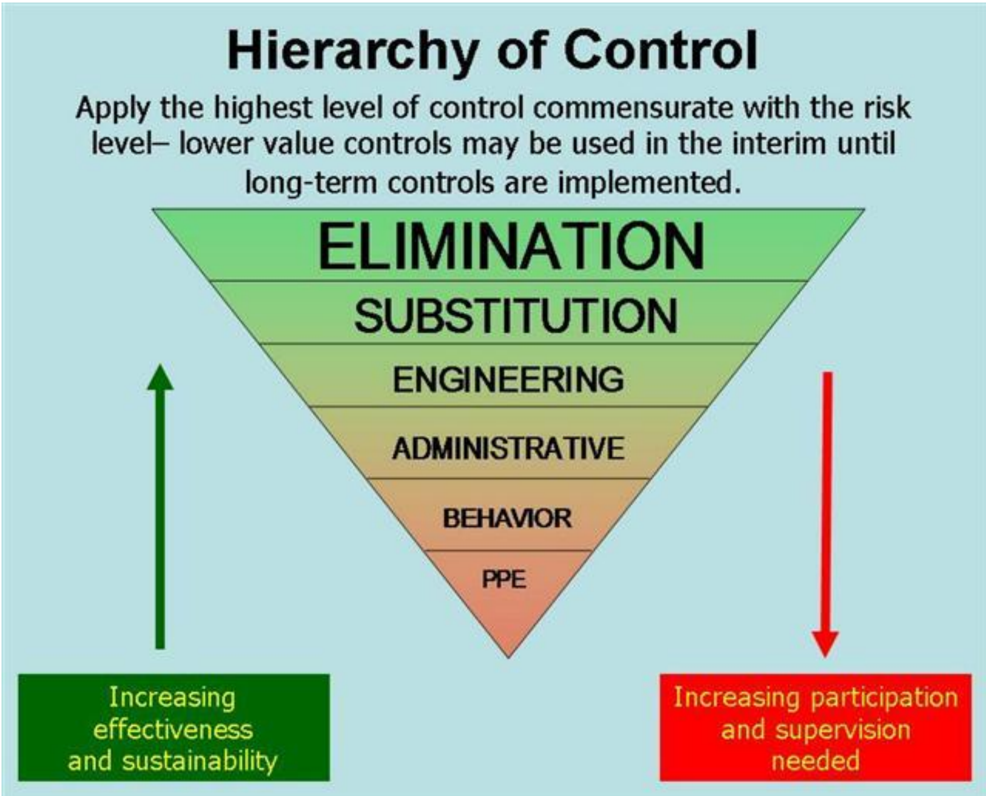

Figure (7) – Hierarchy of Control Diagram [9]

The risk register may contain dates and names for identification of each line item, severity, consequences, controls, dates and names for actions, level of severity and likelihood after mitigation.

Figures (7) and (8) show the hierarchy of the control for safety risks, however the levels 1 to 4 of the hierarchy can be usually used to control other types of risks, as well.

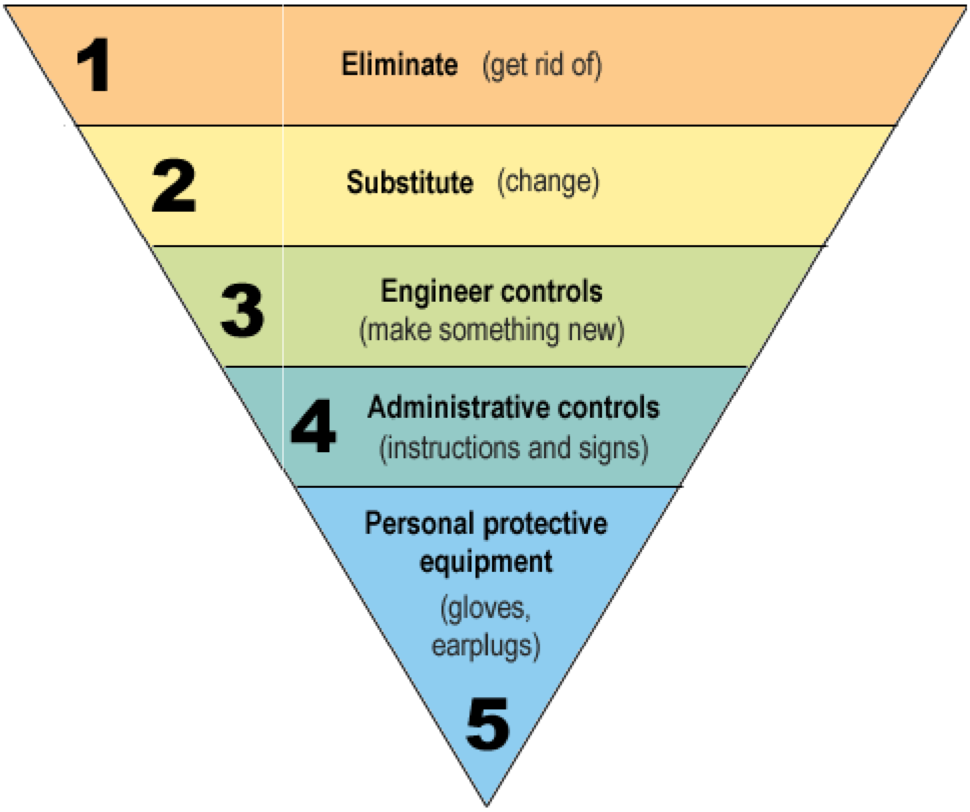

Figure (8) – Hierarchy of Control Diagram

Similar to the risks, which are generally negative in nature, opportunities also must be listed and assessed during the whole project life from initiation to close out. Opportunities are the changes may happen during the project and if assessed properly and beforehand, may have positive effects on the project delivery.

Although opportunities are as important as the risks to be identified, in most cases they are omitted or missed due to lack of attention.

There are always some risks in the projects which cannot be eliminated or managed completely and the project management team must implement the controls and deal with the residual risks, knowingly. The negative effects of these risks can be minimized by taking advantage of the opportunities and using them in the project.

Management of Change (MoC) is another important item to be discussed in the project execution plan. Almost all the projects always face some changes during their life. No matter how the changes are occurring and they are minor or major, direct or indirect, sensible or insensible, negative or positive and etc, if not managed properly, will cause interruption in the delivery of the project.

Although types and nature of Changes in projects can vary extensively, a well designed Change Management Plan will always be helpful to capture all changes and to eliminate their negative impacts by leading and managing those changes through defined procedures.

Changes to the stakeholders, weather conditions, raw material costs, labour costs, schedule delays, logistics and etc are normally captured in project risk assessment and management plan, however changes to the scope of work and supply, stakeholder requirements and project deliverables are the main areas should be managed through the MoC plan.

In a project management context, change management may refer to a project management process wherein changes to the scope of a project are formally introduced and approved [10]. The aim of MoC is to formally record the changes to the scope, assess the related impacts to the cots and time, obtain approval on the changes to the project targets from the key stakeholders and sponsor before introducing changes to the project execution team for implementation, collect reports and document the implementation of the changes.

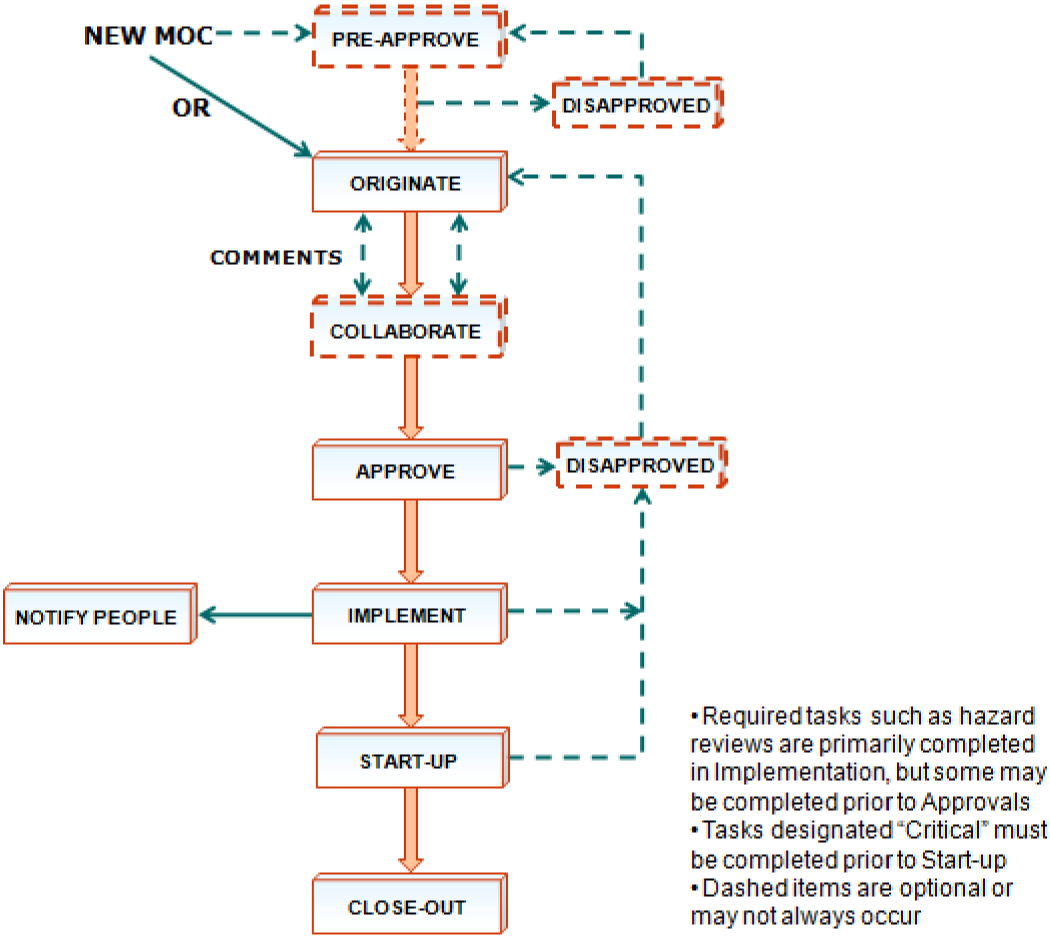

Figure (9) – Management of Change (MOC) Process Workflow [11]

By having a MoC plan and procedure suitable to the project, all changes to the scope can be tracked at anytime with their approved consequences to the original milestones and targets. Projects with rich Front Ending Loading (FEL) in initiation (identification and selection) phase will counter less change to their scope in the definition and execution phases. Lesser change to the scope, healthier project will be delivered.

There is another concept called "Change Management" which in most instances is used instead of "Management of Change" to manage the changes to the scope of work and supply, however the main area of application of Change Management is the internal changes to the working systems and procedures, organisational structure and project team and resources.

Internal changes can occur on purpose and in a planned manner to leverage the productivity and efficiency of the operations, such as systems improvements and upgrades, promotions, functional responsibilities, company charters, new safety rules and regulations, new procurement procedures and etc. Although this kind of changes are purposed to have positive outcomes, implementation of them still will need to be managed correctly to prevent distractions to the normal operation of the whole organisation.

No matter what type of changes the project management want to apply, a change management process must be determined and followed to ensure the success of the implementation. The change management process is the sequence of steps or activities that a change management team or project leader would follow to apply change management to a project or change. Based on Prosci's research of the most effective and commonly applied change, they have created a change management process that contains the following three phases [12]:

Phase 1 - Preparing for change (Preparation, assessment and strategy development)

Phase 2 - Managing change (Detailed planning and change management implementation)

Phase 3 - Reinforcing change (Data gathering, corrective action and recognition)

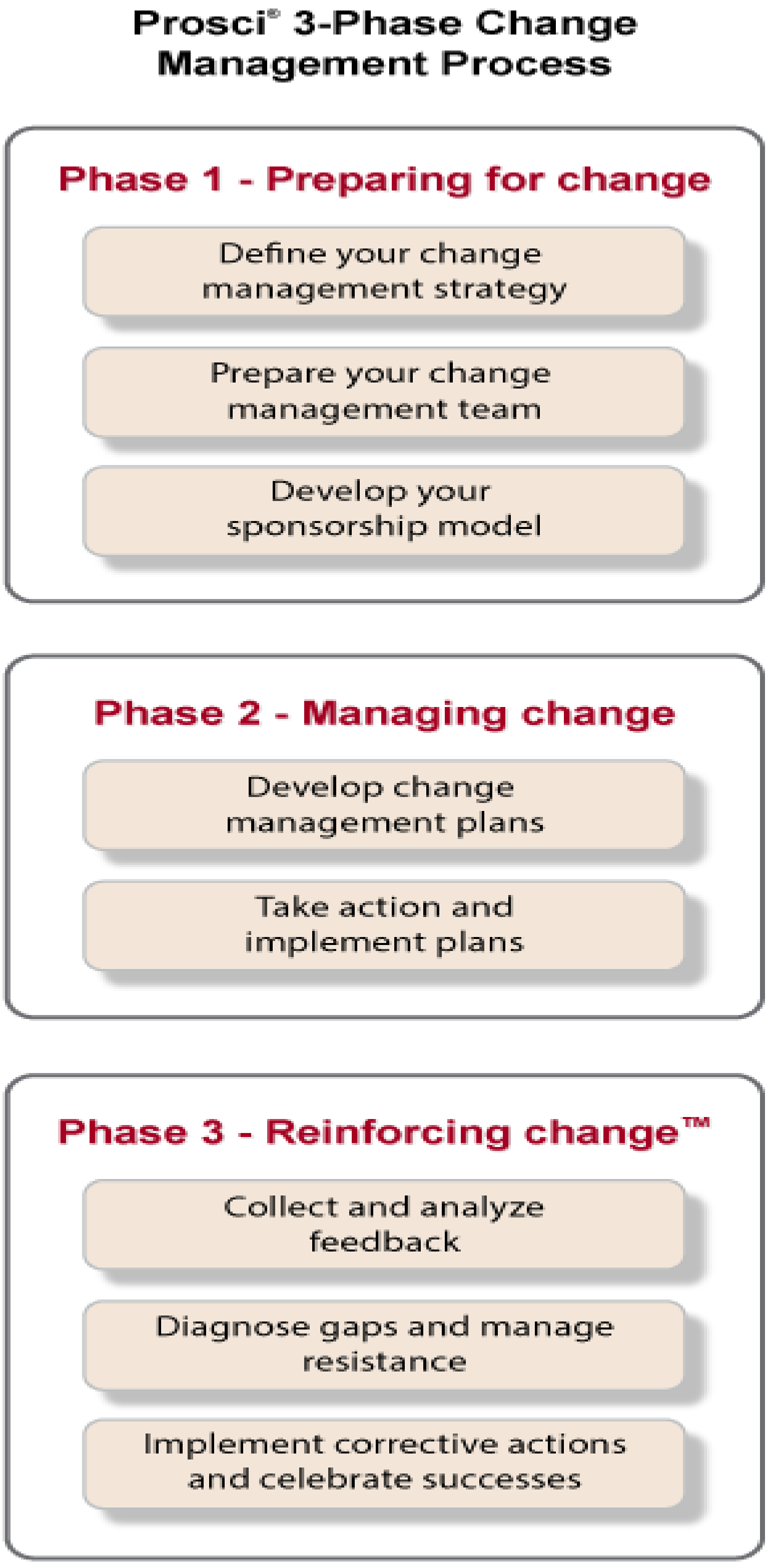

Figure (10) – Prosci 3-Phase Change Management Process

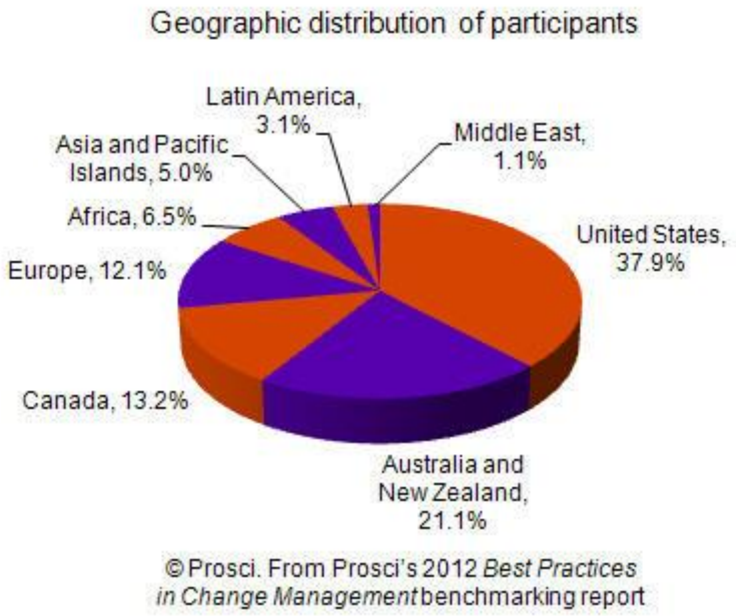

Figure (11) – Geographic Distribution of Participants in 2012 Prosci Research [13]

Internal changes can also occur unplanned and without purpose. These are the type of changes that can have very deep negative impact on projects, if not managed in a proper and planned manner. Managing such unplanned changes in a planned manner needs a change management plan in place with all pre-determined risks, controls and actions to ensure minimum distraction hits the normal operation of the project team.

Risk Related Costs

Risks in construction projects are characterised by three major categories: Safety Risks, Risks to Schedule and Risks to the Costs. Regardless of their type, all risks have direct and indirect impact on project costs. Hence a detail and comprehensive risk assessment should be conducted for the project, prior to pricing.

Majority of risks to costs have been covered on previous clauses above. The only remaining cost related risk is the Force Majeure situations which are quite difficult to predict and are primarily covered by appropriate insurances for the project and also shall be considered in management contingency applied to the total estimated cost of the project.

Risk to Schedule

Risks to schedule include a very large range of items may result the extension of the project duration. These can be weather condition, lack of resources, lack of tools and equipment, non-efficient execution, lack of skills, poor planning, poor estimating of work volume, out of sequence works, plant break down, commissioning issues, custom clearance issues, international freight issues and etc.

Delays in each activity, if located in critical path of the project schedule, may lead to a delay in project delivery. Activities out of the critical path, normally have floats in their execution time and delays on these activities, if fall into the allocated float, do not affect the project length, however still can cause complications in resources, overlaps and final costs of that activity.

In some cases, if the backlogs of non-critical activities are not resolved in due time, the activity can change to a critical one and hence affect the project delivery target. So it's important when assessing the risks to the schedule, we pay attention to every single task, even non-critical, and determine the potential risks and required controls for risk reduction or elimination.

All schedule related risks ending up with extension of the project duration have both direct and indirect impacts on project cost. In most cases extension in project duration may increase the costs for project management team, such as managers, engineers, staff, offices, administration and logistics, accommodation and etc. These are the visible side of the indirect costs, which can be easily measured and quantified.

In some instances, the extension in project time schedule may have some indirect effects on project costs. Changes in resource plan, losing the skilled resources due to overlaps with and market demand from other similar projects in the area, increase to the price of goods and services, extra administration works to re-validate the quotes from sub-contractors, extra planning efforts, extra costs of holding specialist equipment and etc. are examples of the other indirect costs incurred from the extension of the project.

Costs to mitigate the risks are the other costs incurred when the project management team or the contractor wishes to avoid the extension of the project duration. Adding extra resources to the work, adding extra working shifts, provision of new tools and equipment to improve the productivity and etc are the examples for this case.

In general, the efforts required for fixing an issue and rectifying a delay or a miss-planned activity in a project are much more than the efforts required for a proper planning, risk assessment and mitigation plan and project control. When the schedule goes off track, all minor risks start to accumulate and create a big risk portfolio putting the whole project at risk. As discussed earlier, even this can change the critical path of the project plan.

The issue is, in most cases the risks to schedule are the last ones being assessed by the contractors and hence the risk management plans generally do not include the actions required to mitigate the risks to the schedule and related costs. If proper risk assessment is conducted on the scheduled tasks, then by considering a realistic time contingency in conjunction with the residual risks on a specific task, the project management team can reduce the level of uncertainty in the project schedule.

Schedule Risk Factors are those conditions that occur that appear to significantly correlate with slips in schedule. These risk factors are in effect particularly when project managers are dealing with technical and other highly skilled personnel that must deal across functional boundaries. Some of the most common and important risk factors are [14]:

- Optimistic Scheduling: This factor could be called "tell them what they want to hear". Or "just do it", dictated by management and / or project sponsor without regard to real and practical limitations. It often involves a tacit collusion among the parties.

- Piling on People: This could be called the "mythical man month" syndrome. Throw people at the project at crisis points or near the drop-dead milestones.

- Employee Turnover and Introduction of New Tools, Technology, or Processes

- Poor Communication between Groups: This is phenomenon involves inter-group sparring. It is especially prevalent between divisions, and accentuated by professional and functional style and knowledge differences. It is exacerbated by physical distance. Things "fall between the cracks" or important information doesn't get exchanged.

- Parkinson's Law (Poor Utilization of Resources): The work expands to fill the time available. It often involves poor planning.

- Personal Agendas within the Group: New tools, software, hardware, management approaches, etc. drain time away from real work. This is a problem with highly skilled resources that are focused on goals other than those of the project. It sometimes is a product of general, rather than closer, management or the higher technical skill of a project resource than that of the manager.

- Unknown Unknowns That Come Up: These are highly schedule adverse events that occur during the execution of the project. In this case, there can be no planned response, since the event is unknown. There is no contingency plan in place to detect and handle these events.

After the risks are identified and rated, it's the time to determine the controls and contingency plans to reduce or eliminate those risks. Some strategies for this are [14]:

- Get Upper Management "Buy In": Optimistic Scheduling is often a risk factor when upper management is not fully behind your plan. Upper management will better understand the consequences if they change their minds and the team can focus on minimizing scope changes.

- Reduce the Organizational "Always Behind Schedule Syndrome": People inside companies get an "always behind schedule" attitude after three or four major schedule slips. Frustration settles in, and people come to assume that every schedule will eventually slip. To turn this "always behind" perception around, you must take preemptive measures. One strategy is to acknowledge tasks that complete on time to reinforce the idea that it does happen. Also, clearly communicate the consequences of being late on a schedule. This lets people know that projects can be done on time and that late projects have a price.

- Get Leadership Training for the PM

- Get Team Effectiveness Training for the project team

- Generate a Schedule Feedback Method and Have "Lessons Learned" Meetings: During project planning you can implement measuring systems to monitor the progress of the project. Specify a definite amount of time or number of tasks to trigger your corrective actions. Another pre-emptive strategy would be to review the "lessons learned" of a prior project and apply that knowledge towards the next project.

- Look into Modern Project Management Methods

- Reward Schedule Speed and Accuracy: Most rewards for a job well done are given at the end of a project when everything is completed. Without some recognition during a project, people tend to hide in their cubes, communicate less, fill up their time looking busy (Parkinson's Law), and some even perform extra curricular work outside of the project. Recognition is a great motivating factor for people, and the two most important contributions to a project are speed and accuracy. Those that do their work quickly and do it well are an asset. Rewarding these people with a certificate, or announcing their good work in front of co-workers, or giving them a gift certificate for dinner are nice, inexpensive techniques. It helps morale and lowers "Employee Turnover".

Cost of Safety Risks

Safety risks are considered the most common risks that contractors are used to assess. The issue is that they are generally assessed prior to the job starts to ensure the controls are known and in place, and not in the pricing and tendering stage, hence the costs for eliminating these type of risks are not included in the project initial price. The other problem is that the costs related to the safety risks are really very high in most of the instances.

Safety related risks in engineering construction projects, generally have three different kinds of cost to be considered while estimating the initial costs of the projects: First, costs of study, risk analysis and all initial software works being done to identify and assess the risks. This generally includes the direct costs of purchasing the softwares, tools and specialist human resources involved in assessments and analysis. Some indirect costs are applied to this part of works which generally are incurred from administration and logistic costs for meetings and workshops, loss of production time for the attendees, communicating of the outcomes within the organization and etc.

Second, is the cost of applying all the controls to eliminate or control the risks during the project life and continuously monitoring and improving of the controls. Similar to the first stage, there are direct and indirect costs involved in this stage. Purchasing of the proper tools and equipment, personal protection equipment, hiring safety advisors, provision of barricading and nets, conducting training and induction courses, hiring external inspectors and consultants and etc are examples of direct costs to this phase, however loss of production due to trainings and inspections, loss of production due to implementation of the physical controls, restriction to the sequence of works due to additional controls, administration activities for reporting and training and etc form the indirect costs to the control implementation phase.

Third, the costs incurred from an incident resulted from un-controlled or unknown risks. Depending on the size of the project and severity of the incidents, the cost impacts of this case could be quite considerable, and in some cases un-affordable for the contractor. Loss of production time due to investigations, low efficiency of the crew due to emotional impacts of the incident are some of the indirect costs incurred from an incident which generally are not considered in the risk assessment stage during the price estimation of the project. In some cases when a project is a brown field one or the project completion and commissioning target is linked to the owners commitments to external customers, shutting the plant and
project down for post incident investigations, may cause huge damages to the project's financials. Direct costs resulted from an incident such as death or injury to the personnel and / or damages to the equipment are normally covered through the insurance policies the contractors purchase for the project, however the extend of the coverage should be carefully selected based on the complexity and size of the project.

Earned value

It is true that past performance is a good indicator of future performance, and therefore using trend data, it is possible to forecast cost or schedule overruns at an early stage in a project. The most comprehensive trend analysis technique is the Earned Value method. Earned Value is a useful tool for predicting the outcome of projects in terms of time to completion, cost to completion and expected final costs.

NASA defines the Earned Value Management (EVM) as an integrated management control system for assessing, understanding and quantifying what a contractor or field activity is achieving with program dollars.

Earned Value shows how much of the budget and time should have been spent, with regard to the amount of work done so far. Earned Value provides the project manager with an objective way of measuring performance and predicting future outcomes. This can enable him or her to report progress with greater confidence and highlight any overrun earlier. This in turn, enables the management team to make cost and time allocation decisions earlier than would otherwise be the case.

It is necessary to get the actual costs incurred for the project from the organisations' accounting system. This cost is compared with the earned value to show an overrun or under run [15].

Although the earned value management seems to be a tool to be used during the project, the understanding of the project management team of EVM and establishing the tools and mechanisms such as work breakdown structure, work packages and weight factors will help to achieve better results from cost estimates and also manage the changes to the scope and project time schedule.

Earned value management is all about measuring and managing the performance throughout the project by monitoring the actual progress of the works with the planned value. Planned value is the base lined plan for the projects showing which value must achieved in each time period of the project. To have an accurate planned value, the project team need to have the initial work breakdown and cost estimates done very diligently.

3. Methodology

In this research the data from two projects executed in Iran will be disclosed and the characteristics and methods used in pricing will be introduced. Further, the trend of changes to those prices will be analysed and the reasons for the changes will be challenged.

Following the opening section, there will be a broad approach to justifying the several reasons the tenderers and contractors in Iran (and most likely in Middle East and other developing countries), end up with a lower initial price for the projects.

In the third section of the research, data from a similar project in Australia will be discussed and analysed and a comparison between the initial prices of the similar activities will be accomplished having the reasons discussed. The process of the price changes and the proportional factors will be analysed in the last section.

4. Data Comparison

4.1. Sample Projects (Iran)

In this section two construction projects in the Oil and Energy sectors have been reviewed for their initial and final costs. Both projects are selected from the portfolio of one company involved as contractor to provide construction and commissioning services. Engineering activities of the projects along with the procurement of the specialist process equipment have been executed by other companies. To focus the research, only certain aspects of these projects are considered and data for one or two disciplines have been discussed.

4.1.1. Project 1

The scope of Project 1 was to build an Aromatic plant in a petrochemical complex in the south of Iran. The contractor has been invited to the tender with a limited time of less than two calendar months to review and respond to the tender documents. At the time of tender, the documents were not finalised and the engineering was still in progress. The contractor decided to use the benchmarking method for quick estimation of the project price to avoid missing the tender target. Similar plant had been started a year ago in another location and was under construction by other contractors at that time. The overall winning price of the similar plant was used as a base for the estimate and adjusted by applying some appropriate escalation factors for annual increase of prices and also the size of the plant. The validity of the escalation factors have not been scoped in this research.

After the scope has been broken down to lower activity levels and quantities were surveyed as per the available documents, the figures from the unit prices from the previous projects of the company were applied to the quantity and formed the new prices. Costs of activities summed up to give the costs of each discipline and then the overall cost estimate of the project was compared against the factored price of the similar project to confrim the accuracy of the estimates and the level of confidence.

Work packages selected for this research purpose are selected based on the value of the changes in these disciplines. According to the company authorities these activities has attracted the majority of the price changes in most of their projects.

4.1.1.1 Initial prices – Project 1

Below is table (3) showing part of the work breakdown in pipe works with initial prices in local currency:

WBS #	Description	Unit Price (IR)	Quantity	Unit	Price (IR)
1.1.1	Excavation	1,090,000	2600	M3	2,834,000,000
1.1.3	Concrete	1,230,000	1160	M3	1,426,800,000
1.2.1	CS Piping	520,000	6324	M	3,288,480,000
1.2.2	Alloy steel Piping	1,300,000	2040	M	2,652,000,000
1.2.3	S.S Piping	1,300,000	3590	M	4,667,000,000
1.2.4	Valve installation	200,000	400	Nos	80,000,000
1.3.6	Power Cable installation	22,000	21,500	M	473,000,000

Table (3) – Initial prices for project 1

4.1.1.2 Costs at completion – Project 1

As discussed earlier, capturing of all costs at completion with high level of accuracy needs extensive analysis skills to enable to recognize the direct and indirect costs of each item and correctly allocate the indirect costs to the relevant activities. Both quantity and expenditures need to be calculated carefully to give better accuracy in the cost at completion for every portion of the project. This information below is provided to the best of contractor's knowledge.

WBS #	Description	Cost At Completion (IR)	Final Quantity	Unit	Unit Cost (IR)
1.1.1	Excavation	4,959,500,000	3380	M3	1,467,307
1.1.3	Concrete	1,997,520,000	1334	M3	1,497,391
1.2.1	CS Piping	4,110,600,000	5892	M	697,657
1.2.2	Alloy steel Piping	3,049,800,000	2224	M	1,371,312
1.2.3	S.S Piping	5,600,400,000	3103	M	1,804,834
1.2.4	Valve installation	108,000,000	386	Nos	279,792
1.3.6	Power Cable installation	756,800,000	27,100	M	27,926

Table (4) – Cost at Completion for project 1

To provide better visibility on changes to the prices the following table and chart have been prepared to demonstrate the comparison between the initial quantities and unit prices.

By analysing Tables (3) and (4) it is observed that costs are increased for all activities, however the quantity of works have both positive and negative variances. To have better view of the price changes and to be able to analyse and discuss the changes in each case, the cost at completion per unit of works has been calculated for each line item and comparison has been shown in Table (5) and Figure (12).

WBS #	Description	Initial Unit Price (IR)	Unit Cost at Completion (IR)	Cost Increase (%)	Initial Quantity	Final Quantity	Unit
1.1.1	Excavation	1,090,000	1,467,307	34.6	2600	3380	M3
1.1.3	Concrete	1,230,000	1,497,391	21.7	1160	1334	M3
1.2.1	CS Piping	520,000	697,657	34.1	6324	5892	M
1.2.2	Alloy steel Piping	1,300,000	1,371,312	5.4	2040	2224	M
1.2.3	S.S Piping	1,300,000	1,804,834	38.8	3590	3103	M
1.2.4	Valve installation	200,000	279,792	39.8	400	386	Nos
1.3.6	Power Cable installation	22,000	27,926	26.9	21,500	27,100	M

Table (5) – Initial and final price and quantity comparison – Project 1

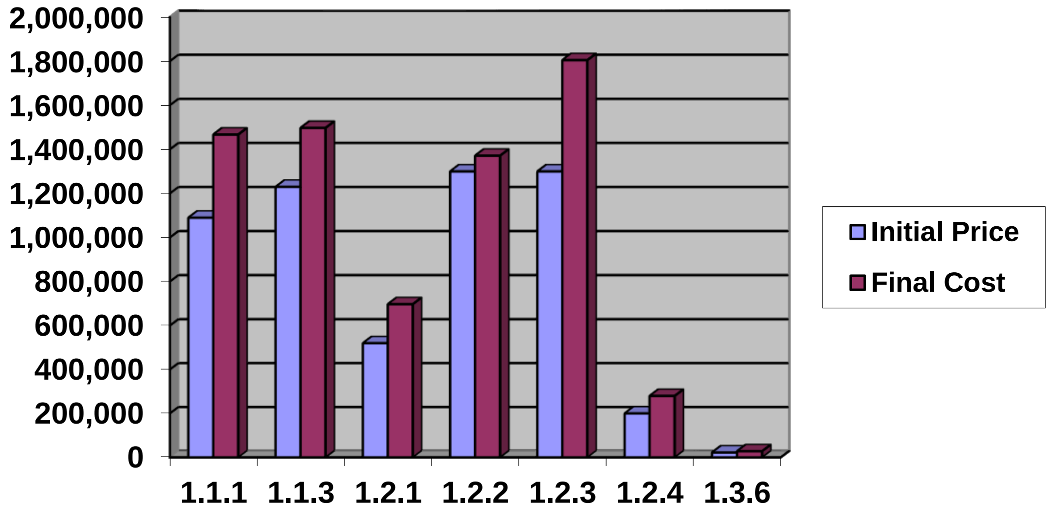

Figure (12) – Initial price and final cost comparison – Project 1

As shown above, the positive variance between the initial price and the final costs is varying in a wide range of 5.4% to 39.8%. The amount of variance depends on the type of changes to each particular activity and hence needs to be analysed and discussed specifically.

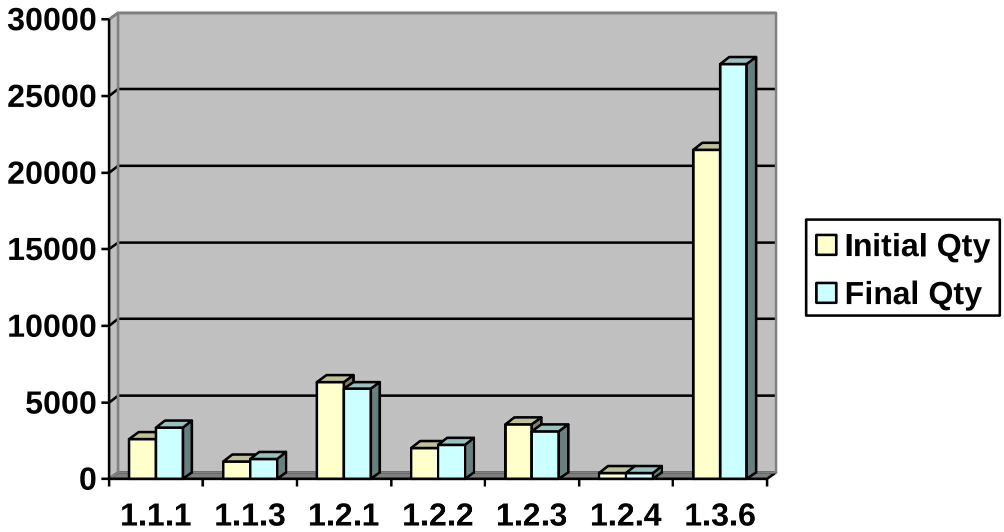

Figure (13) – Initial and final quantity comparison – Project 1

4.1.1.3 Data Analysis - Project 1

The significant range of variance between the initial prices and the final cost per unit of works, lead this research to several interviews with the responsible personnel in the company to gather more info on the way the estimates had been conducted and the references had been selected for benchmarking. Following findings are the result of this process:

- The reference project was located in a different geographic location, in proximity of less than 15Km from one of major industrial cities with a good climate.

  This means the availability and accessibility to the resources was very high and due to the proximity to the city, the proportional percentage of local and residential manpower employment with lower costs was greater than project 1 located in more rural area and far from the major cities. Less requirement of accommodation for the employees, variety of skills and trades, high willingness of the resources to be employed in the project, easy and low cost transportation of the work force and the plants and

  machinery to the site, lower costs and variety of options for hiring the plants, easy and cost effective maintenance for vehicles and hired equipment, quick access to the logistic network and also easy and low cost communication and one on one meetings with external stakeholders of the project and government authorities to resolve issues and etc, are all advantages, which project 1 suffered from due to its remote location.

  Also being located in the central part of the country with a normal climate, the reference project benefited from efficient working time during the day and also more workable days in the year. Project 1 was located in the far south east of the country with a hot and humid climate and suffered from low efficiency of the work force during the day and also reduced working hours in the summer due to longer mid-day breaks. Furthermore there were issues around the logistics costs for mid-day transportation and camp facilities during the hot season.

The temperature of the concrete before the pour and also ambient temperature for installation of concrete is one the important elements in the structural works and was controlled very diligently. During the hot season additional arrangements were required to keep the temperature of the concrete down by the use of chilled water for preparation and insulated concrete trucks. Also the pouring time is limited to the colder times of the day and most of the time the concrete installation works were shifted to the night shifts which tends to attract greater cost.

Higher costs and efforts required to provide and maintain fully air conditioned camps and messing facility, higher costs and intensity of providing and maintaining the health and quality of the foods in such a hot weather, incidents incurred from dehydration and heat stress, risks and lost times related to the works inside the tanks, towers and other confined spaces form just some of the factors the company overlooked during the bench marking process.

Costs and complexity of roster arrangement, flights, transportation, extra manpower and accommodation required due to the replacements and overlaps between rosters have also affected the rise in the final costs of project 1.

High turnover of employees due to hard conditions of living in remote areas, community issues arising from accommodating the fly-in / fly-out employees in the small towns, demand for higher wages and conflicts of social behaviours resulted from multi-cultural society of workers are some of other issues incurred due to the different geographical location which were not considered in the price estimate process for project 1.

- The project used as reference for benchmarking, had not been completed at the time and the estimates for project 1 have been based on the tendered price of the reference project and not based on the actual costs at completion. This could be rated as one of the major and most influencing errors in benchmarking. The reference project should be a completed project and the basis of the estimates for the new project must be based on the facts and figures accurately calculated and appropriately recorded containing all the costs related to the project from initiation to close out.

  The main issue is that the detailed and accurate record of the final costs at completion for the project remains with the company executing the project and they are rarely accessible to other companies and competitors (due to competitive and strategic reasons); hence this practice should be done in-house for each company and this is the reason why appropriate recording of the information for each project is one of the key factors in continuous improvement of the companies.

  In the case of Project 1, the company had only the 'winning' price of the project and did not have information relating to prices for each discipline Therefore, after applying the adjustment factor to the total price, they have distributed the price to the disciplines, based on their best estimation.

- Although both projects were similar in the type of process plant, the concept design and even the patent for these two projects were different and hence the detailed designs were not comparable to each-other. The plant in the reference project has been vastly spread within a large area and hence access to the equipment and pipe works are much easier than the plant in project 1 where it was part of a petrochemical complex and was compacted to fit in the limited area in the seashore.

  Congestion in the plant was the source of the majority of the cost increase elements during construction, as all the movements of the plants and equipment and machinery such as excavators, trucks, cranes, and etc are affected by limited space and hence the planning for the works becomes more complicated. Any delay in one activity, may cause huge delays in other activities in the same area or areas which share the same access path. In most cases increasing the resources and / or number of the machines will not assist with catching up the lost time, as increasing the mobile plants creates more congestion to the site.

Safety hazards and risks increase with the congested site, proper sequencing of the works need more knowledgeable and skilled planners and also the supervision of the activities gets more difficult. Interaction between different groups increases, waste of time and material also will help to the inefficiency of the execution.

In some cases size of the machines are limited due to the access roads and narrow path ways between the buildings and equipment. For example in project 1, use of big size excavator was not possible due to the limited operational area for the machine and also the double trucks could not be used in most of the areas and even the number of trucks couldn't be increased due to the traffic limitations. Less volume of excavation per hour and / or less volume of earth moved has direct impact on the extension of time and hence increasing the cost for completion of the activity.

As per company, two of the heavy towers in the plant were asked to be fabricated in smaller segments due to ease of installation with smaller cranes, as the big size crane could not operate in the area left between pipe-racks and buildings. Breaking the towers to smaller pieces means transferring part of the shop fabrication activities to site, meaning a completion costs of three to five times more expensive than the shop fabrication.

Due to sensitivity and importance of the time laps between the concrete trucks during the high volume concrete pour, all access paths were kept clear of any other machinery and / or excavations until the installation of the concrete is finished in that area. This also made some interruptions to the plan and delayed other activities causing additional costs to the project.

One of the other characteristics of project 1 was to have multilevel pipe-racks which this also is due to the limited area and compact site design. As a result of this design the height of working levels for both steel structure and pipe works is increased and additional scaffolding is required for temporary safe working platforms. Scaffolding was always one of the indirect and supporting services which have direct impact on costs and time. Also having pipes running in several levels of the pipe-racks makes the installation process more complicated and time consuming and hence costly.

- Project 1 was located in a seashore area in south west of the country where six other petrochemical complexes were located adjacent to each other in a compact field; hence the project site had no capacity to contain the material lay down areas and fabrication workshops in it, they were located well far from the installation site. This 10 -12 Km distance between the material lay down area and the fabrication workshop and the same distance from the workshop to the site, not only increased the costs of the transportation, but also had lots of indirect impacts on the time and logistic costs, as well as requiring a very accurate planning.

  Like every indirect costs matter, some of these costs are direct costs by their nature; however they impact the project targets indirectly.

  For example, having the spool fabrication far from the site, not only cause the transportation costs, but also increase the requirement for planning and also extra resources to dispatch and receive the transported spools between two locations. Also this may cause increase in the traffic volume in and out of the site interrupting the normal operation of construction machinery, resulting with delays in execution of planned works and hence delaying the whole project. The administration works for sourcing, hiring and managing of the trucks required for off-site activities also are time and cost consuming efforts which affect the project overall costs indirectly.

When the fabrication shops and material lay down areas are within the project working site boundaries, site management team are able to manage all relevant activities and also the job site insurances and security arrangements are applied to the workshops and lay down areas, as well as the other disciplines; however the costs and efforts required to cover all these responsibilities in separated off site areas bear additional costs to the project, which in some cases are invisible in the first instance.

Due to the proximity of the project site to the seashore, some excavations were carried out below sea level and hence needed appropriate provisions for executing the works. Additional costs of activities such as dewatering and installation of temporary retaining walls to prevent the soil from running to the excavated trenches and foundations are examples of the visible impacts to the costs; however time delays to perform these extra preparations and also low efficiency of working in this condition are examples of the 'invisible' aspects of the indirect costs.

- As per the company's records, the percentage of the local employment for project 1 was estimated around 30% and hence the initial price was adjusted accordingly. At the time of initial estimation, this was almost 50% lower than the reference project being established in the close proximity of a major city and was deemed to be well estimated; however due to the high demand of the several projects running at the same time in the area, there was a lack of local workforce and the contractors was urged to bring the skilled and even semi skilled workers from other major cities. Costs of accommodating the fly-in / fly-out workers in a small town, controlling their social behaviour and resolving relevant issues within the community, uncertainty of continuous cooperation of these workers within the project, high demand for increased wages and fringe benefits were some of the direct costs of this employment strategy.

When roster workers are used, the number of the total people employed for a specific project in the company increased by approximately 25% - 30%. This is due to the days off of the roster workers that required replacement and further some extra days for overlaps with 2/1 or 3/1 rosters. Increase in the number of employees means increase in administration workload, accommodation and messing, transport, uniforms and personal safety gears consumption, larger buildings and site facilities, higher utility consumption etc.

Employing human resources from different locations with different cultures causes conflicts of behaviours and hence requires greater control, monitoring and management efforts. This is not only limited to the workplace and working hours, but also during the off-work hours.

- Due to the delay in the process of contractor selection and contract award, the mobilisation of the contractor was delayed and hence the earthworks and civil activities fell during the wet season. Inefficiency of operations in the wet weather and muddy site, slow movement of the machinery, preventive actions to reduce and eliminate the risk of slippage and other hazards, poor visibility, repetitive civil works to fix the damages from the heavy rains and surface water- runs caused excessive increase in the costs of these activities and also delays in their successors.

  This is an element that is usually missed by the contractors when the contract awarding process is lengthened. Often the contractors are more focused on the winning of the tender, particularly in long term and high value contracts, that they often ignore the changes occurring to the initial conditions of the project and hence they do not revise their estimates according to those changes. These mistakes can occur in the circumstances when during the final negotiations, clarification and Q&A sessions, the scope of supply changes slightly or the scope of works is interpreted differently.

In most cases the managers from the contractor side do not realise the changes and their impact on the schedule and costs; however in some cases even if the technical and contract experts notice the changes, their advice are not taken seriously and the impacts are deemed to be very minor and negligible. As a result of this ignorance, the contractor even before commencing the project commits to delivery of something which is already not considered in the initial estimates for the project.

- The construction part of the project started while the design was not complete and the procurement of the project material was still in progress. Changes to the design, delay in receipt of long lead and client supplied items caused serious delays to the works and even the sequences of some of the activities were altered to match the sequences of receiving the design documents and material. For example, due to late design and procurement of the air compressor units, the concrete foundation for these items have been executed 3 – 4 months after all adjacent concrete works were completed and even the pipe works were in progress all around. This resulted in a series of changes to the pipe works already installed and also delayed all other mechanical and electrical works in that area.

  Another example is receiving the fabricated steel structural parts out of sequence of installation. The contractor was mobilised as per the plan and completed some works on the steel structure erection; however the material have not been delivered on time and in order. They received the secondary beams and bracings before the main columns and beams are delivered, therefore no efficient works could be completed and the resources were idle or operating with low productivity, and the project schedule began experiencing serious delays.

Although the majority of these delays and incurred costs are claimable, the accuracy of the claims and the certainty surrounding covering all incurred losses with these claims is the one important aspect which is always in doubt. As per the company, there was no specific department responsible for claiming on additional works and losses. The site management team with help of the technical office and site supervision were working on the claims and it was very obvious with the other responsibilities they had in the project, they may have overlooked some claims and or the accuracy of the claims were questionable.

On the other hand, the client for the project, being a governmental company, had a specific committee with both technical and commercial experts responsible for this task, only. This made the claiming process more diligent and in some cases the outcomes were not to the contractors' favour.

- One of the other parameters affecting the rise of the costs at completion for the C.S and S.S pipe works is the change of shop / site fabrication ratio. In standard projects with design drawings ready prior to the construction, approximately 70% of the pipe works are performed in the fabrication shop and spools are made and labelled prior to handling to site for installation.

  Fabrication of pipe spools in a shop condition is less costly and more time efficient than performing the same works in a site condition. Control of environment such as wind and rain which affect the quality of welding is much easier in an enclosed workshop. The controlled temperature of the workshop increases the efficiency of the work crew, whilst hot and humid climate of the site reduces the productivity extensively. The supply of utilities such as power is much easier and cheaper in a workshop, as the source is more steady and the failures and breakdowns are less than site installed power generators. In a workshop, the welding machines are fed from a central power supply, whilst several diesel welding sets or portable sets of combination of a generator and electric welding machines must be used, which makes the transportation and maintenance more costly.

In a fabrication shop, the number of the workers can be easily increased depending to the workload, whilst increasing of the manpower in site conditions need lots of assessments and preparation works for their tools and equipment, site specific inductions and safety risk assessment.

When the design is not completely progressed and drawings are still in process of review, the dimensions and even in some cases the size of the secondary pipelines are not finalised and hence the prefabrication of the pipe spools cannot be completed prior to installation. This also happens due to the shortage of company supplied material received to the site.

In Project 1, as per the company, many of the flanges and other fittings were delayed due to late ordering or custom release issues. Having the crew on site as per plan and also having some of equipment installed, the company was urged to start installation of the pipe works to avoid the delays in the successor activities to the piping. As a result of this strategy, the pipe spools are transported to site in a half fabricated condition with some flanges and fittings missing at the time. Depending to the arrival time of the material, some of these spools are completed on site prior to installation in their place and some were installed without the missing parts requiring even more efforts to be completed in place. Additional scaffolding, late removal of existing scaffolding, difficulties in quality tests, additional number of workers qualified to work at heights and etc are the consequences of this transfer.

One of the very invisible parameters in increasing the costs and time of the installation of the transferred shop welds to the site, is the increase of percentage of the NDT tests involved in the site welds. As per the standards currently used in major industrial construction projects, the number of sample joints selected from the site welds is higher than the shop welds.

Considering the time spent for the tests and waiting time for the reports and also time and costs for repairs and re-tests, the impact of taking the shop welds to the site can become one of the major drivers for higher completion costs, which usually are omitted or missed completely or partially.

There are several other factors and parameters involved in heavy construction projects in which play major roles in increasing the completion costs. As shown above, some of these factors have direct impact on costs and some affect the costs by influencing the time schedule and / or indirect efforts. The level of analysis of and accuracy in estimates

Some of the changes are due to external stakeholders, which generally are reimbursable in time and cost, if the contractor has solid reasons and strong justification for claiming. In project 1, as per the company, the major claims made for extension of time and also the extra costs, were the additional works which have the clear instruction and formal request from the client. Also the impacts of economical issues the country were facing at the time of the execution of the project and the un-expected rise in the costs of services, were documented and claimed based on the national reports from the government and reimbursed by the client. Although the company did not act very well on documenting all extra works and did not conduct deep analysis of cause and effect on the changes, part of the losses were compensated through the above accepted claims and hence company has only tolerated some minor losses in the piping and cabling sections.

4.1.2. Project 2

To have better resolution on the further discussions and analysis of the prices and drivers for the changes, the second project used for research purpose is selected from the portfolio of the same company for project 1. This time a recent project of with almost the same geographical condition and EPC contract with a fixed lump sum price is chosen. The company was responsible to do the engineering works, procurement and construction of a storage tank farm with complete pump station for one of the oil refineries in Iran.

As per company, the initial pricing for this recently completed project had been improved in comparison to the previous projects, however still some variances are observed between the initial and final costs. The reasons behind these changes will be analysed and discussed in further clauses of this research.

4.1.2.1 Initial Prices – Project 2

Data collected from the construction phase of project 2 are shown in Table (6). Activities are chosen to be similar to project 1, so the comparison between the initial prices of two projects can be performed easily and the areas of improvement in pricing can be observed clearly.

This time, the company has used the lessons learned from the other project to have more accurate pricing for project 2. They have noticed that both projects have located at almost the same geographical location, so no additional factor is applied for this purpose. Due to the nature of the project, the amount of works for each activity, are significantly different to the similar activity in project 1.

Also the parameter of time is different between these two projects, and an approximate of 3% increase per year has been allowed. The unit prices shown in Table (6) are calculated by considering the final costs of each activity in project 1 factored by 9% to cover the three years gap between two projects.

WBS #	*Description*	*Unit Price (IR)*	*Quantity*	*Unit*	*Price (IR)*
1.1.1	Excavation	1,599,364	23000	M3	36,785,372,000
1.1.3	Concrete	1,632,156	19000	M3	31,010,964,000
1.2.1	CS Piping	760,446	4500	M	3,422,007,000
1.2.2	Alloy steel Piping	1,494,730	0	M	0
1.2.3	S.S Piping	1,967,269	900	M	
1.2.4	Valve installation	304,973	30	Nos	9,149,190
1.3.6	Power Cable installation	30,439	6000	M	182,634,000

Table (6) – Initial prices for project 2

4.1.2.2 Costs at Completion – Project 2

Similar to project 1, the costs at completion have been calculated for the unit of works to eliminate the negative influence of the change in quantities in the analysis of the costs.

This time having three years past from the previous sample project (1), the company had better vision on the indirect costs and the way they should be allocated to the activities. The company believes that as a result of lessons learned and added experience from the previous projects, the cost allocation has been done more diligently and hence the data are more reliable and accurate this time. Table (7) shows the data collected from the company.

WBS #	Description	Cost At Completion (IR)	Final Quantity	Unit	Unit Cost (IR)
1.1.1	Excavation	37,369,222,648	22648	M3	1,650,001
1.1.3	Concrete	31,075,558,800	17930	M3	1,733,160
1.2.1	CS Piping	4,378,857,648	5522	M	792,984
1.2.3	S.S Piping	2,295,025,578	1103	M	2,081,326
1.2.4	Valve installation	8,932,392	28	Nos	319,014
1.3.6	Power Cable installation	161,482,720	4960	M	32,557

Table (7) – Costs at Completion – Project 2

Similar to project (1) the quantity of works has been differed from the initial quantity estimated at the beginning. To avoid misleading the analysis of costs, due to these negative and positive variances to the volume of works, the costs at completion for project (2) are calculated for the unit of works and compared with the unit prices initially estimated for each activity. Table (8) and figure (14) show the comparison between the initial unit prices and the final unit costs for project 2.

WBS #	Description	Initial Unit Price (IR)	Unit Cost at Completion (IR)	Cost Variance (%)	Initial Qty	Final Qty	Unit
1.1.1	Excavation	1,599,364	1,650,001	3.1	23000	22648	M3
1.1.3	Concrete	1,632,156	1,733,160	6.2	19000	17930	M3
1.2.1	CS Piping	760,446	792,984	4.3	4500	5522	M
1.2.2	Alloy steel Piping	1,494,730	0		0	0	M
1.2.3	S.S Piping	1,967,269	2,081,326	5.8	900	1103	M
1.2.4	Valve installation	304,973	319,014	4.6	30	28	Nos
1.3.6	Power Cable installation	30,439	32,557	6.9	6000	4960	M

Table (8) – Initial and final price and quantity comparison – Project 2

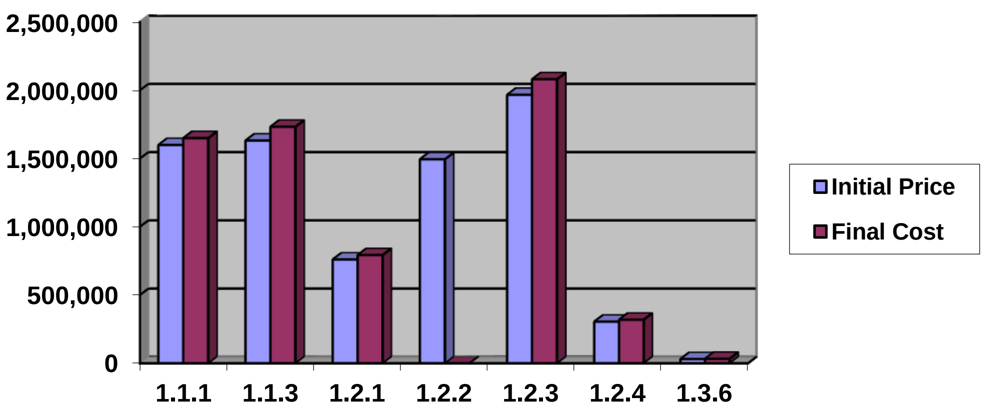

Figure (14) – Initial price and final cost comparison – Project 2

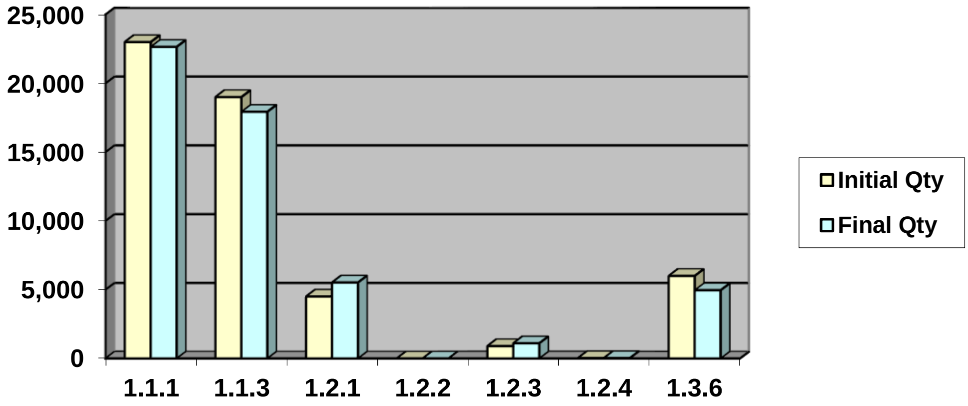

Figure (15) – Initial and final quantity comparison – Project 2

4.1.2.3 Data Analysis - Project 2

Same as what was done for project 1 in previous sections, the data from project 2 are also reviewed and the company responsible persons' comments and statements are discussed in following sections of this research.

Refer to table (8) above, it is noticeable that similar to project 1, the cots at completion of the activities in project 2 have differed from the initial prices estimated for those activities; however the variance is much more less than project 1. Comparison between these two projects and discussion on the reasons why the variances are different between these two will be discussed in further sections of this research and in this section the reasons for increased costs in project 2 will be reviewed, only.

- The geographical location of the project 2 was almost similar to the project 1, hence benchmarking has worked well for this project; however due to the booming of the area and high demand for resources of several projects running at the same time, the costs for hiring the plants and machinery was increased. In most cases the contractor was obliged to bring the equipment from other states, which attracted more transport cost and additional hiring time allowed for transportation. Due to long distance hiring, the flexibility in the hiring term was low meaning that the contractor must keep the hired equipment for longer period, regardless of the availability of the work-front for the machine.

  The direct cost of hiring in the non-industrial cities far from the booming area is generally lower, however the indirect costs incurred from the longer hiring period and extra transportation pushed the overall costs of the plants and equipment upper.

- Similar to the raised costs for machinery, the high demand for the manpower for the projects in the area caused lots of issues for the company in managing the resources and in average every 3 – 6 months either a pay-rise or monthly and casual incentives was implemented to the site employees. As per company records, during the execution of the project the wages have had an average of 30% rise. Part of this percentage was due to unusual economic issues in the whole country and the other part was due to the high demand for skilled and semiskilled workers.

- When the there is a booming in the area and the workforce are in high demand, the project workers start to move from one project to other for better working conditions or higher income. The high turnover of personnel has also impacted the costs directly and in indirect way.

- Delay in design has a negative impact to the on time procurement of the project material. For example in project 2, the storage tanks being standard equipment with known specifications, were designed on time; however the design of the pumping system, including the selection of pumps, delayed the finalisation of the pipe works and also the civil works for the pump stations. Also the control narratives for the plant were determined and finalised with delay which lead to late the ordering of instruments and control equipment. Due to these delays, the installation of the electrical systems also was delayed.

  The company was mobilised on site for initial civil and mechanical works; however other works did not proceed as per the plan and there was periods the site crew was waiting for the drawings and material to be delivered so they can work for installation. Catching up of the plan was not easy, as even by having the material and the drawings in hand, still the sequences of the activities need to be followed.

  Despite to project 1, in this project the company as an EPC contractor, was responsible for engineering, procurement and construction as a whole package; hence no claims could be raised for the delays to the external stakeholders.

4.1.3 Comparison Project 1 & 2

In the previous sections the data for each project are reviewed and analysed and the reasons for changes in the costs of each project are described. In this section these two sample projects will be compared and the reasons for the different level of cost changes at completion will be discussed.

As mentioned earlier, both projects were selected from the projects portfolio of the same company to make the comparison easier and focused. Table (9) and the chart in figure (16) show the summary of the variances of selected activities in both projects.

WBS#	Description	Variance Project 1 (%)	Variance Project 2 (%)	Notes
1.1.1	Excavation	34.6	3.1	
1.1.3	Concrete	21.7	6.2	
1.2.1	CS Piping	34.1	4.3	
1.2.2	Alloy Steel Piping	5.4	0	No A.S pipe in project 2
1.2.3	S.S Piping	38.8	5.8	
1.2.4	Valve Installation	39.8	4.6	
1.3.6	Power Cable Installation	26.9	6.9	

Table (9) – Unit cost variances for project 1 and 2

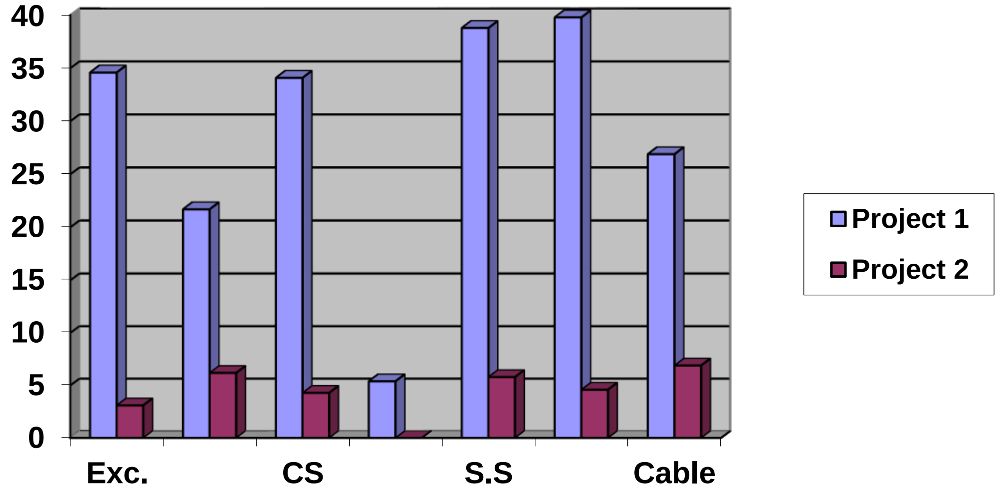

Figure (16) – Unit cost variances project 1 vs. project 2

4.1.3.1. Positives

As shown in the above table and chart, there is significant difference between the variances in project 1 and project 2, which according to the company should be considered as a big improvement in their estimating processes.

In a general note, following factors have helped with the improvement in the estimates for project 2:

- The reference project is selected from the projects portfolio of the same company intending to bid on the project 2. This is one of the key factors which need to be considered when using the data of one project as a reference for another. The culture of the company, organisation structure, quality assurance levels, documentation and archive systems, staff behaviour, level of technical awareness, skills and knowledge of the key employees, contract management systems, procurement management systems, softwares used, history of the success and failure of previous projects and etc are some unique characteristics belonging to every company. These characteristics working all together in a company, determine the overall behaviour of the company to the internal and external factors, stakeholders, risks and opportunities.

Even the level of expectations of the companies for the success and their interpretation of the profits from the projects may vary from one to another. One company may be interested on the short term benefits such as net profit in a limited period, whilst the other may be looking to establish better stakeholders relationship for future opportunities and a long term business success, even by sacrificing part of their immediate profit from one project.

These characteristics are generally based on charter of values of the company and hence are identical to each organisation. As a matter of fact, most of these characteristics specially the ones in relation to the employees are not easy to observe, measure and access. The only thing is visible are the results of this culture and behaviours, which will be very hard for the external parties to quantify and hence using other companies data as a reference will lack this important parameter and could lead to an error in estimates.

- The reference project1 is a project completed almost three years before the estimating for project 2 starts, so the collected data and information for project 1 are all matured and processed based on the facts and figures occurred in project 1. Although this is a valid point, do not guarantee correctness and completeness of the info, meaning that even three years lag between these two projects could give sufficient time to the company to collect all data from the direct and indirect costs occurred to project 1, however the accuracy of the cost allocations and distribution of the overheads and indirect cost elements to different work packages and activities depends on the skill set and knowledge of the cost controllers and analysts.

On the other hand the knowledge and capability of the estimators in using the historical data with application of proper technics and tools will be a key driver to the most accurate results.

- The reference project chosen for benchmarking is almost similar in scope with project 2. The disciplines and activities required for completing the construction portion of project 2 are identical to the ones completed for project 1, hence the WBS designed for construction package of the project was almost the same and the collected information for each activity from project 1 are used for estimating the price of the same activity for project 2.

4.1.3.2. Negatives

Although the variances shown in the comparison table (9) indicate a massive improvement in estimated prices for project 2, by showing much lower percentages for project 2 variances compared to project 1 activities; a deeper observation and analysis can lead to some interesting facts and indicators in project 2 estimation, which are discussed below.

In fact the completion costs of the activities in project 2 should be much lower than what are shown in the table (7) and (8). Some of the reasons for this statement are discussed below:

- Working site in a tank farm (project 2) is less congested than building a process plant (project 1), hence better planning for individual activities and easier access to every part of the site help the efficiency of the crew and machinery to increase and therefore the indirect costs reduced. Even

  the similar activities can be planned for the same time frames (days) with a proper planning and segregation of locations, meaning that different groups can do similar works in different parts of the site at the same day,

  hence the resources can be shared between the groups bringing the indirect costs to a lower point. Also the sequences between the activities can be managed more effectively, due to open spaces for work and transportation.

  Bulk material, fabricated spools and parts can be stored close-by. Even the on site fabrication and pre-assembling shops as well as temporary site offices and crib facilities can be located adjacent to the working area, so less transportation, supervision, administration and security efforts are required to manage the works and the costs for the utility also come down significantly.

- Majority of excavations in a tank farm (project 2) are for storage tank foundations, which are categorised as bulk excavation works which cost much less than minor excavations involved in building a process plant (project 1). For example, the price to dig and remove of $1000m^3$ of earth from a tank foundation is much less than removing the same amount of earth from separate foundations ($2\text{-}5m^3$ each) spread all over the site.

  Identifying the underground services present in the excavation areas and managing the isolations and excavation works around these services in order to meet the requirements of the protection and safety are one of the most time consuming and cost absorbing activities for excavations, which are more manageable for bulk excavations (project 2) rather than minor volume works distributed all over a process plant site (project 1).

- Concrete works are one of the very important and quality focused activities in the major construction projects. Accurate planning and effective construction management is the key to assure the quality of the poured concrete meets the requirements of the project specifications.

  Similar to the excavation, concrete works are more manageable and programmable with the bulk works rather than small volume pours spread all over a congested site with lots of transportation limitations. Post-pour activities such as exclusive controlling and curing are as important as the managing of the preparation and pouring activities. Recording and quality documentation works are also easier and hence less costly when the bulk pours are the case, rather than installing concrete in several separate locations.

- The nature and characteristics of the pipe works in a tank farm (project 2) is completely different to the pipe works in constructing a process plant (project 1).

  The average size of the pipelines are larger in tank farm so the efficiency and productivity of welding per joint is higher and hence the cost per unit is lower than joining the small bore pipe works. For example, to weld a 10" joint, the welder and all tools are located in one place however with a pipeline size of 2" in the site run conditions, the welder and all equipment must move and relocate to 5 different locations to produce 10" of welded joints. All these movement, take time and absorb both direct and indirect costs.

In a tank farm (project 2), the pipelines are generally running either on the ground level with concrete sleepers as supports or on the low height steel or concrete pipe supports / racks, whilst in the process plants (project 1), majority of the pipes are located on the single or multilevel pipe-racks and structures with significant height. Temporary safe access and barricading requirement for working at height, protection for falling objects, slow movements of people and tools on the elevated platforms, special training and qualification required for working on the platforms, lost times during the wet season and etc are all parameters affecting the time and costs associated with the installation of pipe works in height for constructing a process plant project.

Pressure and temperature rating of the media contained in the pipelines dictate the thickness of the pipes and fittings. Generally the pressure rating of the pipelines used for transferring the media to / from tanks in a tank farm is lower than the process lines used in process plants, hence the thickness of the pipes and fittings in project 2 were smaller than the thickness of pipes and fittings installed in project 1.

Thinner pipes and fittings mean less preparation and welding time, less welding material, less labour and therefore lower installation direct costs. Also the indirect expenses decrease significantly when the rating class / thickness of the piping material is low. Examples of these costs are lighter and cheaper transport; lower crane capacity and less crane hiring cost for loading, unloading and installation; lighter pipe supports; less risks of dropped objects; less weld defects due to less welding passes; less time for repair or cut-off of the defects; lighter NDT source requirement and shorter shouting time and etc.

- Safety risks involved in the works in a tank farm construction (project 2) is much lower than similar activities performed for construction of a process plant (project 1). Due to the majority of works being at ground level and also due to more open space around the facilities, not only the likelihood of hazards is low, but also the consequences are also less critical, so the risk levels (rating) for each activity are considerably lower in project 2.

Also the implementation of the controls is less time and effort consuming and hence less costly. For example traffic management requirement for a congested work site is much more complicated and costly, than a site with lots of open movement spaces around the working points.

Another example is to physically isolate the area around the location where the works are being performed at height and the dropped object hazards exist. Barricading and implementing the exclusive controls around the tanks is much easier than implementing the same controls all along the pipe-racks and structures where the majority of works are being done in a process plant construction site.

- Majority of the electrical cabling for a tank farm site are installed under the ground level using the trenches with proper backfilling. This not only save lots of time and cost for installation of heavy cables, but also simplify the activities sequence issues, as well as further traffic movements around the site. Heavy or mid-heavy cables need special provisions to be pulled along the cable trays installed on the structures and pipe-racks specially when working at height is a requirement, however laying these cables in the trenches using the simple rollers is more convenient, less risky and quicker. Using of winches for pulling the cables in the trenches comes very handy when the cable drum is standing on the ground level inline with the trench and the trench is only 1.2 – 1.5m depth, whilst the above ground cable routes in a process plant building (project 1) conclude bends and tee sections with lots of offsets and height changes following the structures holding the equipment and walkways.

Protection of cables from damaging during the installation process and pulling is much more difficult in a multi level and multi-bends routes rather than a sand bedded trench.

4.1.3.3. Analytical Approach

In this section the focus of the research will be to approach the above findings from an analytical perspective. As discussed in the previous sections, project 2 had some improvements in the estimating of initial price for the observed activities, hence there are smaller variances (gaps) between the initial prices estimated for the activities and the final costs, compared to project 1, which is considered as a positive outcome and improvement in estimating procedures for the company.

Although the result looks perfect and the cost variances in project 2 have been knocked down by almost 10 -fold in most areas, the final costs are still higher than the estimated initial prices. This variances lead to the fact that the process used for defining the initial prices for project 2 was not as accurate as should be, therefore more diligent study is required to analyse the data from the previous projects and to implement the correct factors (either positive or negative) to reach to a better estimate for the new project.

In using project 1 as a benchmark reference for project 2, although every effort has been put to select the similar activities and disciplines as the reference for the estimation, the specific conditions of work and also the characteristics of the activities in different type of plants have not been taken in account and the adjustment factors have not be applied. Therefore, the prices estimated for sample activities from project 2 are not accurate enough.

In fact, if the right factors were applied to the estimation, the initial prices for project 2 should be much lower than what is shown in table (6) and considering the figures for the costs at completion shown in table (7), the variances would be much higher than what they are. So despite to what the company is thinking of the improved estimating process, is not quite right and the variances are not reflecting the correct indicators.

4.2. Sample Projects (Australia)

In this section two construction projects in Mining sector have been reviewed for their initial prices and final costs. These projects are selected from the portfolio of a South Australian company involved as contractor to accomplish design and build works for a major mining company. To narrow down the research, only parts of this project are considered and data for one or two disciplines are selected to be discussed.

4.2.1. Project (3)

The scope of this project was to design and build a maintenance workshop facility in one of the mining sites in North Western Australia. The facilities consist of approximate 1,500m^2 of workshop building in 13 bays separated with internal portioning walls, an air-conditioned storage room and a 40t overhead travelling crane. Also an approximate 160m^2 office block with all internal fit out works being included in the concept drawings and scope of works tendered between five tenderers. Being a D&C (Design & Construct) contract, the engineering activities of the projects along with the procurement of the equipment and project material have been executed by the same company. Excluding fabrication and installation of the steel structure and internal fit out works, all other works including the design, electrical, civil and concrete works and piping were all outsourced from local and interstate subcontractors.

The project has been priced as a fixed lump sum contract and was planned to be completed in 10 months from the award of the contract, including 2 months of engineering and 8 months of installation.

4.2.1.1. Initial Prices – Project 3

The initial prices were estimated with a combination of benchmarking, parametric and bottom-up methods. The company has several numbers of similar buildings design and build in SA and also in WA. Although the size of the buildings and the clients and geographic locations were different, the company has tried to find and apply the most accurate estimating factors to reach to a reasonable estimate and competitive price enough to place the company in the winner list of the project.

WBS #	*Description*	*Unit Price (AUD)*	*Quantity*	*Unit*	*Price (AUD)*
1.0	Design Works	110	1,159	Mhrs	127,487
5.0	Concrete	946.83	1,350	M3	1,278,230
12.1.3	CS Piping	128.57	540	M	69,426
7.0	Steel Structure	4,149	225	T	933,536
6.0	OHT Crane	569,474	1	No.	569,474
10.2	Power Cable installation	31.15	2,900	M	90,324

Table (10) – Initial Prices Project 3

Costs of design works have been estimated based on the efforts and engineering hours spent on the company's previous almost similar project. The reference project was delivered to another client different to the client involved in our sample project (3). Couple of other projects with almost similar size of building were executed in another location which considered as the reference for this estimation.

Company has used the designer having a long time relationship with their projects in town and industrial areas. The initial price for design works have been estimated by adding a company mark up percentage to the quote received from the designer.

Costs of all other works also have been referenced from other similar projects, however some factors were applied to the estimates to cover the costs of executing works in remote locations in WA.

The quantities are the best estimated based on the scope of works and the concept drawings used for tendering purposes.

4.2.1.2. Cost at Completion – Project 3

At the time of research the project was newly completed and the company was in process of gathering all data and finalising the findings and the final costs. The data for the selected activities were available and are shown in table (11) below.

Although the final figures and close-out reports do not show considerable profit gained in this project, the company in general was satisfied with the outcomes of the project as their first job in real mining site with a operational environment. Also getting familiar with the client's technical specifications and requirements which in most cases are higher than the national standards the company was used to work with, is part of the non-financial benefits the company has gained which can potentially drive the accuracy of their pricing in future and guaranteeing much better financial profit in long term relationship with this client.

WBS #	Description	Cost At Completion (AUD)	Final Quantity	Unit	Unit Cost (AUD)
1.0	Design Works	155,255	2,100	MHrs	73.93
5.0	Concrete	1,228,090	1,270	M3	967.00
12.1.3	CS Piping	101,500	700	M	145.00
7.0	Steel Structure	1,090,000	250	T	4,360.00
6.0	OHT Crane	602,458	1	Nos	602,458
10.2	Power Cable installation	79,992	2,400	M	33.33

Table (11) – Cost at Completion – Project 3

Table (12) shows the comparison between the initial price and final costs, as well as the comparison between the initial and the final quantities of works. In some cases like design works, the man-hours spent for the works have had significant increase (81%) comparing to what was estimated earlier, however by using a South Australian subcontractor for the design, the company has brought the costs per man-hour of the works down and hence the total cost at completion has been increased by 21.7%, only.

In some other cases like power cable installation works, reduction of the work volume, has helped the total sum of the project price to be steady and hence the project didn't suffered from extraordinary losses.

WBS #	Description	Initial Unit Price (AUD)	Unit Cost at Completion (AUD)	Cost Increase (%)	Initial Quantity	Final Quantity	Unit
1.0	Design Works	110	73.93	- (32%)	1,159	2,100	MHr
5.0	Concrete	946.83	967.00	2.1%	1,350	1,270	M3
12.1.3	CS Piping	128.57	145.00	12.7%	540	700	M
7.0	Steel Structure	4,149	4,360.00	5%	225	250	T
6.0	OHT Crane	569,474	602,458	5.7%	1	1	M
10.2	Power Cable installation	31.15	33.33	6.9%	2,900	2,400	M

Table (12) – Initial and Final Costs and Quantity Comparison – Project 3

The reason the total costs at completion for the design works has increased significantly by 21.7% is that the designer had based the design data on the national standards and code of building, whilst the client had introduced its own codes and technical specifications which although they are referenced to the national standards, in most cases their design criteria are higher than the national standards and codes.

These requirements and reference document list have been clearly mentioned in the project scope of work, however the ignorance of those specifications caused duplicated design and drafting works for architectural, civil and structural drawings.

Part of the piping and electrical design works, also were affected by this ignorance. The contractor hasn't enquired the clarification on this matter and spent approx five weeks to produce the first version of the drawings and submitted for client review, which during the review process it is found that some parts of the design do not meet the design criteria specified in the client's codes and technical specifications referenced in the scope of work. Also the contractor was not aware of the multi-stage review process of the drawings between the designer and the client, hence the time required for this review process has not been accurately estimated and considered in their plan. A total effort of 2,100 engineering man-hours are spent against the initial estimated amount of 1,159 man-hours. As a result, the estimated duration of eight weeks for completion of the design and preparing the working drawings is almost doubled and extended for another eight weeks allowing the contractor to revisit the design and re-produce the drawings as per the client's specifications.

Although part of the time extension requested by the contractor for re-producing the working drawings has been accepted by the client, no cost implication for this error was acceptable and the contractor beared all the direct and indirect costs of this re-work. Other than the design works, this delay caused some changes to the execution schedule of the other works and pushed the start of related activities further, which having the delivery target date pre-fixed, the contractor was obliged to produce a catch up plan for construction works to squeeze the time frame originally allocated for site works. This resulted in additional labour and resource assignment to the installation works to be able to task force some critical activities and to perform some tasks in parallel with the others, with some more safety risk taken by the contractor, as well as extra costs.

Another parameter missed in the contractors estimates are the requirement of preparing the project drawings in compliance with the client's Document Control system. As per the scope of work and referenced documents in it, the drawings must be CAD conformed and drafted with Microstation software. The selected designer was used to work with Autocad and extra time and cost were required to convert the drawings.

Part of the changes to the costs of concrete works is also due to the client's codes and project specific standards and technical requirement, as well as implementation of client's quality control and quality assurance procedures to the works. As shown in tables (8) and (9), the cost per unit for the concrete works has increased by 2.1%, however due to reduction of the quantity of the concrete works, the final total cost for this activity is 3.9% less than the initial price allowed in the contract which was a fixed lump sum price type, the contractor was able to save some budget from this portion to compensate part of the budget shortfalls in other activities.

A similar situation has happened in cable installation, which carries an increase of 6.9% in unit cost, while the final total cost for this activity is 11% less than the initial price allowed in the contract. Due to the client's technical requirements some more trench works and safety precautions along with different bedding material and backfill procedure were the main drivers to the cost increase, however in this case also, reduction of the work volume without affecting the fixed lump sum price of the project, has helped the contractor generating some savings.

The estimated initial price for the overhead travelling crane, has been purely based on the quote received from the supplier of the crane plus a mark up to cover the administrative and indirect costs from the contractor side. The costs from the vendor of the crane were kept still, however the time and efforts required for the process of registration of the crane with Department of the Mines and Petroleum which was in contractor's scope of work, has been well underestimated at the tender submission. This is where the importance of knowing the external stakeholders of the project and awareness of their requirements at the beginning of the project comes to the priority.

As shown in the above tables and blow charts in figure (17) and (18), both piping and steel structural works are impacted by an increase in the costs per unit of works, as well as increased volume of work; therefore the total cost at completion for each of these activities have been increased.

Similar to other activities, unawareness of the contractor about the requirements of the scope of work and reference codes an technical specifications, as well as being inexperienced of following the work procedures related to the mining sites in an operational and brown field environment were the main reasons for this increase in the costs.

This failure, not only has caused extra direct costs of labour and material, but also has impacted the time frames and duration of the activities resulting special arrangement to catch up the committed project targets and hence absorbing more additional indirect costs to the overall project.

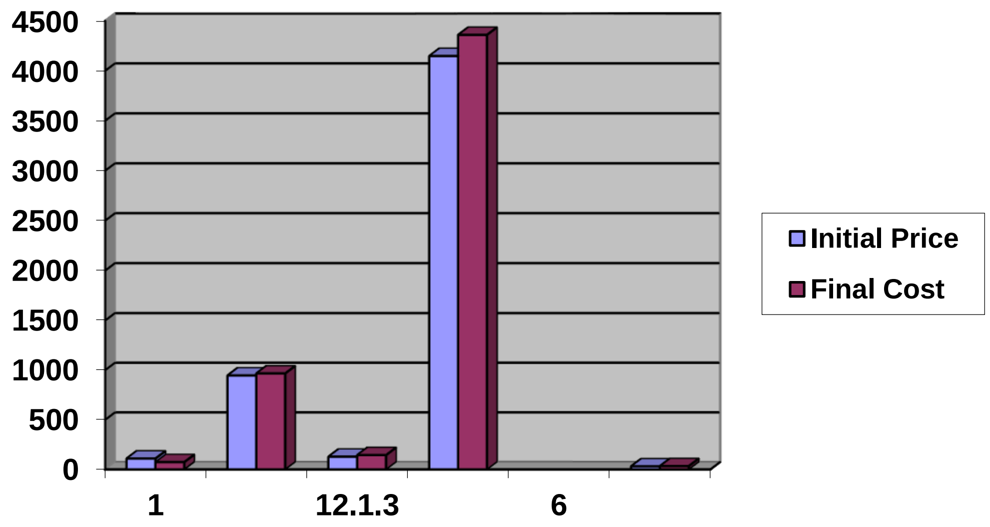

Figure (17) – Initial and Final Costs Comparison – Project 3

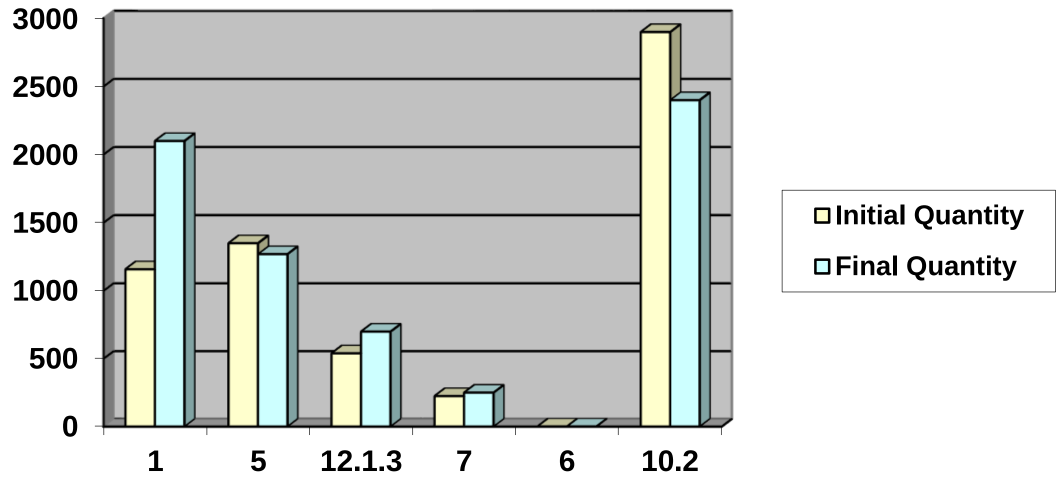

Figure (18) – Initial and Final Quantity Comparison – Project 3

4.2.2. Project (4)

The other project picked from the same Australian company's project portfolio is a small construction project consisting of fabrication and installation of walkways and access platforms around the equipment in a water treatment plant. This project is located at the same location as project 3, however the plant is part of the non-infrastructure facilities and is located outside of the mining site. This water treatment plant is considered an asset for the mining company and is operated and maintained by the mining company, however it provide potable water to the township as well as the mine site.

The platforms and walkways were designed by others and then the construction works have been tendered to the contractors. Ahrens being busy with some other project in the same area and having a workshop and local staff in the town has been selected as the contractor for this job. Steel works have been fabricated in their workshop in SA and transported to the site in WA for installation.

4.2.2.1. Initial Prices – Project 4

The company has used the bottom-up method to estimate the costs and some adjustment factors have been applied to generate enough contingency to cover the costs of potential delays in the works due to the plant operational condition and limited site access during the installation works. Also the company has taken the lessons learned from the other project with the same client, in consideration to better estimate the affecting parameters which could blow the costs up during the fabrication and installation phases. All safety precautions, efforts required for risk assessment and to apply all the controls to eliminate or reduce the risks, as well as the quality control and quality assurance procedures and project specific codes and requirements according to client's technical specifications are all included in the adjustment factors determining the amount of the schedule and cost contingencies added to the raw estimates.

Some major activities with their initial prices and quantities are shown in table (13) below.

WBS #	*Description*	*Unit Price (AUD)*	*Quantity*	*Unit*	*Price (AUD)*
1.0	Shop Detailing	110	480	Mhrs	52,800
3.0	Concrete	1,120	106	M3	118,720
4.1	Steel Fabrication& Supply	2,500	84	T	210,000
4.2	Steel Erection	3,400	84	T	285,000

Table (13) – Initial Prices Project 4

4.2.2.2. Cost at Completion – Project 4

Above activities have been planned to be completed in 18 weeks time including 5 weeks for preparation of the shop fabrication drawings. Everything went well with the shop detailing and preparation of the fabrication drawings. Then the fabrication started and continued as planned and all steel works were delivered to site on time. Although the installation started couple of weeks later due to site access issues, this delay did not have any effects to the costs, as the contractor have not been mobilised to site until the site access permit is granted.

After the installation started, there were some minor issues with the original design and the coordination of the concrete footings, which were followed and resolved by the company and client as variations to the original price and schedule, hence no un-controlled change occurred to the project. All MoC documentation has been done completely during the project lifetime and both client and the contractor were aware of the causes and effects of each change.

WBS #	Description	Cost At Completion (AUD)	Final Quantity	Unit	Unit Cost (AUD)
1.0	Shop Detailing	53,200	485	MHrs	109.7
3.0	Concrete	123,000	108	M3	1,138.88
4.1	Steel Fabrication& Supply	212,000	84.7	T	2,502.95
4.2	Steel Erection	350,000	84.7	T	3,732.23

Table (14) – Cost at Completion – Project 4

As shown in table (14) above, the cost at completion for the selected activities are not changed extensively in project 4.

The reason for this stability of the price and final costs can be highlighted in below items:

- The contractor has used all their lessons learned from their previous project with the same client and site. All the difficulties occurred during the design phase of the previous project and un-familiarity with company's requirements for the detail design works have been taken in consideration in this project to better estimate the time and efforts allocation for preparation of the shop drawings, according to client's technical specifications and standards.
- Shop detailing of the already designed drawings have been accomplished in SA where the costs of resources are much lower than WA.
- The contractor was not involved in overall and detail design of the platforms and walkways. The design portion of the works have been performed by one of the designers with a long working relationship period with the client, therefore every technical requirement of the client has been taken in consideration in the drawings, keeping the fabrication and installation compliance issues in minimum for the contractor.
- The number of the activities involved in this project was considerably lower than the project 3. Low complexity of the project helped with better risk assessment and therefore more accuracy of the estimates.
- Shorter duration of the project also, helped with reducing the unknown working conditions and unexpected risks to schedule and costs, which lead to better allocation and use of the contingencies.

WBS #	Description	Initial Unit Price (AUD)	Unit Cost at Completion (AUD)	Cost Increase (%)	Initial Quantity	Final Quantity	Unit
1.0	Shop Detailing	110	109.7	- (0.2%)	480	485	MHr
3.0	Concrete	1,120	1,138.88	1.6%	106	108	M3
4.1	Steel Fabrication & Supply	2,500	2,502.95	0.1%	84	84.7	T
4.2	Steel Erection	3,400	3,732.23	9.7%	84	84.7	T

Table (15) – Initial and Final Costs and Quantity Comparison – Project 4

- The contractor has used two estimation methods to verify the costs of the project. The costs at completion from the previous project have helped the contractor to have an overall idea on the lump sum price of the project based on the quantities, while the costs for each activity have been calculated to apply a bottom – up method for more accuracy.

- Two completely separate portions of the scope of works for this project consisting of manufacturing and installation have helped to better managing the time schedule and related risks for this project. Managing of a steel manufacturing project in their established office and workshop in SA carried almost no risks for the contractor, as every aspects of the scope were entirely known to them; however installation of concrete and steel works on site had some changes to the schedule and costs incurred due to discrepancy between the design and the site conditions, which are compensated by client.

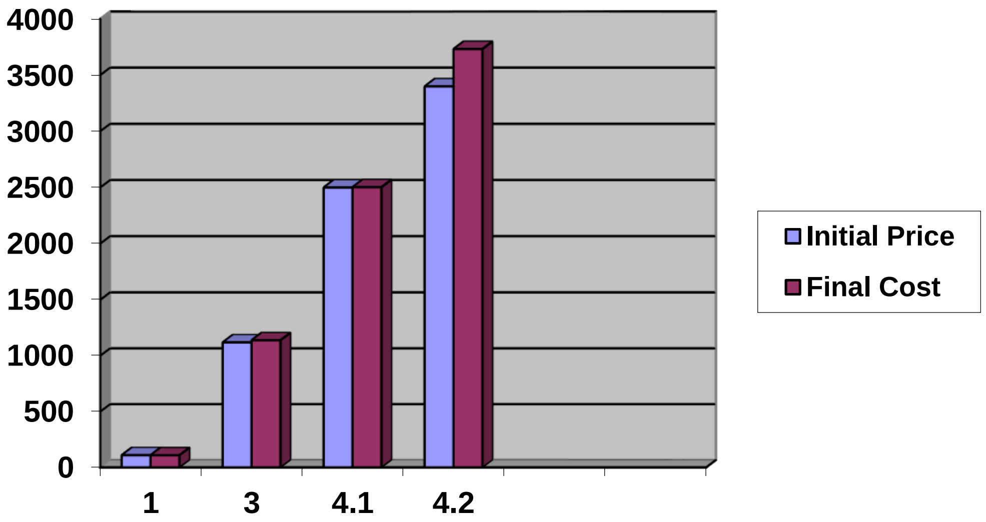

Figure (19) – Initial and Final Costs Comparison – Project 4

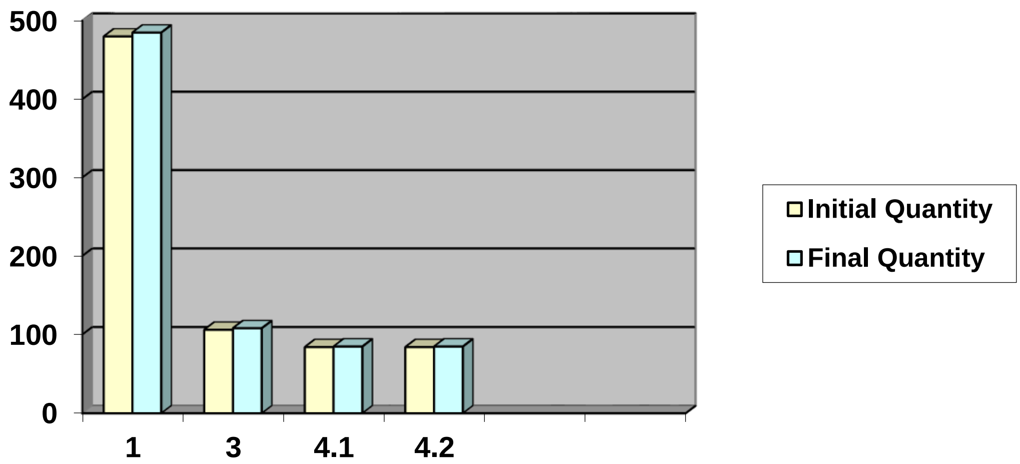

Figure (20) – Initial and Final Quantity Comparison – Project 4

- Not having mechanical and electrical components included in the scope of work reduced the complexity of the project and simplified the process of readiness for operation and therefore an easy and smooth handover and close-out phase for the contractor.

- Complete separation between fabrication and installation in the project schedule, allowed the contractor to plan for an effective mobilisation on site, so no overrun of costs incurred from the site resources being idle due to the delay in manufacturing and supply.

4.3. Analytical Comparison of Projects in Developing and Developed Countries

In the above sections sample projects from developing and developed countries have been discussed individually and the nature of changes and the amounts of the cost impact on each project have been reviewed. In some cases even, two sample projects from the same country have been compared with each other.

In this section, the overall differences between the projects in developing and developed countries will be reviewed and reasons for the lower initial prices in developing countries comparing to the developed countries will be discussed.

- In general, projects in developing countries are suffering from the lack of planning and accurate estimations from the local contractors' side, however contractors in developed countries try to be more accurate in their planning and use of the best estimating methods and risk assessment skills to reach to the most accurate estimates on their time and costs.

- Front-end loading is one of the key factors in achieving a high accuracy in the estimates, which is less focused in the middle-eastern countries. Front-end loading is performed for the projects in initiation and study phase, however it is essential to allocate time and resources to collect the data and information might assist in estimating the costs for construction works before the execution phase starts.

- Lessons learned from the previous projects are also one the valuable sources for the information which can help with leveraging the accuracy of the time and cost estimates, as well as risks in project execution. Not only using the lessons learned is important in the new estimations, but also the documentation of this info from the previous projects is important. In addition to the data collected and listed in the document named "Lessons Learned", categorising the data and also the way these data are analysed is a specialist activity which requires expert skills and knowledge.

- Using two or more estimating methods for verifying the price and assuring the level of accuracy of the estimates is another key factor which attracts less attention from the local contractors in developing countries.

- Team work during the data collection and in process of estimating the costs and time for the projects is important. A good and efficient combination of the specialist individuals in the estimation team will result to more accurate estimates and confident pricing.

4.3.1. Changes in Projects

Changes are part of the projects and they are not avoidable during the lifetime of the projects from initiation to close-out. Even in very early stages, such as selection or identification, changes happen; however their effects are more visible and highlighted in execution phase of the projects. Changes in early stages might be major and even the concept of the project and the objectives might be affected by those changes, however due to nature of the study works which they are more documental, the impacts are not as visible as the changes occurring during the execution phase.

This process of change is not specific to a region, country or company; even it’s not related to a specific industry and area of expertise. As discussed in previous sections of this research, changes might not be directly related to the price, however it’s important to note that any change lead to a change in the price of the works completed. No matter how big the change is, when and why is happening, how many times and how often has occurred, in which stage / phase of the project is occurring, by who is forced and which portion or discipline of the works is experiencing the changes; any change will finally have an impact on the costs and therefore will change the price of the works from what was estimated before the occurrence of the changes.

Changes might not be completely avoidable, however they can be definitely controlled and their impacts to the project time and cost can be minimised by proper analysis, planning and estimation process.

The main reason this research is focusing on the price changes in developing countries, is that in majority of the construction projects executed by domestic contractors, the gap between the initial price and the final costs at completion are considerably high. Part of this huge gap between the initial price and final costs is due to lack of planning and estimating knowledge and skills, however in some cases other reasons and drivers are also involved which will be discussed in next section.

4.3.2. Reasons for price changes in Developing Countries

Culture

In most of the developing countries the local contractors have the intention to win the tender and get the job, hoping that they can deal with the costs during the project and also they will find ways to deal with the clients to get the prices changed to their benefit.

As a matter of fact, this strategy works in many occasions, however it's not guaranteed and in some cases due to several factors such as structural changes to the client organisation, economic conditions, budget constraints, strict financial audits and etc, things do not go to the contractors' expectation.

Not only the contractors, but also the clients / owners of the projects in the developing countries have this culture and expect the contractors to bid with lower prices preparing themselves for further challenges and negotiations between two parties during the project lifetime.

Besides the uncertainty in budgeting and cost planning for the contractor, these pre-set and foreseen challenging financial disputes during the project execution may sometimes lead the project to a very critical conditions and failure. Even if the results of these disputes may appear to be to the contractor's benefit, the long period of this process from initiating of a contractual dispute to finalising the results and implementation of the decisions may cause inconsistency in the execution schedule and also shortfalls in the monthly cash-flow which can have very deep and unrepairable damages to the quality and progress of the project, as well as the reputation of the contractor. There are lots of examples of the projects with huge backlogs in their monthly payments to the labour, equipment and plants, sub-suppliers and etc in the developing countries.

The other aspects coming from the culture of local contractors and clients in developing countries is relying on verbal agreements and promises. This happens when the contractor relies on the verbal agreements and promises of the owner/ client during the QA sessions, preliminary discussions about the project and the tendering process. This type of mistake also, happens when a contractor builds his estimates based on the verbal commitments and promises of the subcontractors and sub-suppliers during the pricing process. Both above mentioned cases are very common practices in developing countries and they are very much related to the culture of those countries, where asking for a written confirmation for variations and amendments looks disrespectful and can harm the business relations; however most of the problems causing the delays, quality and / or cost blow out in projects are being generated by unclear scopes, specifications and commitments.

Safety Costs

Safety costs consist of both preliminary and ongoing costs in the projects, and both need to be foreseen properly and included in the initial price of the project.

The preliminary costs to safety, include the efforts and resources used to prepare the risk assessment documents, conduct the risk assessment and HAZOP workshops with stakeholders, provision of required licences, certificates, tickets for the company and individuals, preparation of the pre-mobilisation documents such as Traffic Management Plan, Roster Plan, Fatigue Management, Safety Management Plan, Emergency Response Plan and etc which generally are not the matter of interest for neither the contractor nor the client in the developing countries. These type of documents generally are considered as a formality in those countries and are produced once for the company and been used for all jobs with minor changes on the names and logos; whilst in developed countries these are part of the mandatory documentation for mobilisation which should be submitted, reviewed and approved prior to mobilisation for the works, however even in developing countries the smaller organisations do not follow this procedure and do not pay enough attention to the quality of risk assessments and documentation.

The ongoing costs for safety are the ones the contractor shall consider for ensuring all controls are known and are in place to the level which is required to eliminate or reduce the risks. Costs of maintaining safety advisors on site, reviewing and updating the risk assessment documents, conducting safety inspections and audits, running safety workshops, tool box meetings and training sessions, implementing the engineering and separating controls such as changes to the design when required, barricading, signage, isolating and etc are the main factors contributing in the direct expenses for safety reasons.

Another example of ongoing costs for safety in projects is the cost incurred from the incidents. Safety incidents cost business a vast sum in not just workers' compensation, but also by causing severe hits to productivity via lost work days, human resources time spent on incident investigation, decreased leadership efficacy and other operational and organisational costs.

The contractors in developing countries generally do not put much effort in implementing the controls entirely. Also due to less matured risk assessment and management plans, most hazards and controls stay unknown until an incident occurs. Workplace injuries create more harm than just direct cost associated with worker compensation and they are associated with an array of other indirect costs such as decreased morale and lost productivity.

The inconsistent, reactive and compliance-focused safety culture which seems to be a cost efficient solution to the safety of the projects, become a root of the issues and incidents during the execution phase and in some cases ends up with huge impacts to the cost at completion.

In more developed countries the companies generally think of improving the overall safety and welfare of employees by creating a pervasive safety culture that would not only keep workers safe, but facilities optimized. To successfully achieve this outcome, they normally focus on three main goals: first, reduce employee injuries with the ultimate goal of an injury-free workplace; secondly, establish high performance standards and empower employees on-site to effectively contribute and manage all aspects of the operation; lastly, move the safety culture from reactive and compliance-based to proactive. All these improvements and controls cost money and time to the project, however the returned value will be higher than the cots.

Reworks and their Costs

Various interpretations of rework can be found in the construction management literature, however, the Construction Industry Development Agency defined "Rework" as "doing something at least one extra time due to nonconformance to requirements"[16]. Essentially, rework can result from errors, omissions, failures, damages and change orders throughout the procurement process[17]. The reworks the contractors should consider in their risk assessment are the ones resulted from errors, omissions, failures and damages. The costs incurred from the change orders are not considered as risks for contractors, as these costs are usually claimed as extras to the main scope; however, the contractors shall follow the same process of risk assessment for the change orders as well, to ensure the costs of all aspects of changes are captured.

No matter what the root cause of the reworks are, the direct and indirect costs can be enormous and hence need to be considered in the initial price estimates using proper probability factors. Rework, as a percentage of cost growth was calculated and found to amount to 52.1% of the total, so it can be concluded that rework can make a significant contribution to a project's cost overrun. In the other words, mean direct and indirect rework costs were found to be 6.4 and 5.6% of the original contract value, respectively [18]. Some contractors in developing countries, try to assess the risks for the reworks at the time of estimating the costs for the projects, but majority of them either omit or under-estimate the indirect costs relevant to the reworks, while as per research the indirect rework costs can have a cost-multiplier effect as much as five times the actual (direct) cost of rectification [19].

In projects, reworks are different to the extra works or additional works. Reworks are the efforts and time which need to be spent for more than once to complete each defined activity.

The direct costs related to Reworks may be a result of a construction error or poor workmanship, which ends up by demolishing of what is built and re-doing the activity. There are also indirect costs incurred from the reworks which usually are not visible and less cared about. As an example, if a welded joint need to be cut and re-welded due to poor quality of the weld and non-compliance to the standards, then the costs of cutting, re-welding and repeating the NDT test will be counted as direct costs, however re-installation of the access facilities to the weld joint, repeating the documentation, delaying the successor activities such as painting, insulation, commissioning and etc will cause a range of the additional costs impacting the project budget indirectly.

Likewise to the safety, if preliminary works are not performed and proper quality control plan and quality assurance systems are not implemented in the project, the number of errors and repairs will rise up which will increase the volume of the reworks and finally project time and budget will be affected.

In most cases, in developing countries the importance of the quality and adherence to the standards and technical specifications of the project are neglected by the local contractors in the price estimating stage, hence the initial estimates do not contain the costs for the pre-mobilisation activities. Also the ongoing safety workshops and trainings are not popular in those countries.

Cost of Equipment and Tools

One of the main differences between the developed and developing countries is the use of hired plants, equipment and tools. The range of the equipment and tools available for hiring in developed countries is much vaster than the developing countries. Number of the companies specialised in the rental services for equipment and extend of their operational areas in developed countries are much higher than the developing countries.

Variety of the equipment and tools and expert advice services provided by the hiring companies also is part of the advantages attract the contractors to use rental equipment for their project.

When a company chooses to use rental equipment and tools, estimation of the costs becomes very much easier than when using their own equipment. Generally, the quote from the hiring company includes every services required for continuous and healthy operation of the equipment for the specified duration. In most cases everything except fuel and power is covered by the hiring company, however they offer the optional costs for supply and delivery of the fuel and power source in their quotation, so the company even preferring to not use these optional services, can use those quotes to establish their cost estimates accurately.

Availability of the rental equipment and tools in every industrial area and big cities in developed countries and also quick delivery services to the remote areas gives huge flexibility to the contractors to hire the equipment as per their plan and minimize the idle time of equipment between two working periods. This, results to optimize the costs of plants and equipment required for each activity and therefore the overall costs of tools and equipment during the project life reduces considerably.

Direct costs of operating and maintaining of the hired plants and equipment are also much lower than contractor owned equipment. Most of the rental companies have their mobile service facilities to perform the regular services on the plants which cost much less than having permanent site based employee. Even in some cases the rental companies take the equipment to their workshops for servicing and repair at the end of rental period of between the hiring periods.

The indirect costs related to the use of company owned equipment are also higher than the rental equipment and tools. When dealing with the hiring companies, the purchasing process of the company is followed, whilst by using contractor owned equipment, every part of the organisation is involved. HR needs to employ the operators and maintenance crew; logistics must provide transportation, consumables and spare parts; site management must consider area and workshop facilities for maintenance and lay down area for the idle periods between works; planners must work on the regular service time and etc.

On the other hand, since every equipment has a specific size and criteria of functionality, the company must have a set of equipment with different sizes and specifications to fulfil all the range of the works involved in the scope of work, no matter how much work of each range exists.

The other issue with the company owned equipment raises when the company has planned to use the only plant or equipment they own by releasing the plant from one project to another in a certain time. This generally happens for the very special and high value equipment such as high capacity cranes, barges, buggies, concrete pumps, trucks and etc; however can be generalised for the general equipment with large number of demand in the project such as welding machines, cutting sets, scaffolding material, temporary office and storage facilities and etc. In these cases, any delay in completing of one project and releasing the equipment affect the next project in time and cost directly.

Initial investment for purchasing of equipment and plants is high and if sourced from the project budget, will have very deep negative impact in the project cash-flow, unless properly budgeted in the initial price estimate for the project.

With all the advantages discussed above, still majority of the contractors in developing countries are estimating their prices based on the option of using company owned equipment and tools. This could be either because of the limited availability of hiring options or driven by their belief that hiring equipment and tools is much more costly than using their own equipment.

Regardless of which option the contractor decides to go with, the costs must be calculated accurately and all the preliminary and ongoing expenses must be taken in consideration during the initial estimates. As a matter of fact, the contractors usually cannot calculate the costs incurred of using their own equipment and tools correctly. The majority of indirect costs and negative impacts failures and delays, maintenance overheads, interest of the funds spent to purchase and also the depreciation of the value are some of the items are generally neglected or miscalculated in their price estimating process.

These contractors even are not able to use the proper cost per day or per hour of equipment and plants for the claiming purpose for the additional works and / or the delays out of contractor's control. This is another reason why their actual cost at completion is higher than their initial price.

Another aspect of this very common mistake happening with the project costs estimate is that the proportional cost effect of the assets and belongings of the contractor, used for the project, is either ignored or mis-calculated in the cost estimating process. The contractors having their own tools, equipment, machines, portable buildings, vehicles, do not or cannot accurately estimate the costs of their assets contributing in the project; so they come with lower price estimates than other bidders, while in the process of execution, the direct and indirect costs of this type, affect their project cash flow resulting serious financial issues, especially in long term contracts. The best way for the bidders to avoid this mistake, is to consider the hiring rate for all their assets for the duration of their contribution in the project. This will help them to have their estimates accurate and still competitive to other bidders.

On the other hand, even if the contractors estimate their initial prices based on the costs of hired and rental equipment and tools, the costs of these items in the developing countries are lower than the developed countries. The reason behind this difference is in the level of the services the hiring companies are providing to their clients in the developed countries. The generation of the equipment supplied, frequency of the regular inspections, registration and compliance certificates and etc are the main factors differentiating the costs of the rental equipment between developed and developing countries.

Indirect Costs and Preliminaries

Preliminary and indirect costs of projects are the other aspects that contribute to the initial prices in developed countries being higher than equivalent projects in developing countries.

Not only the net costs for either purchasing or renting of the vehicles, temporary office and messing facilities in developing countries are lower than the developed countries, however also the level of quality and quantity of these provisions contrast vastly. The employees' expectations of site office facilities and transportation in developing countries are much lower, hence the companies provide the minimum possible as part of their site mobilisation.

Accommodation and travel are also less costly in developing countries. Sharing a room with other colleagues, poor quality rental houses and room facilities, less or no entertaining and sporting provisions are some of the key factors bringing the costs of accommodation down in developing countries.

Generally the indirect efforts required to complete the project are not accurately estimated in developing countries. This is due to the extension of these works and the effects they can have on the outcomes of the project are usually underestimated by the contractors. At the outset, the companies allocate one person for each indirect and supporting role such as administration, project control, logistics, office assistant, material control, safety advisor and etc. Even in some cases they envisage some of these roles to be merged together. For example some companies plan to use just one person to cover two or even more roles simultaneously. This approach is appreciable if all the parameters involved in those roles are carefully assessed and the decision is made based on the size of the project, level of the management expectations from each role, duration of the project, geographical location of each role and etc, to avoid compromising the quality and other project targets for little savings.

Companies in developed countries take the costs of a large degree of preliminary and ongoing training, inductions and other types of people, safety and skills improvement programs in consideration in their initial price estimation. Some of these programs such as inductions and specialist qualification trainings are mandated by either the clients or by the statutory rules and legislations, however some the non mandatory training are planned by the companies in developed countries to improve the level of the skills and knowledge of their employee. Although the clients and statutory requirements for qualification of the employees in developing countries are not as strict as the developed countries; there are still some requirements which the contractors must fulfil during the project life. The positive aspect of these training programs is that the costs for running them are much lower in developing countries; the negative is that sometimes they are entirely missed from the contractors cost estimations.

Costs related to appropriate handling and warehousing of the project material are another parameter forcing the initial prices in developed countries to rise. The standard of the packing, marking and transportation of the goods and project material is higher in developed countries and hence the costs attracted by these activities are also higher than the developing countries.

Storage facilities, warehousing and material control procedures are part of the requirements in every major contract in both developed and developing countries, however is less concerned and tracked in developing countries. Accordingly, the costs of producing and implementing of these procedures are also generally neglected by the local contractors during their price estimation process. As a result of this negligence or underestimation, the unbudgeted costs of managing the material during the execution phase of the project must come out of the project budget which will affect the overall performance of the project. These expenses might be incurred due to establishing the material control and warehousing systems to meet the requirements of the contract or costs to repair the damaged material due to poor storage or cots of replacing of the lost and /or stolen material.

Taxes and Fees

Taxes, custom clearance fees, statutory fees and surcharges are regulated and strictly controlled in developed countries, whilst in developing countries there are lack of control system and also lack of law enforcement to comply with these rules. The rates of taxes and other statutory fees and the variety of them in developed countries are also higher than the developing countries. There are ways to scape from paying the right tax, custom clearance fees and etc in those countries, so when estimating the costs, the companies count on the least they will pay for these fees, however if the conditions vary, then the company must tolerate the difference between what was estimated and the amount to be paid.

Corruption and bribery also are still very common in most of the developing countries and local companies try to take advantage of it to pay less taxes and statutory charges and therefore keep their initial prices lower.

People rather than machines

Contractors in developing countries use more people to execute the tasks rather than using machines. Lower wages and paid allowances in those countries, compared to developed countries is one of the other reasons for the initial price to be lower. A vast range of the employees in developing countries do not have enough knowledge of their entitlements and are so desperate to get and keep a job that generally do not complain on their incomes and benefits. This gives the opportunity to the companies to pay lower wages to the human resources and therefore they come with lower cost estimates for this portion, in their initial prices.

Problem with using people for the tasks which easily can be done by use of plants and equipment is that the process of employment and releasing of the human resource is much longer than hiring equipment. Plants and equipment are ready to be used upon arrival to site; however people need a preparation and on-boarding period to be functional. The other issue with dealing with people is that there are lots of factors and parameters in human that make the estimation of their indirect costs so complicated and in some cases impossible.

Costs of maintenance of tools and equipment

As discussed earlier, the equipment and plants used in the developed countries are maintained in a more controlled and systematic way than the equipment in developing countries. Regardless of company owning the equipment or using a hiring company for supply of the plants and equipment the quality of servicing inspection and operation of the equipment in developed countries follow higher standards which not only help the longer working life for the equipment but also assure the quality and safety of the tasks being performed and in some cases they are even enforced by the client through the contract.

In developing countries the companies using their own equipment and tools, generally do not have or do not completely follow the maintenance schedules and procedures of the equipment and usually stick to the very basic services until the machine fails. The local hiring companies have more interest in maintaining their plants and equipment; however the level of their knowledge and understanding of the quality of the works required is limited. No matter which strategy the contractors in developing countries choose, the costs of maintenance of the tools and equipment are not estimated accurately and hence do not show correct figures in their initial prices.

Poor Front End Loading (FEL)

Past improvements in average-cost growth were driven by having a project adequately defined before the funds were authorized. This successful strategy goes by the term front-end loading (FEL). FEL is the key driver of improved project costs [3]. FEL consist of all activities performed in gathering information, analyzing the data, reviewing the historical information and lessons, project cost planning and any other information-based activity, which assist the cost estimators to have more accurate estimates for the projects.

One of the main areas in FEL is the cost engineering of the project and predicting the cost of a new project by studying the outcomes of the previous similar projects.

This will be possible only, if an organized system is in place and costs have been classified to appropriate cost pools. Accuracy in cost prediction is a function of the accuracy of individuals' estimates of all possible predictor-target relations. Accurate prediction requires individuals to accurately estimate the sign and magnitude of these relations. This includes determining whether potential predictors actually have a statistically significant relation with the target [20].

There are some other FEL activities which are much more practical for the contractors to approach, however they still remain as part of the common mistakes leading to in-accurate price estimation for the projects. A wrong and inadequate Work Breakdown Structure (WBS), will certainly results an in-accurate cost estimate, as the total cost of the project is a sum of costs estimated for each activity. On the other hand, by generating a WBS for a project, the contractor will need to go through the details of the scope and quality requirements and hence a complete picture of the project will be illustrated to the contractor.

When WBS is generated correctly, estimation on duration of the tasks and resource allocation can be performed easily and with a higher level of accuracy. WBS is where the relations between the different activities in a project are determined. As an example in one of the projects in 2001-2004 the contractor for piping had not broken down the activities accurately, so the relation between the scaffolding and installation of the pipe works in some areas had been omitted and hence the direct costs for scaffolding and also the indirect costs related to the hold down time to complete the scaffolding prior to pipe works had not been foreseen correctly.

Duration and resource allocation for activities in a project is based on the workload determined for each activity. Historical information from previous projects, if properly stored and analyzed, can be useful for estimating the workload, duration and resources required for each single activity in the WBS, which consequently will generate the total estimate of duration and resources required for the entire project and hence, by applying the proper adjustment factors, will end up with an accurate estimate of costs for the whole project.

Selecting Inappropriate Estimation Methods and Tools

There are various and vastly contrasting methods for conducting the estimations. Each of these methods and tools are designed and are more efficient only in one or some types or in specific conditions of the projects. For a data processing project a method based on the requirements gathering time can be used effectively, while this method is not reliable for estimating of the costs for a multidisciplinary construction project. In the above method the companies working on the data processing and software projects, estimate the time and costs of a project by using a factor called “Grady’s Ratio” to predict the time required for the whole project and knowing the costs per hour of the resources, the estimates for the total project costs can be achieved.

Robert B. Grady believes that the requirements /specification phase generally takes up 6% to 8% of the time it will take to complete the entire software project [21]. It is obvious that this method does not fit construction based projects.

Benchmarking is one of the most common methods used to determine the costs of the construction projects when time is a constraint for pricing. As an example, if the contractor is invited from company’s other projects to do almost similar works in a live refinery complex, they often do not consider the specific conditions of the site and they simply bench mark the other projects with same company without considering that in the new site being a live refinery facilities. They would potentially face some restrictions in material handling and delivery to site, works hold ups and access roads closure in case of emergency situations to the live plants around, limited lay down areas and working hours and restrictions to accessing the site, they will end up with inaccurate cost estimation and hence underestimation of the project price.

This is where the major mistakes could potentially happen and place the contractor delivery of the project in jeopardy. In this method, the contractor bases all of the estimates on the similar projects executed in the past or even on the projects still in execution. The factors and ratios used for adjusting the new price are determined by the contractor, the best of his knowledge. Using this method is one of the most complicated ways to reach accurate estimates in large and multidisciplinary projects; however it can be useful where only budget estimates are required or a very high level estimate is needed for initiation phase of a project by the owner team.

There are several factors to be considered when benchmarking. Geographic conditions, timing, particular conditions, specific requirements, resource limitation, economic conditions, access conditions, weather and seasonal conditions, work break down structure, weight of activities, lessons learned, owner/ client preferences, social conditions, safety and quality requirements and etc are some of the factors to be applied for adjusting the project price.

One of the main factors primarily ignored is the accuracy of the data collected from the other project. The estimator shall validate the accuracy of the data being used as a basis of the estimates.

Inappropriate Benchmarking

As discussed in previous chapters, benchmarking is one of the most common techniques for estimating the costs for projects and is vastly using in both developed and developing countries. The main reason can turn this method to a cause for errors in estimates and failure in accuracy of the initial price, is the fact of mis-using the benchmarking method. If the reference project is not selected properly or benchmarking is used as the only method and source for estimations.

Benchmarking is one of the best methods to verify the estimates performed through other methods and can be used to gain more confidence on the initial prices prior to the tender. Most of the contractors in developing countries are suffering from relying on this method as the only method to finalise their initial price; whilst the contractors in developed countries use this method in combination with other methods.

No or poor Risk Assessment

Risk assessment is one of the main lacking activities in project cost estimating process by local contractors in Middle Eastern countries. Generally the word "risk" is known as safety related risks and even with this definition, it is not being assessed efficiently and hence the related costs are not usually considered accurately in the estimates.

Safety related risks in engineering construction projects, generally have three different kinds of cost to be considered while estimating the initial costs of the projects: First, costs of study, risk analysis and all initial software works being done to indentify and assess the risks. Second, is the cost of applying all the controls to eliminate or control the risks during the project life and continuously monitoring and improving of the controls. Third, the costs incurred from an incident resulted from un-controlled or unknown risks. Depending on the size of the project and severity of the incidents, the cost impacts of the last case could be quite considerable, and in some cases un-affordable for the contractor.

Risks to the schedule are another type of risks to be assessed during the price estimation for projects. There is a direct relation between the duration of the project and the costs, so any omitted risk to schedule, will directly result the in-accurate estimation of costs. Assessment of this type of risks is not as easy as safety risks, as there are several factors involved in them, so assigning expert persons is highly advised. Reworks are one of the main drivers for schedule risks.

In the other hand, in an effort to meet the project's scheduled completion date, design and construction firms may have to employ additional resources. Such actions may lead to the opposite of the desired effect. That is, pushing beyond the limits of effective concurrency increases complexity and this can increase the time to complete tasks [22].

Absence of risk assessment or conducting poor risk assessment also may cause failure in reaching to the accurate price for the projects. Specially when a fixed lump sum contract is in place, the level of awareness on risks and controls and the costs involved in minimising or eliminating those risks is a main factor to ensure the accuracy of the estimates for the initial price.

Contractors in developing countries pay less attention to the risk assessment in the initial stages of the project, so they generally do not consider the consequences of the changes to the schedule or costs due to the un-foreseen risks in their price estimation.

Poor Understanding of the Scope

Awareness of the scope has two different aspects which both are important to know. The contractor must carefully read and understand the entire scope of work and supply of the project and any attachments, amendment, appendices and reference documents to the scope. This is the part generally the contractors know about the scopes; however the contractors / bidders must be able to realize the missing compulsory information of the scopes, as well. In the other word, an expertise contractor and an experienced bidder shall understand and enquire the information necessary for accomplishment of the project scope and must seek clarification on them. This is the part most of contractors don't realize during their cost estimation process.

There is a very common thinking in contractors in developing countries (Middle east), specially in mid-size ones, that asking for clarifications or more clarity on the information given in the scopes, may change the clients idea about the contractor and may reflect as their non-awareness about the job and hence losing their creditability and the chance to get the job.

On the other hand the clients of mid-size projects in developing countries think that keeping some areas of the scope unclear will give a chance to get more works performed by the contractor, than what is being paid for. This unfair and non-ethical approach of taking advantage of the low awareness of the contractor, might be useful for the clients in some cases, but in long term will destroy the morals and also will weaken the contractors' potentials for growth.

One of the other mistakes happening with the scope is benchmarking the scope of the new job with apparently similar projects the contractor has been involved before. This should be known that there is no project can be exactly replicated and since every project is unique by itself, every scope of project also is unique and hence it is worth to be carefully read and examined.

Poor and unclear procurement strategy

To reach to an accurate and reliable price estimate, it's essential to have a strong and solid procurement strategy. This strategy is unique to each project and must clarify different procurement requirements and roadmaps for different situations in a project. Contractors, from the early stages of the costs estimating process, should be aware of the type of the contracts and methods of the procurement they will apply for their sub-suppliers for a specific project. This awareness can help them to have a better understanding of the vendors' requirements and also to assess the risks to schedule and cost incurred from the vendors.

Unknown procurement strategy will cause a doubtful price estimate and a poor risk assessment which can lead to various uncontrolled changes during the execution of the project.

Poor understanding of technical specifications and requirements

There are some requirements which are very well known for all of the projects in the same field; however each project has its own specific requirement which may effectively influence the duration, resources allocation and hence, the costs of the project. Technical requirement, reference documents and standards, quality requirements, statutory legislations, insurances and bank guarantees, local resource constraints, social factors, particular traffic considerations, seasonal climate of the area, accommodation limitation, client organization and workflow, communication and reporting requirements, project close out documentations, and etc are some of the various requirements specific to every project, which need to be considered when estimating the costs of the projects.

5. Conclusion and Recommendations

5.1. General

The calculation of the budget and the provisions for the projects is the key to delivering profitable projects. In a market situation it's important to provide a competitive price to the client for the required services in order to secure the project ahead of other competitors. In addition, allowing sufficient budget to actually complete the projects with a reasonable profit is the key to the long term survival of the companies. Poor initial budgeting can be serious downfall of the project managers and professional service providers.

The effort and approach used to determine the budget depends on the type of contract required by the client. A schedule of rates contract indicates that the client is prepared to carry some of the risk associated with the budget estimate; whilst a lump sum or fixed price contract transfers all of the budget risks to the contractor. There are also other contract approaches based on target incentives attempting to share the budget risks between the client and the contractor, if the project is completed under or over budget.

It is essential that the client and contractor's project manager discuss and fully agree the interpretation of the contract position regarding the budget.

There are three key actions involved in establishing the project budget:

1. **Understand the estimating methods available**

   Project cost estimates are prepared at all stages of the project, even before it is approved to proceed. Initial estimates also called screening budgets or order of magnitude, have considerable uncertainties, however are used as pre-feasibility estimate to determine wether to proceed with the further investigations. Estimate accuracy in this level is approx. +/- 30 – 50%.

As the project continues, the amount and quality of the available information improves enabling the reduction of the uncertainty of the estimates. In the feasibility study stage, the accuracy increases to the level of +/- 15 – 20%.

Capital approval estimate also called project budget has an accuracy of approx. +/- 10% and is based on the frozen process / engineering concepts with full determined project information. This estimate is used for budget approvals, comparing major process options, checking of the contractors' bids and cost control purposes.

Project control estimates with an accuracy of around +/- 5% or better are based on more detailed information such as final process and engineering documents, material lists, quotations, orders and detail layouts. These are used either for comparing the contractors' bids or project cost control during the project life.

Depending on the level of the information available and also the purpose of the estimates, one or a combination of the methods and technics of budget estimating discussed in previous chapters of this research, may be used to develop the budget.

2. **Develop the budget**

A budget is as accurate as the information it is based on. The project manager is responsible to ensure that the required data is available and that estimates produced by one method are cross checked by using other methods. This provides a higher level of assurance that despite the lack of information, the chosen estimating method will provide a reasonable estimate of the final project cost.

In most cases, specially the major complex projects, project budgets will be estimated by a combination of different methods and techniques. Alternatively some methods will be used to provide a cross check on others to ensure that the calculations are accurate.

It is advisable to use standard forms and spreadsheets for calculating the estimate of project budget, so the team members input can be rapidly combined and checked through multiple methods.

Most of the data used for order of magnitude are historical data from other similar projects, whilst in estimating in study and feasibility phase, 1^{st} level data using one or more of the estimating methods have been used for estimating a budget with +/- 15 – 20%.

3. Calculate the Provisions

"Project Provisions" is an allocation in the work breakdown structure and the budget to cover the costs of insurances, escalation, foreign exchange exposure and contingency. Each of these factors can have an influence on the final cost for the project. The components involved in these factors are explained below. Accuracy of each component and adequate review and adjustment of them may ensure the accuracy of the provisions and hence the certainty in the initial estimates.

A project budget may have been estimated many months before the actual expenses are incurred and contracts signed. During this period, the prices in the market place can be changed substantially. The estimate for Escalation is designed to cover these increases.

For the projects in execution, where purchases of goods and services are made in currencies other than project currency, the foreign exchange variations could incur changes to the project final costs.

Insurances are provisions to cover the costs incurred from the public liability, workers compensation, professional indemnity, damages to site facility and project material by transferring the risks to a third party.

Contingency is the budget allowance made to cover the budget risk areas of the project. All projects, unless complete, contain budget risks which can be quite considerable at the early stage of the project such as order of magnitude or feasibility. The level of uncertainty reduces as the project progress to detail engineering and procurement stages.

For contingency the expectation is that combinations of factors will occur on every project resulting debits and credits to the available contingency. At the completion of the project, the available contingency remaining will most likely be zero.

Contingency is not an allowance to cover the major changes to the scope of the project. Each major scope change should be accompanied by a re-estimate of the costs and a new contingency which may still be included in the original estimate. Contingency will depend on the types of contracts awarded and the current stage of negotiations with tenderers [23].

5.2. Last Words

Although there are various factors for the initial project prices to be lower in the developing countries, poor front end loading (FEL) and lack of knowledge on the scope of work and scope of supply can be considered as the most responsible factors for project cost initial estimation usually being wrong. Using of expertise resources for estimating and also properly breaking down the works and conducting proper risk assessment can extensively reduce the risks of under-estimation of the initial prices for the projects.

Further researches in the area of FEL focusing on the importance of comprehensive and detail front end loading, parameters to be considered in FEL, processes and methods to achieve a time effective and reliable FEL, effects of EFL errors on the cost estimates, the ways to improve the FEL and specialist resources used for a successful FEL might be helpful to the industries to manage the budget of their projects more effectively and smoothly.

Also researches in type and structure of the scope of works and scope of supply, along with the analysis of how the poor understanding of scope can end up with an inaccurate cost estimation, the parameters to be considered in scopes, improvements to the production of the clear and understandable scopes as well as improvements to the way of reading and analyzing the scope of work and supply, might help the industries to deal with more accurate initial prices and hence less changes and challenges during the project life.

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