Accuracy of FEL 2 Estimates in Process Plants

Melissa C. Matthews

Abstract—Estimators use a variety of practices to determine the cost of capital projects at the end of the select stage when only a small portion of engineering is complete. The expected accuracy of these conceptual estimates is usually quoted at plus or minus 30 percent. However, many projects finish with costs outside that range. AACE® International recommends that projects have a class 4 estimate when upwards of 15 percent of engineering is complete, which is approximately the end of the select phase. Data from actual projects in the process industries show that conceptual estimates labeled as class 4 are not as predictable as expected. In fact, most class 4 estimates resemble the predictability of class 5 estimates. Given this, the question that follows is: What drives variance in performance measured from the FEL 2 estimates? Using Independent Project Analysis’s (IPA’s) extensive database, the author looked at project estimates and practices to identify approaches that improve the accuracy of FEL 2 estimates.
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Introduction

Cost estimates are a key component of any project planning phase. A cost estimate puts a monetary value on the proposed scope of a project to help assess its economic feasibility and establish the necessary budget. In the first stage of the project planning process, Front-End Loading 1 (FEL 1), a cost estimate is based on very limited information because not much is known about the project. Once the project moves into FEL 2, also known as the scoping phase, a cost estimate can be developed for the selected scope and should have a major equipment list and completed process flow diagrams that can be used as the basis for the estimate. When the project moves into FEL 3, an estimate can be created based on the front-end engineering design (FEED) information. The detailed FEL 3 estimate can then be used during the authorization process to justify the amount of money that is necessary to move into execution [1, p.202-215].

Cost estimates provide a most likely value and a range of costs that represent where the projects costs will fall given a certain level of confidence [2, p.2]. In parallel with the increased level of information available, the range around the cost estimate should tighten from one planning phase to the next, improving the accuracy of the estimate. This research paper will focus on cost estimates that are developed during the FEL 2 phase, and evaluate how the use of certain estimating practices affects the accuracy of an FEL 2 estimate.

FEL 2 estimates are used by the business sponsors to decide whether or not a project should move into FEL 3. Even though FEL 2 estimates come with a range, the central value is what the business will remember. Therefore, the more estimators can cut down on the uncertainty, the better. The focus of this paper is to look at specific practices that are used to create FEL 2 estimates and determine the benefits and tradeoffs of using detailed information and techniques.

The purpose of a cost estimate developed during the FEL 2 phase is to determine how much the project should cost based on the finalized scope information. Because these estimates are developed before FEED, when a number of engineering deliverables are matured to “issued for design” status, there is variability around the level of detail in the information used to estimate each cost category among companies within the process industries. The research sample shows that cost estimators used an assortment of techniques to develop estimated costs of projects and their associated range at this early stage in a project. The combination of the level of detail in the engineering information and the estimating methods can be an indicator of the estimate’s accuracy.

Accuracy in this paper refers to the deviation from the project’s estimated cost at FEL 2 to the actual cost, which will also be denoted as cost deviation. Typically, cost deviation is measured from the authorized amount to the final cost, but for the purpose of this research, the following equation was used to calculate project cost deviation. Any time project cost deviation is mentioned in this paper, it is referring to Equation 1.
Cost Deviation = \left( \frac{Actual \ Costs^N}{Estimated \ Costs \ at \ FEL \ 2^N} \right) - 1

N: Normalized for time (escalation) and currency to January 2003 US dollars

Equation 1

In theory, if given the choice, most people would prefer to use an accurate estimate to make a business decision rather than an estimate that has the potential for excess growth. However, there is a perceived trade-off that a more accurate estimate will take more time and cost more money to develop. Given this trade-off, the improved accuracy is not viewed by the business sponsors as necessary for the type of decisions that need to be made at the FEL 2 gate. Within the sample of process plant projects used for this study, there is no statistical difference in the time it took a well-defined project to complete FEL 2 and use semi-detailed estimating techniques and a well-defined project using factored techniques. However, there is a significant trend indicating that using detailed estimating methods in FEL 2 costs more money.

Dataset and Methodology

Introduction to the Cost Estimate Classification System

AACE® International Recommended Practice No. 18R-97 provides a classification system for cost estimates of 5 different classes of estimate for the process industries. The classification system starts with class 5, which is a very basic capacity-factored estimate developed early in a project, and ends with class 1, which is an estimate developed when over 60 percent of the engineering has been complete and uses much more detailed methods of estimating. Figure 1 provides a description of the estimate classes.
**AACE® International Class of Estimate Definitions**

<table>
<thead>
<tr>
<th>Estimate Class</th>
<th>MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES</th>
<th>END USAGE</th>
<th>METHODOLOGY</th>
<th>EXPECTED ACCURACY RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 5</td>
<td>0% to 2%</td>
<td>Concept screening</td>
<td>Capacity factored, Parametric models, judgment, or analogy</td>
<td>L: -20% to -50% H: +30% to +100%</td>
</tr>
<tr>
<td>Class 4</td>
<td>1% to 15%</td>
<td>Study or feasibility</td>
<td>Equipment factored or parametric models</td>
<td>L: -15% to -30% H: +20% to +50%</td>
</tr>
<tr>
<td>Class 3</td>
<td>10% to 40%</td>
<td>Budget authorization or control</td>
<td>Semi-detailed unit costs with assembly-level line items</td>
<td>L: -10% to -20% H: +10% to +30%</td>
</tr>
<tr>
<td>Class 2</td>
<td>30% to 75%</td>
<td>Control or bid/tender</td>
<td>Detailed unit cost with forced detailed take-off</td>
<td>L: -5% to -15% H: +5% to +20%</td>
</tr>
<tr>
<td>Class 1</td>
<td>65% to 100%</td>
<td>Check estimate or bid/tender</td>
<td>Detailed unit cost with detailed take-off</td>
<td>L: -3% to -10% H: +3% to +15%</td>
</tr>
</tbody>
</table>

* [3, p.2]

**Figure 1 – Summary of AACE® International Class of Estimate Definitions**

The natural progression of the classification system has made it easy for many companies to require a certain class of estimate to pass through the gates of their stage-gated planning process. Many companies require a class 4 estimate before passing the FEL 2 gate. The recommended practice suggests that a class 4 estimate is developed by equipment factored estimating methods or parametric models, and is used to assess the feasibility of a project. Class 4 estimates fall within -30 percent/-15 percent to 20 percent/50 percent of the actual cost estimate. These ranges represent the high and low percentage of variation that typically represent a 50 percent confidence interval [3, p.2].

The recommended practice provides a more in-depth description of each class and offers a list of project and engineering deliverables and the required level of definition each one should have to be used in the creation of a cost estimate [1, p.5-9]. These tools have been very helpful to establish industry standards for the various levels of cost estimating. However, even within these classifications, there is room for interpretation, contributing to the fact that while two estimates might fall into the class 4 category, they could be developed in two completely different ways. For example, both projects could fall into the range of 1 percent to 15 percent of engineering complete, but one could just use factored methods, and the other used parametric models for all of their cost categories. Even within the use of parametric models, there exists room for variability. Some parametric models are well-developed models that are based on historical data from similar projects, and other parametric models are high-level and are based on theory. The quality of a parametric model is highly dependent on the past cost data used to identify the relationships. Therefore, the more robust and accurate the data used to develop the parametric model, the better the model will be at predicting a project’s future...
cost [4, p.9-12]. Well-developed parametric models should provide a more accurate estimate than a purely factored estimate, but both fall under the class 4 category. The point of this discussion is to highlight that within each class of estimate, variability exists in the estimating methods used, which suggests that in reality there is a continuous scale of estimate definition rather than a set of discrete buckets.

Dataset Description

To determine the relationship between estimating practices and cost deviation, the author used a sample of data gathered from actual projects through the Independent Project Analysis (IPA) project evaluation system (PES®) benchmarking process (PES® is a registered trademark of IPA). IPA is a benchmarking and research organization that strives to improve the effectiveness of capital projects. IPA analysts collect project information through interviews with project teams and collect over 2,000 variables at various stages in a project’s life. Based on the estimating methods and engineering deliverables used to develop the FEL 2 cost estimate, each project was assigned to a class of estimate. Projects from the process industries that completed an evaluation at the end of FEL 2 and at the end of the project and met the requirements of a class 4 estimate were used.

A sample of 105 projects with class 4 estimates from process industries was selected. Twenty-six owner companies are represented in the sample, which includes a range of project sizes, types, and locations. The projects in the sample had an average cost of $77 million, with a range from $6 million to $650 million. All costs were normalized for escalation and currency, and brought to January 2003 constant US dollars. Most of the projects (67 percent) were executed in the United States, 20 percent in Europe, and the other 13 percent in other countries around the world.

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Industry Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenfield 8%</td>
<td>Speciality Chems &amp; Pharma 12%</td>
</tr>
<tr>
<td>Add-On 17%</td>
<td>Minerals 1%</td>
</tr>
<tr>
<td>Revamp 28%</td>
<td>Chemicals 38%</td>
</tr>
<tr>
<td>Expansion 21%</td>
<td>Refining 49%</td>
</tr>
<tr>
<td>Colocated 25%</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2 – Industry Dataset Projects by Project Type and Industry Sector**
Methodology

Several different statistical methods were used to test the relationship between estimate accuracy and estimating practices, such as one-sample t-tests, one-sample variance comparison tests, linear regressions, and one-way analysis of variance (ANOVA). The author also controlled for factors that could contribute to variability in the accuracy of an estimate, such as project size, sector, practices, and excessive padding in the estimate.

To test the differences in the mean cost deviation between two independent groups, such as projects that used two different estimating techniques, one-sample t-tests and one-sample variance comparison tests were used. When there were more than two independent groups of projects, ANOVA was used to test the statistical differences between the groups.

For each method, a result of “Pr < 0.001” means the probability of generating the results randomly with repeated tries is less than 1 in 1,000. Following standard procedure, results are called statistically significant when the probability of a random (false) positive is less than or equal to 0.05. Results are called directional when this probability is less than or equal to 0.10.

Estimating Practices Used to Develop Class 4 Estimates

Process plant projects typically begin the estimating process by determining how much the expected equipment will cost. At this point in the planning process, the scope should be finalized and the start of a major equipment list, if not a preliminary equipment list with some specifications, should be available for the estimator to use. Once the equipment is estimated, AACE® International recommends that the other major cost categories can be factored, or use a variety of other stochastic estimating methods [3, p.6]. The data suggest that what actually happens is much more variable than this. Many different estimating methods are used in the process industries to achieve class 4 estimates. This section of the paper will discuss the estimating methods used to develop class 4 estimates within the sample of process plant projects from the IPA database across four major cost categories: equipment, bulk materials, detailed engineering, and construction labor.

Equipment

Equipment is typically the first cost category that is estimated, especially if the rest of the cost categories will be factored from equipment. Therefore, having an accurate equipment estimate is foundational to an accurate estimate. Within the sample, five different equipment estimating methods were used, shown in Figure 3. A description of each method is provided below.
Figure 3 – Breakout of Equipment Estimating Methods

**Firm Quotes** – A firm equipment quote is a price that vendors put on a specific piece of equipment based on a set list of specifications given to them by the owner. The price of a firm quote is valid for a determined length of time; during that period, the procurement organization can decide to purchase the equipment at the given price.

**Preliminary Quotes** – Preliminary or budgetary quotes are equipment prices from vendors that can be based on a spectrum of data and do not have a guarantee on the quoted price. Preliminary quotes can be provided with limited information about the project, or with a high level of detail such as preliminary equipment specifications. Cost estimates with preliminary quotes were further classified into two groups: those with detailed data and those without detailed data, based on the definition of their sized major equipment list and major equipment specifications.

- **Preliminary Quote With Detailed Data**: Projects that used a sized major equipment list that was in development and preliminary major equipment specifications as the base for the preliminary quotes were classified as having detailed data. A sized major equipment list was considered in development when more than 15 percent of the work was complete. Major equipment specifications are considered preliminary when they incorporate some engineering analysis (i.e., use conceptual design packages), rather than having no project-specific engineering.

- **Preliminary Quote Without Detailed Data**: Projects that did not use a sized major equipment list in progress or preliminary major equipment specifications for the base for the preliminary quotes were classified as being without detailed data.
**Estimating Software** – Estimating software can estimate the price of a piece of equipment using built-in parameters and assumptions or it can be modified to include project specific information.

**Other** – Other is the category for equipment estimating methods that do not fit into one of the standard methods. Other methods include using older vendor quotes and applying an escalation factor to get the current price, or scaling the price of equipment purchased from another project to be applicable for the new equipment.

Out of all the estimating methods used, obtaining a firm quote requires the most information about the equipment. Having this level of detail in the information used to price equipment translates into equipment estimates that experience less cost deviation (Pr<0.09). However, projects that obtained preliminary quotes that were based on detailed data, classified as projects with sized major equipment lists and preliminary equipment specifications, also experienced much less equipment growth than projects that did not used detailed data to back up their preliminary quotes or did not have a quote at all.

**Bulk Materials**

After equipment is estimated, the next category to estimate is typically bulk materials. AACE® International recommends a factored estimate as the minimum requirement for a class 4 estimate [3, p.6]. Using industry metrics, bulk materials can be factored off of equipment specifications; therefore, it was expected that the majority of class 4 estimates would use this method. Surprisingly, this method was used less frequently than the other methods. The five different bulk materials estimating methods are shown in Figure 4. A description of each method is provided below.

**Figure 4 – Breakout of Bulk Materials Estimating Methods**
Material Take-offs – Material take-offs are quantities derived from engineering drawings by counting the number of a specific material, such as pipe, from a series of drawings and determining the total amount necessary for the project [4, p.9.17]. These quantity values are then costed by applying a price to each unit. Within the sample of projects, two sources of pricing information were used to develop bulk material estimates at FEL 2: in-house pricing and vendor quotes. In-house pricing refers to a database of bulk material prices from prices actual projects paid that is maintained and normalized so the information is in constant dollars. Vendor quotes refer to prices from vendors or fabricators for the estimated materials required for the project. This group was further split into two groups based on the level of detail in the deliverables used to derive the material take-offs.

- **Material Take-off With Detailed Data** – Projects that used preliminary piping and instrumentation drawings (P&IDs) to derive material take-offs
- **Material Take-off Without Detailed Data** – Projects that derived material take-offs from something less detailed than preliminary P&IDs, such as a preliminary sketch or site plan

Factored – A factored bulk material estimate is one that uses the cost of one category and applies a factor of X to derive the material quantities or costs. The factors used can be arbitrary or detailed depending on the project system’s approach. This category includes projects that factored their bulk material estimates from the total installed cost (TIC), equipment costs, or equipment specifications.

Estimating Software – Similar to equipment, bulk materials can be estimating using a software that can use built-in parameters or be modified for project specific information.

Other - Other is the category for bulk materials estimating methods that do not fit into one of the standard methods. Other methods include modifying a bulk materials estimate from a comparable project or using historical data that do not reflect projects from the past two years.

At the FEL 2 stage in a project, definitive engineering deliverables are not usually available. However, the majority of projects were still able to obtain material take-offs. An investigation of the basis of estimate documents from many of the sample projects revealed that there was a lot of variance in the types of engineering deliverables used. Some projects obtained take-offs from early engineering drawings, such as preliminary sketches or site plans, whereas others had access to preliminary process flow diagrams (PFDs) and piping and instrumentation drawings (P&IDs). Projects using preliminary P&IDs for their material take-offs at FEL 2 saw a directional decrease in the average cost deviation for their bulk materials cost account, regardless of the costing method (Pr<0.09).
### Detailed Engineering

Detailed engineering costs depend on the scope of the project; therefore, this cost category is typically estimated after the equipment and bulk materials estimates are complete. Two different estimating methods were used to estimate the cost of detailed engineering, as shown in Figure 5. A description of each method is provided below.

#### Engineering Estimating Methods Used to Develop Class 4 Estimates at FEL 2

<table>
<thead>
<tr>
<th>Method</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detailed</td>
<td>38%</td>
</tr>
<tr>
<td>Factored</td>
<td>62%</td>
</tr>
</tbody>
</table>

![Figure 5 – Breakout of Engineering Estimating Methods](image)

**Detailed** – An estimate using a detailed method to develop engineering costs uses data from a discipline-level resource plan to allocate costs to specific resources or has obtained a contractor quote for the required detailed engineering work.

**Factored** – A factored engineering estimate uses the cost of one category and applies a factor of X to derive the engineering costs. The majority of projects in this category factored their engineering from total installed cost (TIC).

Almost two-thirds of the sample used a factored method to estimate detailed engineering at FEL 2; however, these projects had significantly more cost deviation in the detailed engineering cost category than projects that used a detailed method (Pr<0.05). Using a factored method does not always account for project-specific aspects that could affect the amount of engineering hours that are needed. The basis of estimate documents showed that most factors used to estimate engineering were standard factors that are used on all projects regardless of their scope or complexity.
Construction Labor

Construction labor costs are also a factor of the scope being installed and are estimated after costs have been developed for equipment and bulk materials. The five different techniques used to estimate construction labor are shown in Figure 6. A description of each method is provided below.

**Construction Labor Estimating Methods Used to Develop Class 4 Estimates at FEL 2**

<table>
<thead>
<tr>
<th>Method</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Take-offs Without Detailed Data</td>
<td>29%</td>
</tr>
<tr>
<td>Material Take-offs With Detailed Data and Unit Rates</td>
<td>15%</td>
</tr>
<tr>
<td>Factored Estimating Software</td>
<td>26%</td>
</tr>
<tr>
<td>Estimating Software</td>
<td>25%</td>
</tr>
<tr>
<td>Other</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Figure 6 – Breakout of Construction Labor Estimating Methods**

**Material Take-Offs With Unit Rates** – Projects in this category use bulk material take-off as the base of the construction labor estimate. Labor hour per quantity rates, such as hours per foot of pipe, are applied to determine how many hours are necessary to install the bulk materials. These hours are then costed by applying a price to each unit. Within the sample of projects, two sources of pricing information were used to develop construction labor estimates at FEL 2: in-house unit rates and subcontractor quotes. An in-house unit rate comes from a database of labor prices per unit from rates actual projects paid that is maintained and normalized so the information is in constant dollars. Subcontract quotes are prices from subcontractors for the estimated construction labor required for the project. This group was further split into two based on the deliverables used to create the material take-off. Similar to bulk materials, detailed data refer to projects obtaining material take-offs from preliminary P&IDs, and without detailed data refer to projects using a less detailed deliverable.

**Estimating Software** – Construction labor can also be estimating using a software that can use built-in parameters or be modified for project specific information.
Factored – A factored construction labor estimate uses the cost of one category and applies a factor of \( X \) to derive the construction labor costs. The majority of projects in this category factored construction labor costs from equipment or bulk materials.

Other – Other is the category for construction labor estimating methods that do not fit into one of the standard methods. Examples of other methods include using in-house data to determine the bulk material quantities that are used to estimate hours or using historical factors from contractors.

There is a trend showing that projects using material take-offs and in-house construction labor hour unit rates have less construction labor cost deviation than projects using a factored method (Pr<0.17). The detail that the material take-offs can provide allows the estimators to account for project-specific elements (e.g., such as site congestion, complexity of installing the material, and craft skill level) that will affect productivity. Factoring or using the built-in assumptions of an estimating software do not always account for these elements, often creating more variability in the construction labor hour estimate. Projects that conducted labor surveys, regardless of estimating method, to obtain a local up-to-date labor wage rate also had less construction labor cost deviation (Pr<0.01).

Benefits of Using Detailed Estimating Methods

According to the data presented in the section above, projects with class 4 estimates that used estimating methods above and beyond a factoring method experienced the benefits of reduced cost deviation in the respective cost category. The increased accuracy can be attributed to the additional information used to develop the estimate. Because of the sequential nature of estimating, using a more detailed method to estimate equipment leads to more accurate bulk materials, construction, and engineering estimates, creating cascading effects on the potential cost predictability. However, very few projects used a detailed method for each cost category. Less than 5 percent of projects in the sample had vendor quotes that were based on detailed data for equipment, material take-offs from preliminary P&IDs for bulk materials, detailed staffing plan for engineering, and material take-offs paired with in-house unit rates and a current labor wage from a labor survey for construction labor.

Figure 7 displays the effects of equipment estimating practices first, then the effects of equipment and bulk materials estimating practices, etc., on overall project cost deviation.
Cost Deviation Decreases Progressively as More Detail Is Used to Estimate Each Cost Category in Class 4 Estimates

The data shows that there are benefits to overall cost deviation that are achieved by using more detailed estimating methods for the individual cost categories. Each group introduces another estimating practice to show the compounded effect of practices on cost deviation, beginning with all the projects in the sample to the projects that used detailed approaches on preliminary data for each major cost category. For constant comparison, each sub group was tested against the group of projects that did not have vendor quotes from detailed data or firm quotes. Each sub group lists two test statistics. The first test statistic is the p-value from the t-test of that group against the comparison group, and the second test statistic is the p-value from the variance comparison test between the two groups. An explanation of projects in each group is listed below.

**Sample** – This group includes all of the projects in the sample.

**Vendor Quote From Detailed Data** – This group includes any project that had a firm vendor quote or a preliminary quote that was based on a preliminary equipment list with major equipment specifications.

**MTOs From Preliminary P&IDs** – This group is a subset of the previous group and includes only those projects that also had material take-offs from preliminary P&IDs.

**Discipline-Level Engineering Estimates, Local Labor Knowledge** – This group is a subset of the previous group and includes only projects that used a detailed estimating method for detailed engineering and construction labor. A detailed engineering method includes

Figure 7 – Overall Project Cost Deviation

![Cost Deviation Chart](image-url)
projects that used a staffing plan or had a contractor quote. A detailed construction labor estimate includes projects that used labor hour unit rates and material take-offs to derive their hours estimate, and conducted a labor survey to inform the wage rates. Because of the overlap between projects that used a detailed method for detailed engineering and construction labor, the two cost categories were combined.

These results are not surprising. When more information is known about the project, it can be used to provide added detail to a cost estimate, allowing the project to experience less cost deviation. The data show that many projects are able to use methods that are more intricate than factoring in at least one cost category, and they experience less cost deviation in that particular cost category. However, very few projects used a detailed method in all of the cost categories examined.

One of the reasons companies choose not to create a more detailed FEL 2 estimate is that they want to avoid spending more time and money in the phase than they need to. The next section of this paper will investigate the perceived trade-off between time and money spent in FEL 2 and the accuracy of the estimate. Using the sample of projects split into the groups from Figure 6, the author looked for statistical differences that would indicate the relationship between estimate accuracy and time and money spent in FEL 2.

Trade-Offs Among Estimate Accuracy, Time, and Money

Theoretically, there should be a trade-off between time and money spent in FEL 2 and the level of accuracy that is obtained. Projects spending more time and money to develop an FEL 2 estimate might expect to have an estimate with a tighter range than a project of similar scope that spent relatively less time and money to complete the phase. The risk is spending too much on a project that might be canceled. To test the hypothesis, a one-way ANOVA was conducted to determine if the average percent of cycle time spent in FEL 2 and relative cost of completing FEL 2 change as projects use more detailed estimating methods. The author found no statistical difference in the percent of project time spent in FEL 2 among the various groups (Pr<0.54). However, there was a directional trend in the percentage of project costs spent on FEL 2 (Pr<0.07). This indicates that there is a cost to creating a more detailed estimate, which most likely comes in the form of using more resources in the same amount of time than would be used if developing a factored estimate.

Although projects using detailed estimating methods spend more money in FEL 2, they do not cost more upon completion and they are much more predictable. By spending approximately 1 percent more of the total project costs in the FEL 2 phase, projects with detailed estimates have 9 percent less cost deviation. The extra money spent in FEL 2 for projects with detailed estimates creates more cost benefits because of the improved accuracy of the estimate. If a project passes through the FEL 2 gate, this extra money spent is minimal compared to the potential benefits. This concludes that accurate FEL 2 estimate are achievable at a relatively small cost.
Although accurate estimates are achievable, some businesses might not view them as necessary. Because the business looks at projects from a portfolio level, spending the extra money to improve the accuracy of the FEL 2 estimate of one project when there is still a chance that the project will not move forward in to FEL 3 is not always worth it. However, if the project will represent a large portion of the portfolio or has risky economics, for example a megaproject, semi-detailed estimating methods can be used to provide the business with a more accurate estimate to aid in a more informed decision. The application of this research can be used by project sponsors to show the benefits of the various semi-detailed estimating techniques.

Summary

IPA’s data show that class 4 cost estimates developed during FEL 2 use a variety of estimating techniques for the major cost categories (equipment, bulk materials, engineering, and construction labor). Projects that used an estimating method other than factoring experienced less cost deviation within the respective cost category. Estimating techniques also affect overall project cost deviation. Projects that used a semi-detailed method to estimate equipment and bulk materials experienced directionally lower cost deviation and had a significantly tighter standard deviation than those project that did not. Less than 5 percent of the projects in the sample used a detailed estimating method in all four cost categories. The use of these detailed estimating methods occurred more than expected across the cost categories indicating that some projects were able to create more than a factored estimate during the FEL 2 phase.

Projects using semi-detailed estimating techniques did not spend more time in the FEL 2 phase than projects with factored estimates; however, they did spend relatively more money. From this, it can be concluded that accurate FEL 2 estimates are achievable at a rather small cost. If the project moves forward into FEL 3, this extra cost of 1 percent of the TIC is minimal compared to the benefit of decreased cost deviation.

The purpose of an FEL 2 estimate is to provide the business with the necessary cost information to determine how the project fits into the company wide portfolio and if it should move forward into FEL 3. Spending extra money beyond what is necessary is not always encouraged by the business because there is still a chance that the project will not move forward, causing any costs spent in FEL 2 to be sunk. However, certain projects, such as megaprojects or those with marginal economics, have a large risk associated with them regarding the effect of their cost performance on a whole portfolio. Therefore, in these cases, it is beneficial to consider developing a more accurate FEL 2 estimate.

In summary, the trade-off between the extra cost of creating a semi-detailed estimate and the improved accuracy of an FEL 2 estimate should be considered on a case by case basis. However, it can be concluded that accurate FEL 2 estimates are achievable by using semi-detailed estimating methods in combination with the preliminary engineering deliverables that should be available during the select phase.
References


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