Project –Appraisal Vis-À-Vis Risks and Uncertainty Management in Construction Industry: A Plausible Strategic Maneuver

Prasad I.L.N, Balaji K.V.G.D, Chitti Babu Kapuganti, T. Santhosh Kumar

Abstract: Genesis of risk and uncertainty is an innate facet in any project. A cause, occurrence and consequence are the signature- hallmarks of every risk. Dodging and dealing with plausible critical situations in complex projects demand strategic quantification and management of uncertainties of different nature much in advance. In this milieu, we propose a methodology to classify uncertainties based on the dictates of probability theory, possibility theory, belief/plausibility theory and fuzzy set theory. A general framework of risk and uncertainty management is forwarded. Our recommendation embraces: (1) identification, assessment, analysis and distribution of all possible risk and uncertainty amongst the parties involved or those who might get associated in accordance to their capacity, competency and characteristics; (2) allocation and distribution (governed by the terms and conditions of the contracts) of the various risks and uncertainties to those, capable of handling them better and (3) monitoring, scrutiny, response and mitigation by those assigned according to the contractual-conditions. It is expected that the proposed model shall serve as a ready-to-use template for project valuation to effectively address plausible risks and uncertainties in construction-industries, eventually contributing to the cause of sustainable development.

Keywords: Risk, Construction Techniques, Uncertainty, Risk Management. Project appraisal

I. INTRODUCTION

Risks and uncertainties, being common elements in any construction-engineering project’s life cycle make it imperative to have a befitting strategic planning framework. It is pertinent to note that risks and uncertainties are generally interpreted as factors which may have profound dictating influence, either positive or negative, on realizing the project objectives and expectations. Sometimes these may not have any effects on plans as well. On a generalized note, it is usually agreed that, in risk and uncertainty, the outcome or activities are likely to differ from expectations. The construction-data, environment as well as uncertainties vary on a case-to-case basis. For complex and lengthy projects, construction schedules are less certain with the prediction of multiple facets that could affect the activities’ duration. Generally, owners impose penalties for schedule overruns. So, mostly contractors add extra time in their schedule based on uncertainty- forecast in tune with the complexity involved while executing the project. However, some uncertainties, on the other hand, may augment the project value. To cite for evidence, delay in procurement of equipment may add value to the buyer, if future price is uncertain and happens to fall.

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It may be easily perceived that unclear contractual obligations and imperfect laws generate low-quality of implemented works, executed by unqualified project participants. These pave the way to cost-overruns and schedule-delays, further piling up the risks and uncertainties. Price, weather, and the durations of activities such as design, fabrication, and installation are projected as some of the pertinent and uncertain aspects of construction projects. In some cases, small uncertainties may occur, which could permit modulations in design, analysis and strategies of project in pre-planning stage. Perusal of literature from the past two decades is suggestive of the facts that uncertainty is more than just being a case of natural variability, and the scheduling techniques, primarily CPM, used by most engineers are not designed with such concepts in mind. The fundamental cause of uncertainty is in vague, variable, contradictory, or incomplete information that the scheduler relies upon to estimate the duration of activities. Recently researchers and engineers have stressed upon the indispensability to delve into various types of uncertainties and resorted to applying new tools to quantify from the perspective of ‘more than just variability’ in a construction schedule for an effective planning.

In the planning phase, engineering project valuation, intertwined with uncertainty management is a key to ensure accurate cost estimates of the project and to dodge and deal with plausible risks in financial institutions and firms. The continuous and dynamic process of risk management is a systematized strategy of identifying and plummeting the uncertainty threats vis-à-vis adoption and execution of better decisions right from project-inception and initiation till the project conclusion. Development of a comprehensive insight into uncertainty demands appropriate know-how of the project dynamics and timely availability of information. Addressing ambiguity, incorporation of structure and embracing the apt decisions based on the available data, information, and interpretation are indispensable in this context. For effective decision making, the decision maker needs to distinguish between ‘what is usefully quantified’ and ‘what is best treated as a condition’. Professionals have used probability theories for years to deal with uncertainties. In this context, we have proposed a framework for uncertainty-classification in this article to facilitate the process of project-appraisal in the niche of construction industry. Prior to delving into our model, let us have an overview of the basics of uncertainty and risks in the construction-industry in the subsequent section.

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II. ABCS OF UNCERTAINTY AND RISK—THE BACKDROP OF OUR STUDY

2.1. The terminologies

Uncertainty is associated with variability or ambiguity with either positive or negative effect on project objectives. Variability in construction project pertains to indicators like budget, duration and quality of work executed while ambiguity is attributed to lack of coordination between different project stakeholders, lack of details, lack of data and lack of structure to consider issues. The spectrum includes uncertainty during and about the estimates; uncertainty about design and logistics; uncertainty about objectives and priorities as well as uncertainty about fundamental relationships between project parties. Decision makers may discern uncertain parameters that may be controlled by probability distributions in risky situations. In uncertain situations, however, this may fail in the context of lack of information about the probabilities of uncertainty parameters. All construction projects are expected to face the unexpected situations and uncertainties. Project managers must be supported by risk management team in identifying, analyzing, controlling, and reporting risk.

‘Known’ and ‘unknown’ in the uncertainty-realm refer to the clear and unclear assumptions respectively. The ‘known’ may be analyzed and subsequently managed by considering other alternatives and reporting known potential problems (e.g., heavy showers can lead to shelving of ongoing construction works). Decision maker don’t know precisely what would happen, albeit, these assumptions are intertwined with potential to damage the project. Thus, project stakeholders must conceive strategies to deal with those situations. On the other hand, the unclear assumptions could have profound consequences as their occurrence is unanticipated. Nevertheless, experienced managers may foresee them as general possibility.

On the other hand, bias refers to systematic estimation errors with significant consequences. These static risks maintain their characteristics during their period of existence in contrary to the various other risks, being dynamic in nature. The latter can change their probability and impact during the project’s life cycle. General risks (global and elemental in nature) might influence project objectives, but their control is beyond the project stakeholders, associated with the key project-elements. Global risks may be influenced by the principal or governmental aspects: political, legal, commercial and environmental risk. The elemental risks are associated with the elements of the project, namely implementation and operational risks, and for some projects, financial and revenue risks can play in. These risks are likely to be manageable by project participants. In this setting, project risk management must be a continuous process with availability and analysis of feedback from the beginning of the project to its culmination.

2.2. Origin of risk and uncertainties in the construction-industry

The construction industry is challenged by a plethora a risk and uncertainties. These risks emerge and evolve throughout the project’s lifecycle and in all ambiances. Various external factors, unstable business objectives and ill-defined project realization methods are projected as the three prime sources of uncertainties. To start off, harsh weather patterns, labor unrest, equipment breakdown, unpredictable physical condition of the site, poor site management, poor engagement of skills and manpower, poor selection of equipment and low understanding of the design, etc., endow various risks and uncertainties to production-site. Natural calamities like flood, weather, earthquakes, etc. may affect the project implementations either through direct impediment or indirectly via consequences like destruction of supply routes and causing delays of deliveries. On the other hand, some people either deliberately create bureaucracy bottlenecks to attract bribe for themselves or create “red tape” bureaucracy to circumvent corruption-allegations. This poses a serious risk and uncertainty in the smooth execution of any project. In a similar vein, most, if not all, construction projects are managed through contract and expected contractual performance. Payment by the client in full, partial or non-payment as well as the issue of timely payment pose a serious challenge. From client’s perspectives, the performance of the contractor is a serious concern since a performance bond may not even guarantee the contractual performances. Project management can increasingly face practical snags in execution of a project in the context of adverse public-opinion. In addition, many construction projects in developing countries are challenged by political and insecurity problems. Similarly, the risks and uncertainties associated with donors (supporting the developing countries) are of various natures, ranging from instability in their countries to ‘attachment of strings’ to their support and the shift in their focus. Most importantly, in many developing countries, there is dearth of national standards and quality specifications, with non-consistent enforcement of regulations, resulting in the continual production and use of below-standard construction materials. There is also associated snag with respect to capacity and competency of labor force in developing countries, consequently, upsetting the attainment of quality.

2.3. Managing risk and uncertainties in the construction-industry

Time, quality and economy are considered as the triple-bottom line values in construction-project management. The origin of uncertainties in construction projects is plenty (as highlighted in preceding section). Uncertainty management involves the coalescing of risk and value management protocols. Maintaining competitiveness demands the recognition and capturing of the project values to the max by the construction companies. Traditional construction management methods and tools do facilitate the discerning and determining the relative predictability of some project values. Perusal of literature unmasks that the current management of uncertainties in construction industry focuses on limiting project losses. Construction managers are expected to be aware of the potential causes of uncertainty in projects. However, many construction project conditions evolve over time. Consequently, the conditions, times, and managerial choices for effective decision making cannot be determined completely and accurately during pre-project planning. Additional data collection can sometime improve the descriptions of apparently large uncertainties sufficiently to allow the design, assessment, and selection of alternative strategies. However, often uncertainties are or appear too...
vague for effective design, assessment and selection among strategy alternatives prior to the proceeding of a project. In this backdrop, owners, designers, engineers, architects, and contractors may apply a structured approach for management of uncertainties, embraced under the umbrella of their corresponding responsibilities. Needless to say that uncertainty management not only encompasses handling of apparent threats and their consequences but also recognizing and dealing with all the sources of uncertainties which may be perceived as threats. Risk and uncertainty management should focus on identification; categorization; quantification; sensitivity analysis; appropriate allocation of stakeholders; retrieval and analysis of response from assigned stakeholders and mitigation of various threats and opportunities.

It is pertinent to note that traditional construction project entails inception, planning, scheduling, design, ergonomics, economic assessment, tendering, contracting, construction, hand-over, maintenance and utilization in the gamut of stages during its implementation. All stakeholders are anticipated to act appropriately and information must be disseminated at the right time among the stakeholders in the cascade of these stages. The failure in information exchange adversely affects the project-execution and could lead to longer execution times. It also impacts the demand of unplanned key resources and creates problems in ‘Human Resource Management System’ and ‘Resource Supply Chain’. The various participants try to minimize risk in their respective niche individually, during which the possibility of conflicts between them could impact the project-execution. Failure of the client or project manager to recognize these conflicts often lead to undesirable outcomes. However, assessing uncertainties related with Force Major Situations are beyond the scope of project appraisal.

III. RESEARCH APPROACH: PROJECT APPRAISAL AND CLASSIFICATION OF UNCERTAINTIES

Appraisal (beginning at the time of project inception and completed at the sanction) is an important stage in the evolution of any project as it enables the possibility of making cost-effective changes, right at the early stages. It is prudent to identify and assess risks as well as consider alternatives at a time when data may be uncertain or unavailable prior to initiation of various project-activities to meet the overall objectives. Uncertainty conditions dictate the appraisal, categorized into a concept viability phase and a project feasibility phase. Fixation of project alternatives or obliteration of the effect of uncertainty is expected as the project advances over the appraisal phase (even though, at this stage project is still in progress and involves decision-making during uncertainty conditions). Additionally, a disproportionate part of risk management is operational during the appraisal phase as well. During appraisal, the management-team needs the investment of fund for its functioning. Needless to say that the solutions picked up and decisions made in this stage exert crucial influence on the entire implementation of the project. This necessitates the participation of qualified person with high level of expertise and responsibility.

As can be easily perceived, estimation and assessment of uncertainties are principal tasks in all decision support procedures. Fig. 1 mirrors the influence of the effectiveness of changes and the cost of the changes with respect to both precision of estimated costs during project implementation. Parameters established from the architectural concept of a project are calculated in an alternative analysis. During concept viability and project feasibility study, calculation precision could be ~ ±30%. A project should be arranged in accordance with certain design specifications, which meet the customers’ requirements. During this stage, the calculation precision scales to ±20%.

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Fig. 1. Plot of cost of project’s changes and effectiveness of changes with respect to precision of estimated costs during various stages of construction project

The greatest influence on construction cost estimation (appraisal procedures) occurs at the front end of the project (illustrated in Fig. 1). Cost estimation procedures fail to predict the deviations in their totality, especially the changes in construction cost at the implementation time. If the client can gain reasonable profits from early operation of a completed facility, the project is considered a success even if construction costs exceed the estimate due to inadequate scope definition. It is pertinent to note that poor planning and improper feasibility studies can lead to unsuccessful and deprived projects. In this milieu, we have proposed a tool for dealing with the uncertainty and risk problems and to meet the needs of project managers in appraisal phase.
For making decisions, the first step would be the identification of the uncertainties in a system, like a construction schedule, and the development of an approach for classifying each uncertainty by type. In general, the four most common theories used to describe and quantify uncertainties are described underneath. **Probability theory** covers natural variability, e.g., inclement weather, variable traffic conditions that might obstruct timely arrival of workers; **possibility theory** encompasses non-specificity, such as, poor directions to the job site and imprecise information about the location of buried utilities; **belief/plausibility theory** embraces uncertainties which might be characterized in intervals, or where significant ignorance plagues the information (e.g., existence of unexploded ordinance or historical artifacts in site); and **fuzzy set theory** is concerned with vagueness owing to linguistic descriptors. The process of classifying the uncertainties into different categories is shown in the flow chart in Fig. 2.

**Is the uncertainty due to, or a result of vague linguistic descriptors such as yes near, tight, hot, soft, good, or fast?**

Yes

Use fuzzy set theory to characterize the uncertainty. Methods such as graphical inference or automated methods for fuzzy systems may be used.

No

**Is uncertainty due to inherent or naturally random phenomena such as weather or traffic? Is there conflict between the observation and the expected value such as multiple, but varying distance measurements but still within the instrument’s tolerance?**

Yes

The uncertainty is aleatoric and can be characterized by probability theory. Depending on the system, there are many probability distributions available to determine the likelihood of a particular outcome. Use Shannon Entropy to quantify the uncertainty.

No

**Is the uncertainty due to imprecision, non-specificity, or lack of detail such as vague (not in the linguistic sense) directions, or missing information on a drawing?**

Yes

The uncertainty can be characterized by possibility theory. Use the Hartley Measure to quantify the uncertainty.

No

**Is the uncertainty due to information sourced from someone exercising professional judgment and experience? Is there a natural range or interval representing the likelihood of a particular outcome? Is the source of information qualitative rather than quantitative?**

Yes

The uncertainty can be characterized by belief/plausibility theory. It will be necessary to distinguish all alternative sets of events (focal elements) and whether they are mutually exclusive or intersect.

**Fig.2. Flow chart for classifying uncertainties**

The applicability of the above framework may be perused in the following example. Let us consider that a contractor has good experience in a construction activity such as placing concrete for footer. Over the years he might have determined the requirement of labor-hours to place a certain quantity of concrete and finish the task. However, even after years of historical data at dispense and experience, the outcome seems never to be the same each time. As a representative case, the concrete from one of the transit mixers might have too high a slump and must be rejected, thereby, slowing the activity. The high slump might be the result of a batch plant operator receiving instructions that the required slump should be about 4 inches. This introduces a (fuzzy) uncertainty due to nature of our regular linguistic communication. This may also be bracketed together with the possible late arrival of the transit mixer operator because the directions he received to the job site included the information on the street alone and not the specific address to find the job site. That would be a case of non-specificity or possibility-uncertainty. The eventuality in this simple illustration would be a deviation from the expected number of labor hours to complete the job, which might look like random variability, albeit, the major cause could be an outcome of other types of uncertainties.

**IV. RESULTS AND RECOMMENDATIONS**

Conventionally, risk management is undertaken in the early stages of a project. However, it should be viewed as a continuous and dynamic process, right from the initiation till the project’s conclusion.
Risk management is considered the best practice when the project is in accordance with FIDIC YELLOW Book of Contracts for Design-Build projects and FIDIC SILVER Book of Contracts for Turn-Key projects. Pertinently, in turn-key contracts, contractors must accept all the risks. Analysis of project alternatives and decision-making processes are often done before the work phase.

Active planning and future simulation, early problem recognition and better communication serve as the three fundamental avenues to reduce risks in the niche of risk management. In this regard, project management consultants are expected to provide missing facts and figures and ensure better coordination. Furthermore, we would like to highlight that neoteric approaches like “Project Lifecycle Management (PLM)” and “Four-Dimensional Concept” could be employed to determine the theoretical values of project’s parameters to minimize errors during field execution. We have proposed a few general principles in the realm of risk and uncertainty management, with special reference to construction industry as underneath:

1. [A] Identification, assessment, analysis and allocation of all possible risk and uncertainty amongst the parties involved or those that can get involved according to their capacity, competency and characteristics.

2. Promotion and upkeep of prudent macro-economic management in the context of devaluation and trade liberalization to ensure balance of payment deficit; operational market force to fix prices and eliminate the issues of excess demand and inflation besides reduction in public sector deficit.

3. Deliberate efforts to influence the development of insurance industry, particularly, in developing countries to promote risks and uncertainties mitigation.

4. Development of risks and uncertainty management policies, guidelines and protocols by each firm, focusing on a) The capacity and practices for increasing the stock of corporate information with emphasis on logical and correct interpretation, use and communication to appropriate points or persons.

b) Human resource development in the areas of risks and uncertainties management, to assist, especially, managerial and strategic development for consultants and contractors.

5. Augmented thrust on research and teaching in institutions of higher learning with an interlaced and concerted endeavor to disseminate information on the aspect under discussion.

V. CONCLUSIONS

Albeit, risks and uncertainties are not synonymous with failure and losses, they do, however, place great project management challenges as the outcomes of events and activities deviate from expectations in the context of time, quality and economy of the project. The necessity of a systematic development and utilization-strategy of knowledge, skills and techniques for risks and uncertainties management emanates in this milieu. A few prospective avenues to address risks and uncertainties in construction-industry during project appraisal phase were proposed in this article. Risk-categorization facilitates the determination of the source, relative pertinence and their impacts on the project. We believe that application of modern technologies like BIM and 4-D for simulation of construction-projects would also prove instrumental during project appraisal phase. However, at this juncture, it would be prudent to mention that recommended solutions should be tuned in such a way that the investor does not set his foot back. Approaches to articulate and compare performance objectives and perceived trade-off between the various sources of project uncertainties are a must. Thrust should be streamlined on strategies that do not obscure variability, with lesser reliance on probability impact matrices and adoption of techniques such as the minimalist approach. It is expected that the plausible strategy, highlighted in this article would assist the construction industry to play its rightful and necessary role as well as contribute to the cause of sustainable development, particularly in the developing countries.

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