Delay and Cost Overrun Risks in Sudanese Construction Projects: QuantitativeApproach

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ABSTRACT -It is quite observed and frequently iterated in the risk literature that construction projects are prone to various and interrelated risks. Risks that span over a wide spectrum such as delays, cost overrun, safety, design, construction, environmental, weathering, legal and operational risks. Delays and cost overruns are considered among the leading threat risks that a project can experience and suffer. Quantifying those risks is intricate due to the complex and interrelated nature of construction projects and risks encountered over them. Isolating and quantifying the effect of those risks (delays and cost overruns), apart from the overall interacted effect of other risks, is an important performance indicator. Moreover, it can serve as a useful predictive and proactive tool for Sudanese construction project management professionals in formulating risk response plans. In order to achieve such a goal, special circumstances and conditions shall hold valid. Conditions as holding still the key other risks that are expected to affect the overall project risk interaction. The aim of this paper is to develop predictive models in order to quantify the magnitude of delays and cost overruns. This is sought by incorporating non-probabilityreadily accessible sample (n=19) of solely-steady funding, defined scope, contractual time frame and cost projects. This is meant to isolate (as much as practical) other than delays and cost over runs risk factors. To achieve the stated goal, regression statistical techniques and Monte Carlo simulation are utilized using Minitab, SPSS and @risk softwares. Comparison between the results obtained by the Monte Carlo simulation and the actual finish durations and costs was conducted. It was found that the uniform distribution is the best fit for the actual project durations and Pareto distribution for the actual cost. It was also found that there is a significant difference between the actual and contractual durations, which resulted in significantly large delays. In the author opinion this is can be attributed to one or collateral of the scenarios of owner imposed contractual time frame, non-compensable time extensions, changes and variations, contract miss-management and lack of accurate project scope definition.

Keywords: *Risk, delay, cost overrun, construction project.*

المستخلص- انه من المتعارف عليه في أدبيات إدارة المخاطر أن مشاريع البناء عرضة لمخاطر متعددة. مخاطر ذات نطاق واسع تشمل مخاطر التأخير، زيادة التكلفة، مخاطر تصميمية، بيئية، قانونية وتشغيلية. إن مخاطر التأخير وزيادة التكلفة تعتبر من المخاطر الرئيسة التي يتعرض لها المشروع الإنشائي. إن التقدير الكمي لهاذين الخطرين يعتبر من الأمور المعقدة و الشائكة. نسبة لكون المشروع الإنشائي معقد بحد ذاته و للتداخل بين المخاطر التي يتعرض لها. إن التقدير الكمي لهذين الخطرين من الأهمية بمكان من حيث كونه مؤشر مهم لأداء المشروع، كما انه يزود ممارسي إدارة المشاريع بأداة مهمة يمكن من خلالها المساهمة في صياغة خطط الاستجابة للمخاطر التي تتعرض لها مشاريعهم. إن تحقيق هذا الهدف يتطلب توفر شروط محددة، مثل ثبات المخاطر الأخرى والتي من المتوقع أن تؤثر على الخطر الكلي الذي يتعرض له المشروع. إن هدف هذه الدراسة هو إيجاد نموذج يمثل العلاقة بين الخطرين محل الدراسة. وذلك من

خلال عينة غير احتمالية من المشاريع، ذات صفات محددة مثل كونها أحادية وثابتة التمويل، معرفة نطاق العمل والنطاق الزمني والتكلفة. وذلك بهدف عزل (قدر الإمكان) أي مخاطر غير التي قيد البحث. خلصت الدراسة إلى أن التوزيع الاحتمالي المنتظم هو الأفضل مواءمة للأزمنة التعاقدية. بينما توزيع باريتو الأفضل مواءمة للتكلفة الفعلية للمشروع. وجد أيضا فارق كبير بين الأزمنة التعاقدية والأزمنة الفعلية لإنجاز المشاريع. مما أدى إلى تأخير كبير في أزمنة المشاريع. قد يعزى ذلك إلى أحد أو تضافر احتمالات متعددة، منها الأزمنة التعاقدية المفروضة على المشاريع، التغييرات في المشاريع، التغييرات غير المعوضة ماديا، قصور تعريف نطاق المشروع وقصور الأداء الإداري للمشروع.

INTRODUCTION

It is quite observed and frequently iterated in the risk literature that construction projects are prone to various and interrelated risks. Hence, construction industry is attributed of being a risky industry. The construction project, the mean via the deliverables of the industry is realized, is impaired by various categories and levels of risks. Risks that span over a wide spectrum such as delays cost overrun, safety, contractual, design, construction, environmental, weathering, legal and operational risks. Construction projects in developing countries in particular suffer from poorly and ill-defined scope, design, quality and management systems. Leading to time, cost and quality gaps. Addressing and managing those risks and giving them the due consideration throughout the project life cycle will lead to performance enhancement[1].Delays and cost overruns are considered among the leading threat risks that a project can experience and suffer. Consequently, contributing in attaining the industry of poor performance reputation[2].

IMPORTANCE/IMPLICATION OF THE STUDY

The Sudanese construction industry is working in a highly fragmented manner. It is argued that problems that hinder the development of Sudanese construction industry are limited to studies conducted by pioneer researchers. Hence, accurate reliable and up to date information about the industry status are lacking [2]. Studies regarding the risks of delays and cost overruns are no exception of that. Quantifying delays and cost overruns risks is intricate due to the complex and interrelated nature of construction projects and risks encountered over them. Isolating and quantifying the effect of those risks (delays and cost overruns), apart from the overall interacted effect, is an important performance indicator. Moreover, it can serve as a useful predictive and proactive tool for Sudanese construction project management professionals in formulating risk response plans.

Research problem: the study aims at quantifying delays and cost overruns risks abreast developing predictive models (if attainable) in order to quantify the magnitude and direction of delays and cost overruns risks. In order to achieve such goals, special circumstances and conditions shall hold valid. Conditions as holding still the key other risks that are expected to affect the overall project risk interaction. This is sought by studying a non-probability readily accessible sample (n=19) of solely-steady funding, defined scope, contractual time frame and cost projects. This is meant to isolate (as much as practical) other than delays and cost over runs risk factors.

LITERATURE REVIEW

HillsonD. [3] suggested three reasons and justifications for why projects are risky *“The first reason is that all projects share common characteristics which inevitably introduce uncertainty. Some of these common characteristics are projects are unique, complex, involve assumptions and constraints, performed by people and involve change from a known present to an unknown future. The second reason is that all projects are undertaken to achieve some specific objectives. The final reason is that all projects are affected by the external environment they exist in*".As a result,risk can constrain the achievement of key project objectives.

Riskshave many definitions offered in the literature such as "*An uncertain event or condition that if it occurs has a positive or* *negative effect on a project's objectives*" PMI PMBok® Guide (2013)[4], "*An uncertain event or set of circumstances that, should it or they occur, would have an effect on achievement of one or more project objectives* "APM Body of knowledge (2012)[5]. Risks definitions meltdown to two themes. Namely; risk is uncertainty and it matters. It can be a threat or an opportunity that needs to be managed proactively. Where potential problems are prevented and potential opportunities are sought. As stated above, risks are not confined to the two major pronoun risks (delay and cost overrun), they span over wide categories such as technical, performance health and safety etc. Risks categories can be classified under stochastic (event), aleatoric (variability), epistemic (ambiguity) and ontological (emergent) risks. Stochastic risks can be considered a risk that may or may not occur which can be managed through standard risk process (identify, analyze, plan and implement responses). Aleatoric is a risk with variable characteristics such as unseasonal weather occurrence, it can be managed through quantitative risk analysis, described using ranges and probability distributions. Epistemic risk is a risk of future event of ambiguous characteristics such as new enacting of new regulations with unknown scope. They can be managed through exploring and experimenting. Ontological risk is bounded by conceptual limitations of the surrounding given environment "unknown-and-unknowable unknowns". It can be managed through "project continuity management (i.e. environmental scanning, resilience and flexibility) [6].

Construction projects experience the effect of individual risks in addition to the overall project risk. It is the effect of interacted risks over the project. Overall project risk is "*the exposure of stakeholders to the consequences of variation in outcome, arising from an accumulation of individual risks together with other sources of uncertainty"*apm PRAM Guide (2004)[7],"*The effect of uncertainty on the project as a whole. It more than the sum of individual risks on the project*" Practice Standard for Project Risk Management (2009), PMBok® Guide (2013)[8]. Project manager is responsible for identifying, assessing and managing specific uncertainties within the project (individual risks). He/she is accountable to project sponsor and stakeholders for overall risk exposure of the project (overall project risk)[6]. Overall project risk addresses the questions of how likely a particular project is to succeed or fail and What is potential range of variation in outcome with quantitative answers. Answers to those questions can be reached by utilizing Standard MonteCarlo simulation. Monte Carlo simulation is a "*virtual experiment repeated, hundreds, thousands, even millions of times, all the while generating random samples bound by a set of parameters that are user defined, from each repetition of that experiment. Those random samples are then collected, organized and analyzed to help understand something about the behavior of that process or system*" [9].

The full ranges of possible outcomes, how likely to occur are exhibited as probability distributions. Consequently, identify the most significant items impact and magnitude is achieved. That would enable decision makers to manage risks and making informed and defensible decisions[6].

RISK MANAGEMENT PROCESS

Awareness, recognition and systematic method for monitoring changes and its impacts are essential for successful risk process management. Risk management process is initiated by developing a risk plan. Developing risk register before the initiation of the project, that are regularly updated, in each project cycle and continue monitored through the project lifecycle. There is a plethora of popular and applicable risk management models and methodologies in the construction industry. Such as Boehm, Fairley, Kliem&Ludin, SHAMPU (Shape, Harness and Manage Project Uncertainty),IRM/AIRMIC/ALARM (The Institute of Risk Management/The Association of Insurance and Risk Management/The National Forum for Risk Management in Public Sector), PMBOK(Project Management Body of Knowledge). PMBOK methodology is the most frequently used method in project management.Asstipulated by the Project Management Institute (PMI). PMBOK Guide (PMI, 2008), project risk management is a process which consists of six iterative processes they go in Mohebbi(2012)[10]words as(i) Risk identification- The process of identifying all the risks relevant to the project; (ii) Risk assessment- Determining the likelihood of identified risks materializing and the magnitude of their consequences if they do materialize; (iii) Risk allocation- Allocating responsibility for dealing with the consequences of each risk to one of the parties to the contract, or agreeing to deal with the risk through a specified mechanism which may involve sharing the risk; (iv) Risk mitigation- Attempting to reduce the likelihood of the risk occurring and the degree of its consequences for the risk-taker; and (v) Monitoring and review- Monitoring and reviewing identified risks and assessing, allocating, mitigating and monitoring new risks as the project develops and its environment changes. The full range of risk management process is shown in Figure 1. The focal point of this paper is identification and assessment processes.

IDENTIFYING RISKS

Problems and challenges of construction industry identified in the literature surveys, which can turn into risks, can be categorized as financial, temporal, compliance, production drawings and Clauses[11]. The financial and temporal are the focus of this paper.

Financial issues: There are various types of construction problems related to financial issues. They can go under the category of money availability, overrun of cost which can be attributed to rework, change of scope, modifications/changes. Changes impacts project's cost and schedule greatly. They can increase project cost and extend project duration. They also considered as one of the main causes of disputes and claims that brings a lot of argumentation to the table, and seldom goes as a straightforward process (i.e., who is responsible for the changes) [12]. Moreover, changes of regulations and legislation, re-evaluation of the work after issue of interim certificate can create a risk for the contractor. Lack of project's understanding and proper documentation can also be a cause of cost overrun. Unbalanced risk distribution. "*A great many building contract disputes arise because one party or the other does not realize the fundamental truth that contracting is about the allocation of risk*" *Powell-Smith and Sims, 1990: 3)."*[11].

Temporal issues: There are various types of construction problems related to temporal issues. They can go under the categories of non-availability of time; delay; intention of the parties; liquidated damages; difficulty in identifying responsible party causing delay; failure to meet time for performance; failure to meet deadline for payment and failure to give notices on time. It is worth mentioning that temporal issues are a source of many contractual disputes resulted from the insufficiency of time available. Clear identification of project's completion time should be clearly stated in the contract. It isstressed that "*emphasizes that liquidated damages are an important sanction for the breach of contract in the construction industry where the contractor fails to complete the work by the contractual date of completion.*"[11] Moreover, uncertainty is a considerable contributor to delay;Haidar[13]stated that "*construction and engineering projects are subject to considerable risks and uncertainties".* There are various types and causes of delay offered in the literature. It can be classified based on the party responsible for delay; compensability entitlement and type of delay (Figure 2).

Typical construction risks that may impact the project cost or schedule may include project site risks, such as, coordination with other on-site contractors, related activities not under the control of the general contractor or construction manager, delays in presenting, addressing and resolving site construction problems, permits and licenses,varying subsurface conditions encountering difficult soils, rock and ground water,owner and Design/Construction Team relationships, inadequate compensation/late payment, adequacy and availability of owner representation to facilitate prompt decisions, lack of coordination/communication program among owner, design and construction teams, late or unsuitable owner-furnished material and equipment, post-bidding design changes, unrealistic performance schedules, unreasonable systems performance guarantees. Or Other risks, such as, adequacy of labor force,insolvency,cost escalation, changes in legal requirements/codes/taxes, delays in delivery of critical equipment and supplies, inadequate project funding/inadequate contingency funding and political involvement and interference.

METHODOLOGY

Methodology is concerned with what, why, where, how and when data were collected and how they were analyzed. Among the two main research philosophies cited in the literature, namely; the positivism and the Interpretive. Positivism philosophy is attributed to be "scientific", hypothetic, deductive and quantitative extensive. In actual reality, real research is rarely purely one or the other. Methodologies establish the distinction, but actual research practice usually spans both philosophies. The way data are compiled and then analyzed depends on the chosen research method. This research is positivism by nature. The purpose of the research is mainly descriptive, i.e. the research aims at reflecting an accurate picture (as practical to research limitations) of the situation of the Sudanese construction projects delay and cost overrun risk and depict the relationship between both.Due to time and resource limitations a frame of samples of (n=19) is adopted. There are two main recognized types of sampling, namely; probability sampling and non-probability sampling. The chosen sampling type for this thesis is the non-probabilityreadily accessiblesampling type. This choice is made due to the limited resources and time available for this study.Non-probability sampling type adopted in this study goes in Awad's (2005) [14]words as "*the sample is restricted to a part of the population that is readily accessible, the sample, also, consists essentially of volunteers. With small but heterogeneous population, the sample will inspect the whole of it and selects a small sample of typical units-that is, units that are close to his impression of average of the population. Lastly, the sample selected haphazardly, that is mean selection without planning*."

ASSESMENT OF RISKS
DATA ANALYSIS

Preliminary data exploring is conducted. Table (1) illustrates the delays and cost overruns encountered in the projects (in term of percentages). It is quite observed that the delay is by far more varied and significant than cost overrun.

Table 1: Delay and Cost Overrun Percentages

No	% Delay	% Cost
1	28.88	5.58
2	19.44	20.82
3	21.11	6.36
4	73.89	2.53
5	124.00	9.84
6	13.55	12.11
7	54.42	1.91
8	57.50	10.49
9	25.87	5.32
10	90.00	5.59
11	142.86	6.55
12	100.00	5.52
13	241.18	12.07
14	33.33	3.47
15	44.00	5.01
16	177.25	7.91
17	12.22	4.69
18	120.75	9.21
19	53.41	12.70

Regression Model: There is an adage coated after George.E.P. Box states that *"Essentially, all models are wrong but some are useful*". To capture and detect any existence of relationship between delay and cost overrun variables the steps followed to attempt developing the model were; firstly, assessing the linearity and correlation between the two variables of interest (delay &cost overrun). The correlation and linearity were checked to examine the possibility of using linear regression model through examining the fundamental assumption of it. Linear regression assumes a linear relationship between the dependent and the independent variables.linearity was checked by least square method. It was found that there no linearity between the actual percentage of delay and the actual percentage of cost overrun. Correlation was checked by plotting scatter diagram (graphical representation,(Figure 3)) and coefficient of correlation and covariance aka as Pearson coefficient of correlation (Pearson= -0.511, P-value=0.025).It was found that there is no either apparent nor statistically significant correlation. . Hence, linear regression was rolled out. Secondly, curve estimation model was conducted for linear, logarithmic, inverse, quadratic, cubic, power, compound, S, logistic, growth and exponential distributions. No significance relationship was observed, all R^2 were very low and the P-values were above 0.05(Table 2) and (Figure 8).

Table 2: Model Curve Estimations

No	Model	djusted R Square	ANOVA-Sig.
1	Linear	-.050-	0.71
2	bgarithmic	-0.056	0.847
3	Inverse	-.038-	0.565
4	Quadratic	-.012-	0.428
5	Cubic	-.053-	0.567
6	Compound	-.020-	0.433
7	Power	-.057-	0.869
8	S	-.051-	0.725
9	Growth	-.020-	0.433
10	xponential	-.020-	0.433
11	Logistic	-.020-	0.433

Risk Model: To simulate the risks of delay and cost overrun (Separately) the following steps were followed. Firstly, selecting adequate distribution. Distribution models are generally used for estimation, prediction, simulation and communication. The wrong model is worse than no model at all. If the correct distribution model is obtained, estimations of the confidence intervals are narrower than the empirical model. With regard to the prediction, the distribution model can predict tail probabilities beyond observed data, where in empirical model predictions is limited to the observed data. As both variables (contractual duration and contractual cost) were treated as continuous variables. Distributions were chosen based on Akaike Information Criterion (AIC), Bayesia Information Criterion (BIC), Chi squared statistic, Kolmogorove-Smirnov Statistic, Anderson-Darling Statistic (Goodness-of-Fit). Test statistics for different distribution families were compared. lowest statistic indicates the least bad fit.For the two variables of contractual durationand contractual cost of sample data. It was found that both variables are fitting to Pareto distribution with (Θ=3.2566, a=150) as distribution parameter for contractual duration and (Θ=1.954, a=2550804.8) for contractual cost (Figure 4,6).

Monte Carlo simulations conducted based on the above defined distributions with (1000)iterations (Figure 5,7). It was found that all the actual projects durations are captured by the simulation (99 percentile). It was also found that all actual costs are captured (97 percentile).

As a final step, actual durations and cost distributions are investigated. It was found that the actual duration best fit to uniform distribution (Figure 9). For the actual cost the best fit is Pareto distribution (Figure 10). It is noticed that the contractual and the actual cost distribution belong to same family (Pareto). The contractual and actual duration are not where it Pareto for the first and uniform for the later. This is strongly suggesting that costs were reasonable estimated whereas the durations where miss estimated or imposed.

CONCLUSION

- It was found that there is no statistically significant empirical model that can depict/represent the relationship between delay and cost overrun.
- The max. cost overrun of the studied sample did not cross 20.82% of the actual budgeted cost.
- There is a significant difference and variation between and among contractual and actual contracts durations, which resulted in significantly large delays. in the author opinion this can be attributed to one or collateral of the following scenarios:
  - ❖ Owner imposed contractual time frame
  - ❖ Non-compensable time extensions of time due to changes
  - ❖ Lack of accurate project scope definition
  - ❖ Changes and variations
  - ❖ Contract miss-management

- The best fit distribution is Pareto for actual cost and uniform for actual duration

RECOMMENDATIONS FOR FUTURE RESEARCH

More data to be collected to challenge the suggested distributions of delay and cost overrun and the significance and magnitude of correlation between delay and cost overrun.

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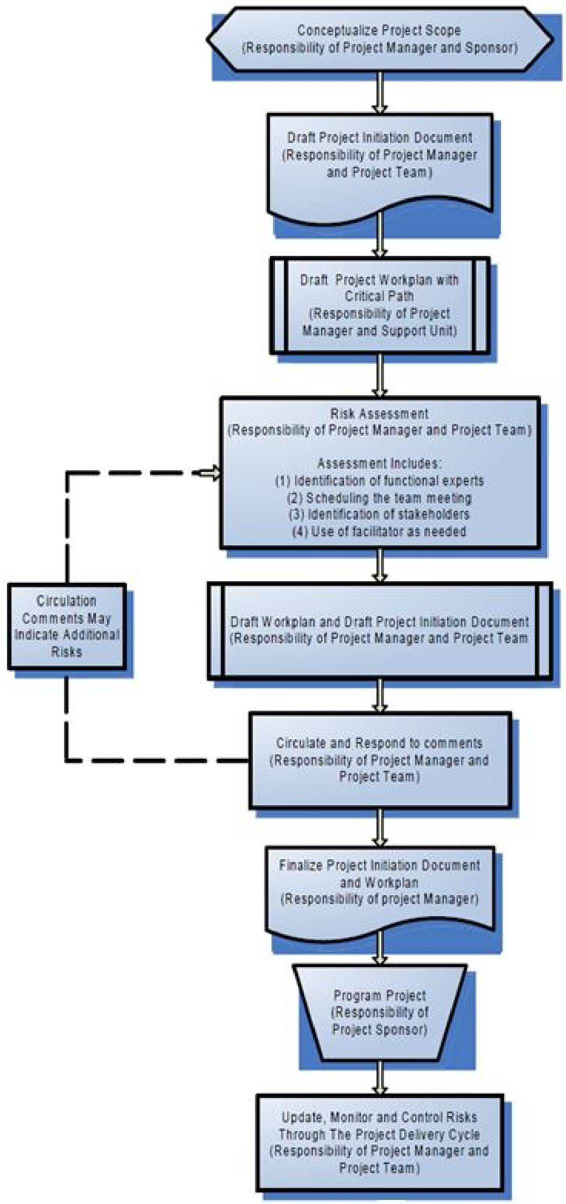

Figure 1: Risk Management Flow Diagram. (Source:Project Risk Management Hand Book, 2007)

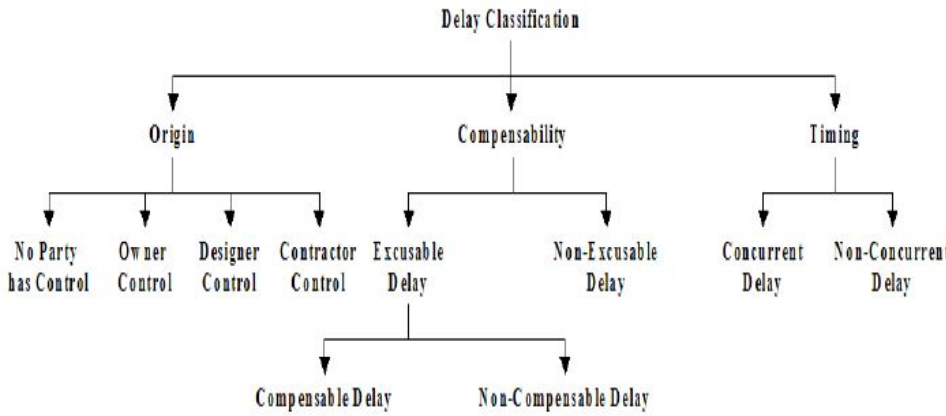

Figure 2: Delay Classification, Al-Humaidi (2002).

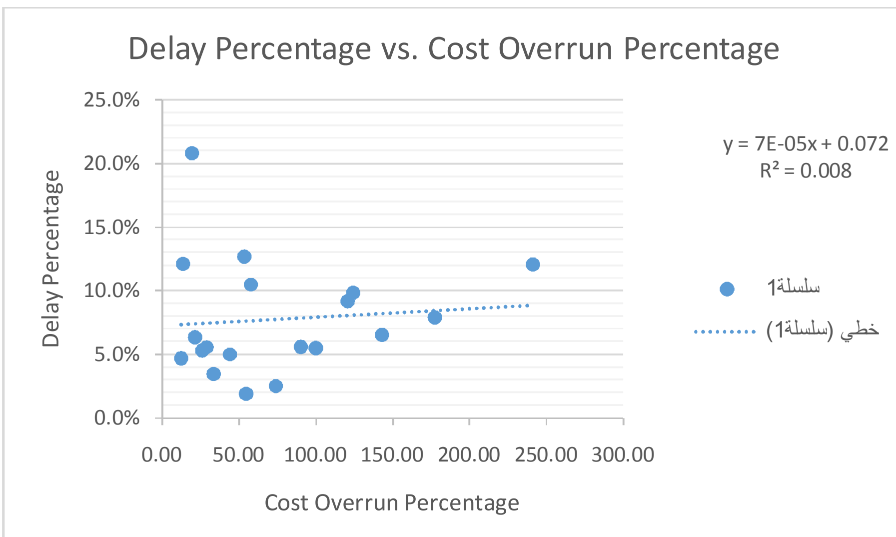

Figure 3: Delay Percentage vs. Cost Overrun Percentage

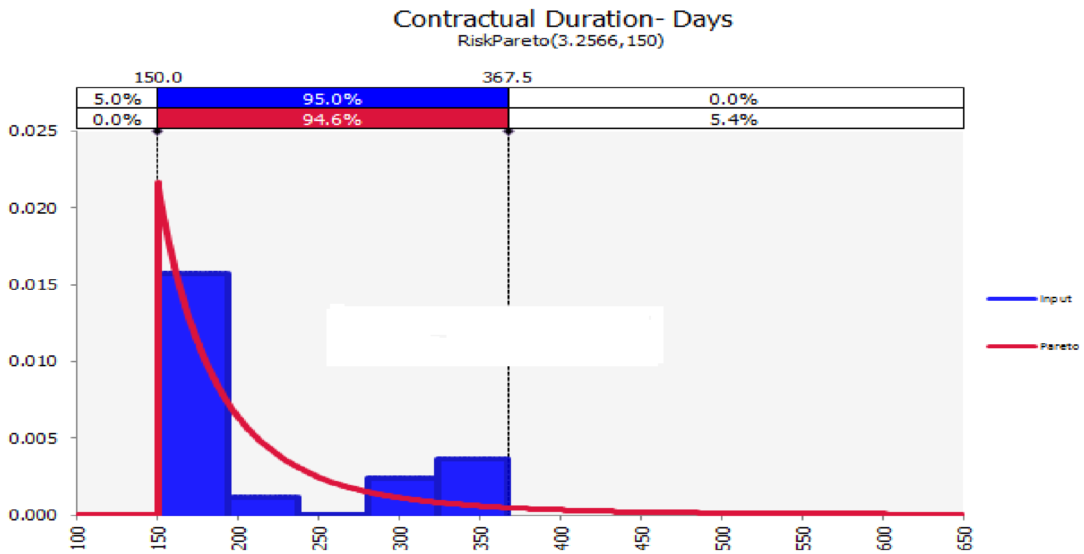

Figure4: Contractual Durations Distribution—Days

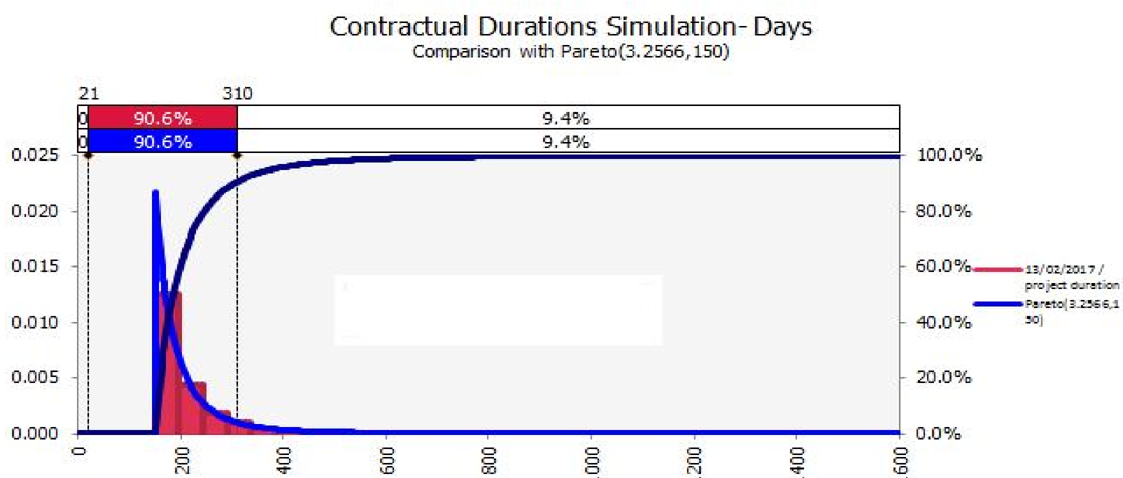

Figure5: Contractual Durations Simulation—Days

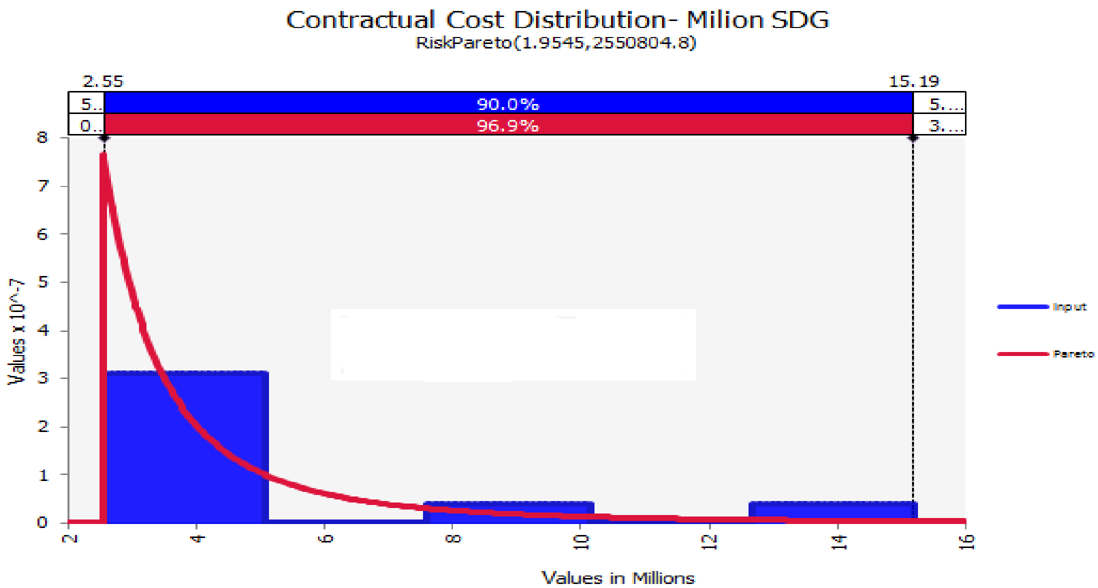

Figure6: Contractual Cost Distribution-Millions SDG

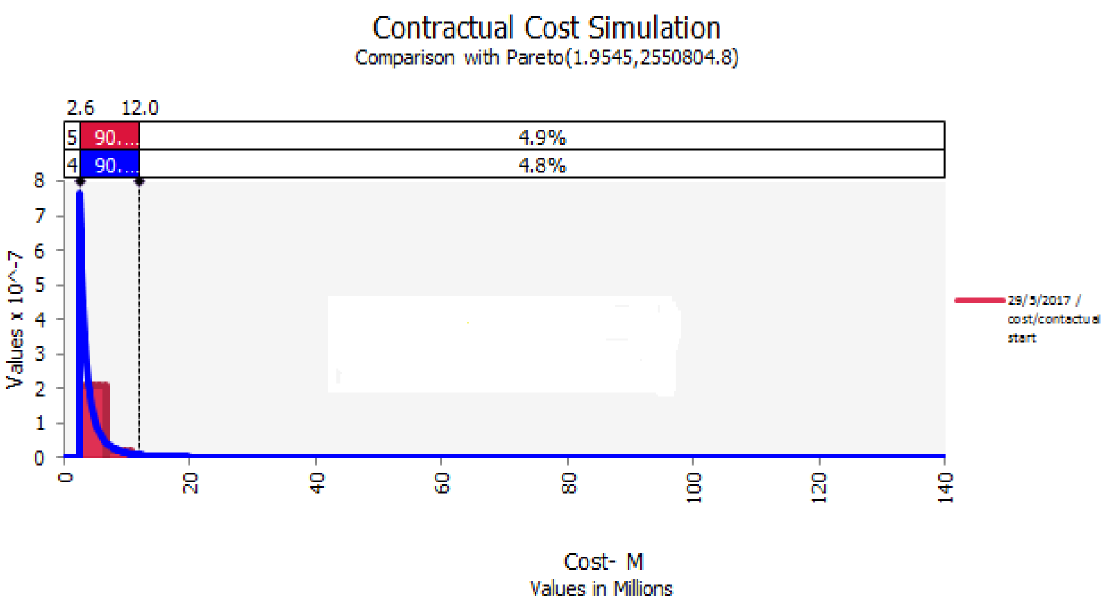

Figure 7:Contractual Cost Simulation-Millions SDG

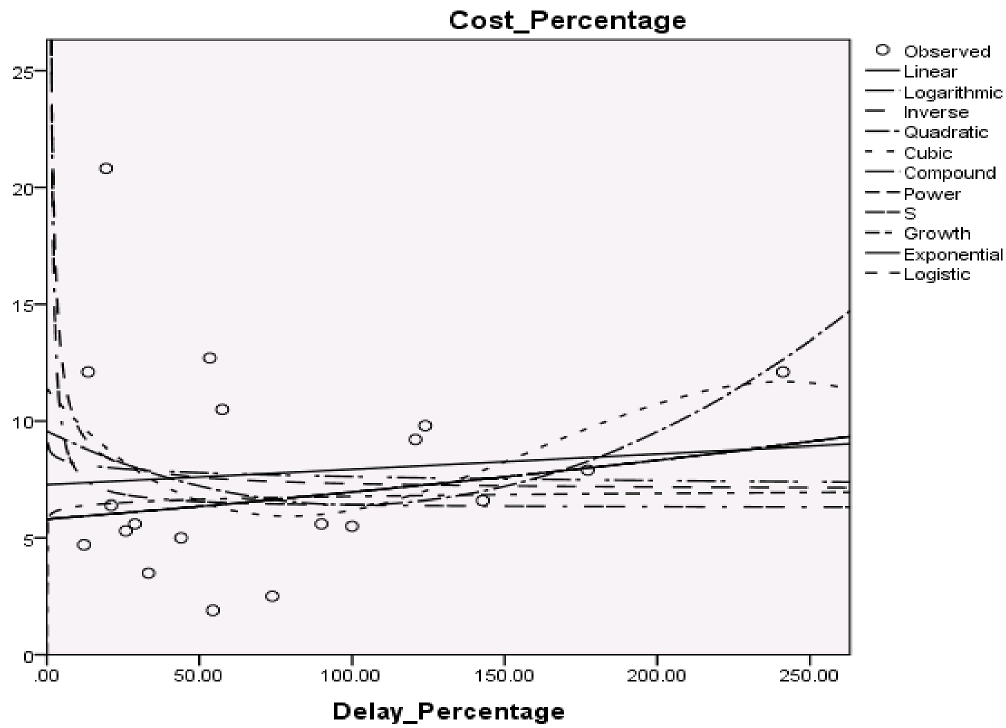

Figure 8: Curve Estimation

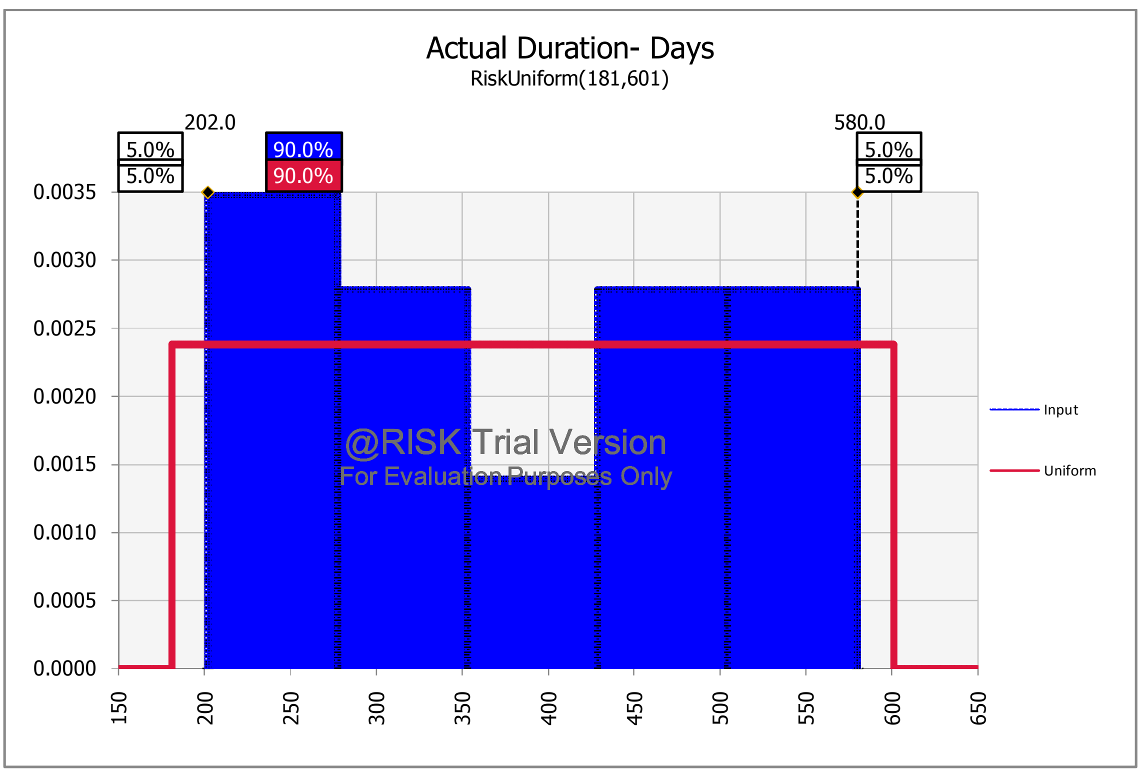

Figure 9:Actual Duration Distribution

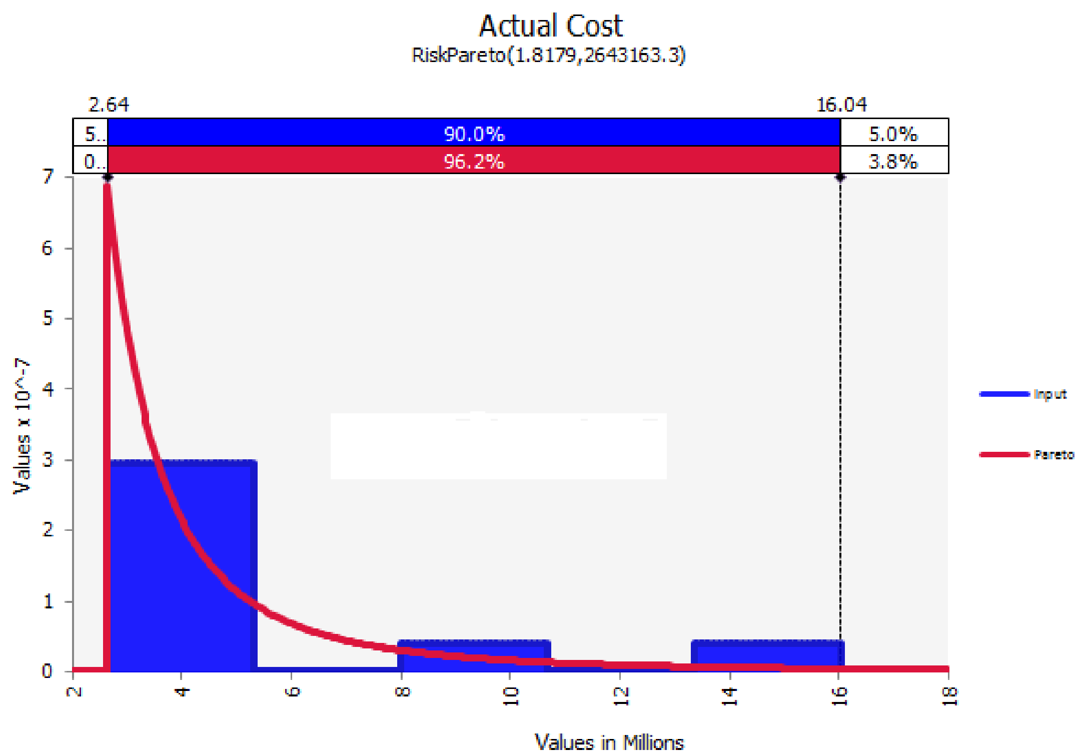

Figure 10:Actual Cost Distribution