RISK ANALYSIS IN FIXED-PRICE DESIGN-BUILD CONTRUCTION PROJECTS - a case study in Albania

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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled **"RISK ANALYSIS IN FIXED-PRICE DESIGN-BUILD CONTRUCTION PROJECTS - a case study in Albania"** and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

RISK ANALYSIS IN FIXED-PRICE DESIGN-BUILD CONTRUCTION PROJECTS - a case study in Albania

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In times of a project-based industry and blooming construction in Albania, the experience and clear objectives of a project manager definitely make possible the success of the project. As construction industry in Albania is mostly working with design-build fixed-prize contracts and on the other hand the economy is still in a transition phase, it is very important for the project managers to manage the risks related with the construction phase.

The review on existing literature found out a lack of existing models for risks management, especially related to the resource categories, therefore our research focuses in creating an analytical model that can help the project managers clearly define and analyse the risks before the construction phase. An interview with five project managers clarified the need of using an analytical model and gave the possibility to validate it through the use of a real case study project. The insightful model created experienced the contextual investigation examination with the utilization of virtual products like Microsoft Project, Excel and Palisade @Risk which utilizes Monte Carlo reproduction. Once the analysis was conducted, its results were compared with the data from the real project results and a final interview with the project manager was made, in order to check if this analysis could have been benefitial for the company if conducted before.

Even though the model was validated, it cannot be generalized as a model to be used in every type of project, so future works need to offer a further validation through other real case projects.

Keywords: *design-build, fixed-prize, risk analysis, risk management, analytical model, Monte Carlo simulation, risk mitigation plan.*

ABSTRAKT

MENAXHIMI I RISKUT NE PROJEKTET NDERTIMORE PROJEKTIM-NDERTIM ME CMIM TE PERCAKTUAR- rast studimor në Shqipëri

Picari, Edvaldo

M.Sc., Departmenti i Inxhinirisë së Ndërtimit

Udhëheqësi: Dr. Julinda Keci

Në kushtet e një industrie të bazuar në projekte dhe një veprimtarie ndërtimore në lulëzim në Shqipëri, elementi më i rëndësishëm në arritjen e suksesit të një projekti është padyshim eksperienca dhe qëllimet e qarta të drejtuesit të projektit. Duke qenë se industria e ndërtimit në Shqipëri funksionon më së shumti me kontrata projektim-ndërtim me cmime të përcaktuara, por ndërkohë ekonomia është akoma në fazën e saj tranzitore, është shumë e rëndësishme që drejtuesit e projekteve të menaxhojne paraprakisht risqet e lidhura me fazën ndërtimore.

Nga rishikimi i literaturës ekzistuese u gjet se ka një mungesë te modeleve mbi menaxhimin e risqeve, vecanërisht per risqet e lidhura me burimet, si rrjedhojë studimi ynë është përqëndruar në krijimin e një modeli analitik që mund të ndihmojë drejtuesin e projektit të percaktojë në mënyrë të qartë dhe të analizojë risqet përpara fazës së ndërtimit. Intervista e realizuar me pesë drejtues projektesh nxorri në pah nevojën për të zhvilluar një model analitik dhe na dha mundësinë për ta bërë këtë model të vlefshëm përmes përdorimit të një projekti real si rast studimor. Modeli i zhvilluar kaloi më tej përmes procesit të analizës, nëpërmjet përdorimit të programeve kompjuterike si Microsoft Project, Microsoft Excel dhe Palisade@Risk, i cili përdor Monte Carlon si program simulimi. Pas zhvillimit të analizës, rezultatet e saj u krahasuan me të dhënat reale nga projekti i marrë si rast studimor, dhe përvec kësaj u zhvillua një intervistë përfundimtare me drejtuesin e projektit, për të kuptuar nëse kjo analizë do kishte shërbyer nëse do të bëhej përpara fazës së ndërtimit.

Pavarësisht se modeli i zhvilluar u bë i vlefshëm përmes rastit studimor, nuk mund ta përgjithësojmë si një model që mund të përdoret për të gjitha llojet e projekteve, kështu që studimet e mëtejshme duhet të fokusohen në përdorimin e këtij modeli në raste të tjera studimore, për të siguaruar një vlefshmëri më të gjerë të tij.

Fjalët kyçe: *projektim-ndërtim, cmime të përcaktuara, menaxhimi i risqeve, model analitik, simulimi me Monte Carlo, plan për zvogëlimin e risqeve.*

Dedicated to my family

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I would like to express my special thanks to my supervisor Dr. Julinda Keci for her continuous guidance, encouragement, motivation and support during all the stages of my thesis. I sincerely appreciate the time and effort she has spent to improve my experience during my graduate years.

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement

In times of constant change, project management in most organisations has become a key practice. Its importance is clearly linked with strategic alignment, leadership, clear focus and objectives. Except for this, good project management brings about realistic project planning, ensures the quality, properly management of risks and proper project process.

Nevertheless, project losses, delays, and dissatisfaction are also much too popular to be ignored. A PwC study of over 10 640 projects found that only 2.5 % of companies complete their projects 100% successfully. The rest either failed to meet some of their original targets or missed the original budget or deadlines [1].

There appears to be a difference between what we need to know about projects and what we currently know, with most projects struggling to meet time and budget targets and many completed projects not meeting their business standards. The actual knowledge is more a linear thinking that needs to gain further dimensions to approach to reality. We think that the gap between perception and fact is always the explanation for major project failures.

In a world of new concepts and solutions being presented, it seems that the solution for a new way of project management is the concept of sustainability. For project management, the foreseen incorporation of financial, natural and social factors into project management does not constitute a comprehensive approach to sustainability.

The foreseen integration of economical, natural and social factors into project management does not constitute a holistic approach to sustainability for project management [2].

One of the most important steps of project management process is the establishment of the risk management system, which seems to be the most unknown part of the process. This is why this study will focus on the issues of risk, risk management/ analysis and the design- build contract system, to propose a schedule and cost risk analysis model.

1.2 Thesis Objective

The research objectives of this thesis will be reached after a cumulative work will be done regarding the literature review. This work includes a review on existing types of contract systems that are mostly applied internatioanally and especially in Albania as a case study, a study of the literature on existing payment methods used for the DB contract system and an analysis of the process of a project management, in order to find out the part of the process, which we mostly lack information for.

Also, a review on the literature on existing knowledge of risk definition, identification, analysis and management, a study of the current methods used to analyze and manage the risks of a project and a data collection of an overall presentation of the undertaking's principle highlights, significant application lacks and a rundown of the experienced dangers will be needed before the research and alaysis is conducted.

The collected information will help the real objectives of the research study, which include:

-Adopt the spreadsheet models for reflecting the project’s schedule and cost characteristics using MS Excel.

-Perform the schedule risk analysis and cost risk analysis using the Monte Carlo technique.

-Compare and analyze the values provided by the simulation in Monte Carlo and the actual ones from the project execution.

After the reaching of objectives, the final work will include providing conclusion about the importance of risk analysis based on research results and analysis and recommend future works based on the limitations of the current research.

1.3 Scope of works

This research will focus on risk analysis with regards to construction contract system and payment method. The risk analysis will be concentrated on the identification of random factors, conviction of the probability of their instance and their impact on the course of construction project.

The type of contract system that will be analyzed is that of design-build, as long as this system is more popular nowadays not only internationally, but also in Albania. Design and build would be helpful in terms of time, as it helps design and construction to coincide, minimizing the average completion time of the project. Other advantages of this type of contract include opportunities to have cost savings and a more accessible design for clients. On the other hand, this type of contract has its disadvantages in terms of quality, but what is more important: it has some lack of clarity in terms of cost and time, what makes it the most interesting case of our research.

The risk analyzes and management is very important in these type of contract systems because they are very much affected by the economic changes of the country, therefore they are the riskiest systems in developing countries like Albania. However, developing countries should not ignore the major disadvantage of design- build contracts compared to design-bid-build contract: corruption.

The payment method that will be analyzed in the research is that of fixed prize, in order to study the risks from the contractor's point of view, while the owner is not affected in these type of payment methods.

1.4 Organization of the thesis

This thesis is divided in 5 chapters. The organization is done as follows:

In Chapter1, the problem statement, thesis objective and scope of work is presented. Chapter 2 includes the literature review, subdivided into 4 parts: design-build delivery system, payment methods in a DB contract, risk definintion and management and current techniques of risk analysis. Chapter 3 includes the methodology part, where we have offered an introduction, an explanation of how an influence diagram works, how the interviews with the SME s are done, how the data collection is realized and finally how the data analysis and model development is done. Further at Chapter 4 we have shown all the results of the data analysis and mode development, htus we have divided this chapter into 7 parts: Introduction, Influence Diagram, Interviews with SME-s, Data Collection, Data Analysis, Model Verification and Model Validation. Finaly Chapter 5 inludes the Conclusions and future recomandations, where we have concluded the final results related to the ojectives and offered some ideas on future recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Design- Build Delivery System

Different contracts between the owner and the design and construction service providers may be performed under various contractual formats. In public and private ventures, two widely used delivery methods are design-bid-build (DBB) and design/build (DB).

In this research, we will be focused on the design-build (DB) type of contract, so first of all we will define this contractual system and identify the advantages that it has compared to the DBB.

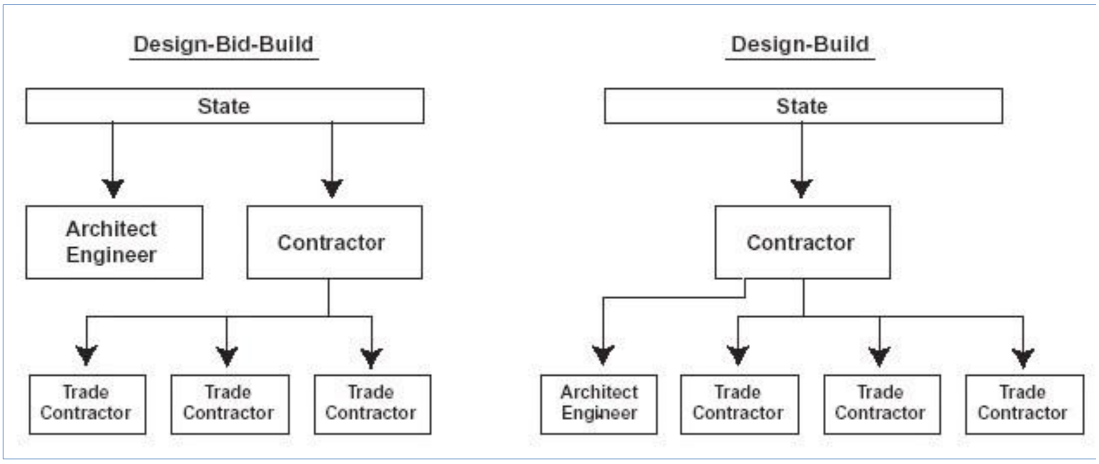


Figure 1 Difference between design bid build and design build [3]

First, in this system, an owner usually hires a single person, the contractor, to design and build under a single contract to perform both design and construction. The entity may execute portions or all the design and construction or subcontract to other companies. Usually, the general contractor is contractually responsible for this method of delivery.

Design Build is also recognized as a duty to design/construct and single-source. Design-building efficiently delivers office buildings, education, stadiums, transportation and water infrastructure programs around the country and around the world with superior performance. Design Build is a design-bid-build option. Design and construction are split-separate companies, separate contracts, separate work under the latter strategy. *(Figure 1).*

The work statements usually use a performance-based vocabulary in design-building (even though practically the specifications are often mixed between performance and design-type specifications). As the design-build entity not only offers construction but also design, the organization is responsible for achieving the goals in the work statement [4]. *(Figure 2).*

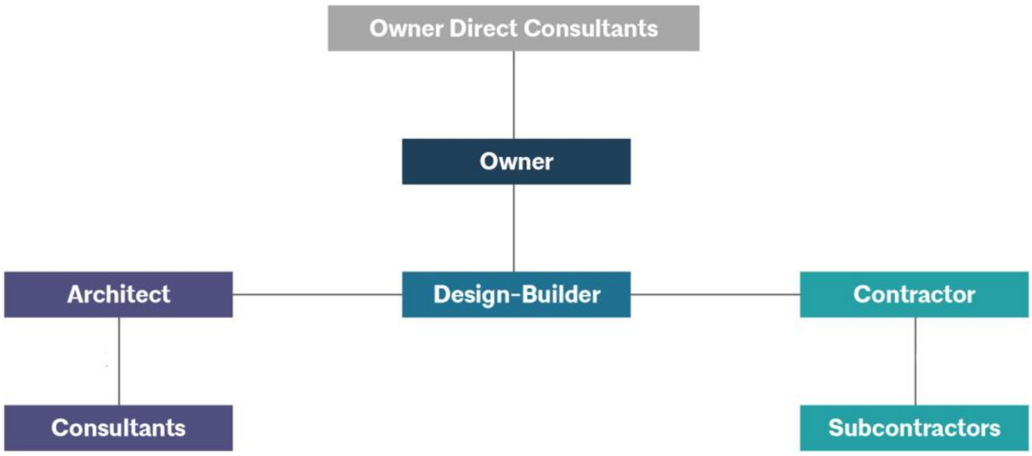


Figure 2 Design Build contract systems

Although DBB is the most traditional type of contract, recently DB is becoming more popular, because of its advantages compared to the DBB.

First of all, the design-build contract is advantageous for the owner/agency as long as it offers a faster delivery system, as the collaborative project management means that work is completed faster and with fewer problems. It also makes possible cost savings as an integrated team is geared toward efficiency and innovation.

The other advantage of design-build contracts is that they offer a better quality, which is also good for the owners. This occurs because design-builders prefer to fulfill performance requirements, not minimum design requirements, often to create ideas to produce a better project than originally expected. In design build contracts the responsibility is concentrated, as one entity is held accountable for cost, schedule and performance.

For the owner, the decreased administrative burden of design-build contracts gives him the opportunity to focus more on the project rather than managing disparate contracts. Also, for the owner this type of contract offers a reduced risk, as the design-build team assumes additional risk.

The reduction of litigation claims is also advantageous for the owner, as in this type of contract they can close some warranty gaps.

On the other hand, the design-built type of contract is beneficial for the practitioner also, because of some reasons. The first contains a higher margin of profit, as the integrated team is completely and fairly committed to cost management. Secondly, as this type of contract offers a decreased administrative burden, it streamlines the communication between designers and builders. The advantage of reduced litigation, which is valid for the owners, is also for the practitioners.

What is more important, design-build contract is very practical for the contractor, as it gives the designer the possibility to leave value engineering alternatives open for discussion and analysis throughout the project. Except for this, it allows for the customization of the design to actual size conditions more easily.

On the other hand, the design-build has its advantages for the owner and the contractor itself. First, in these types of contracts, the owner may lose some of his control of the design process. This is because during the process, the owner does not have the protection (and comfort) to have and A/E function as their agent. The A/E does not have as much input into the design process, even though the owner has an independent A/E interested in managing the project. So, design is also handled during performance by the owner's approval of design documents. Although certain design elements may be specified, flexibility in design is usually provided to the contractor. As one of the causes of conflict in the relationship, recent federal court rulings have highlighted the limits of design and development independence.

Another disadvantage of these contracts includes the need for earlier requirements definition, what means that the owner must lock in its requirements much earlier than in design-bid-build contracts.

In addition, the question that may occur in these types of contracts is subcontractor compliance. The Act on Subletting and Subcontracting Fair Practices allows bidders to list their bids with their subcontractors. For a design-build bidder, this may be a problem. The subcontractors can not accurately estimate costs without accurate design drawings.

Another disadvantage can be less competition. An efficient design-build team may not be put together by every company, and it may be more difficult to obtain performance and payment bonds on this type of project. Even from the perspective of the public procurement specialist, the method requires best-value approaches to the creation, assessment and award of applications not always familiar to construction management staff.

Contract management is also more demanding. Overall, contract management needs further teamwork. The lack of good coordination may be where the growing pains of design-build are exposed.

It is because of these disadvantages mostly for the contractor that we have decided to study these types of contracts in our research and reveal the ways in which the process of managing risks can help make these contracts better and develop further *(Figure 3).*

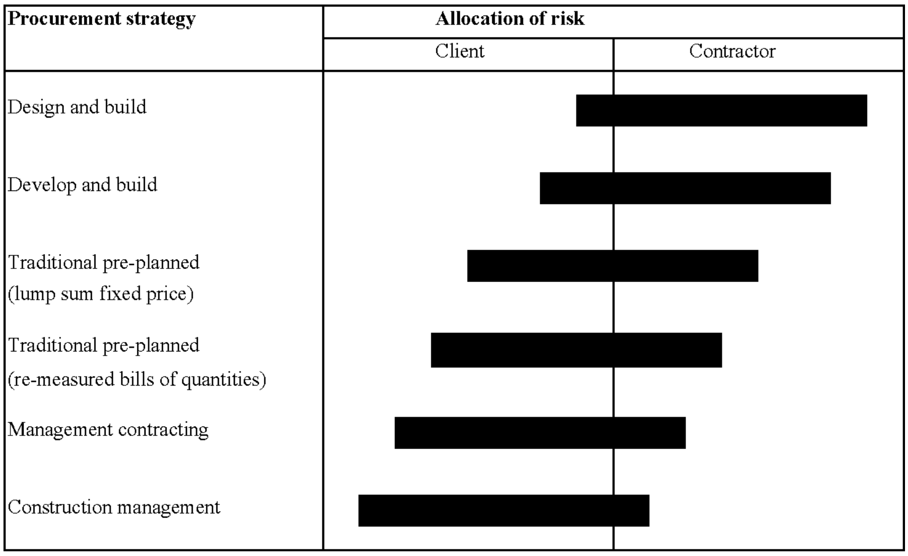


Figure 3 Risk Allocation in design build contracts [5]

2.2 Payment methods in a DB contract

The payment method that we will study in this research is that of fixed prize (lump sum). The reason why, is related to the way the risk is allocated in this type of payment method, where the contractor is mostly affected and takes the biggest part of the responsibility [6] *(Figure 4)*.

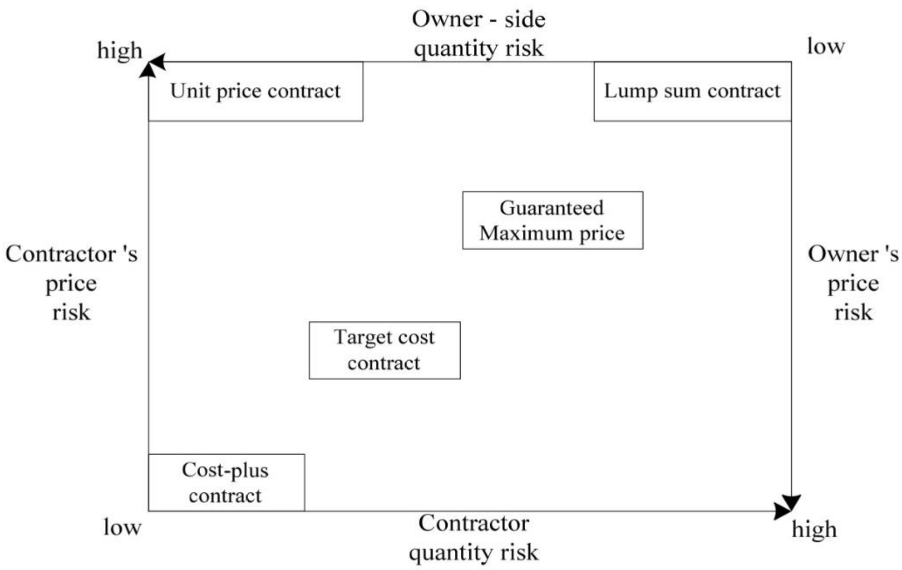


Figure 4 Risk allocation diagram for different contract payment methods

The contractor is expected to accomplish the project at the agreed contract value in this form of payment system, and this is why all risk of price, schedule, falls on the contractor. Therefore, before it starts, the owner knows the actual cost of the project. This payment method also minimizes risk for the owner if the project is well estimated, contractual documents are accurate and project is clearly defined. Clearly, it gives high incentive for contractor to finish and submit works early, so he can move on to other jobs.

This payment methods have its advantages and disadvantages for both parties: owner and the contractor.

First, this payment method provides certainty and simplicity, as long as both parties know exactly how much and what work will be paid for. This is particularly helpful for an owner who is able to restrict his exposure to a project and not worry about cost overruns. Secondly, this payment method makes the contractor compete with his own deadline and estimates, being faster and more efficient than it anticipated it would be. For the owner this means a faster completion of the work, while for the contractor itself it raises the possibilities for a higher profit margin. Third, while a lump-sum contract allows a contractor to be as precise as possible in calculating its costs, the contractor is not expected to keep an accurate record of its project expenditures, resulting in less overhead for the project.

On the other hand, this payment method has some disadvantages. First of all, although the potential of rising the profit margin by reducing time is very important in these type of payment methods, it is not always evaluated by the contractor. And, for a contractor, the flip side may be catastrophic. As long as owners seek for the lowest price, they will seek for bids from different contractors. In order to gain the work, the latter ones will lower the bid, risking having a reduced profit margin or what is worse, eliminating it. Secondly, some contractors might build contingency plans in their bids to protect themselves, in this way putting some risks to the owner. The last disadvantage of this payment method has to do with quality, because some contractors will tend to increase their profit margin by contracting inferior subcontractors. In this way, the owner will possibly see reduced quality in the overall project.

More and more this payment method is required for many public projects, since it is a very good method for well-defined projects and it allows for good price competition in commodity metric. However, this method is considered as bad for ill-defined projects, and that it establishes an adversarial relationship regarding liability and reimbursement for modifications. High contractor danger often usually means starting late and the original meaning of the lump sum is often somewhat different from the “Fixed Fee”'s typical sense.

2.3 Risk definition and management

2.3.1. Risk

The risk is equal to uncertainty. It means that an event might have more than one possible outcome, which will be defined by probability. In project management, risks are related with cost, schedule, safety and technical performance. For the purpose of this study, risk is characterized as exposure to the probability of cost occurrence, or as a result of uncertainty [7].

In this part, we will firstly define the project risk, the difference between known and unknown risks and finally the difference between business risk of the organization and project risk.

So, the risk itself is the possibility of loss or injury. The project risk is an uncertain event or condition that might have an effect on the project objectives. While risk management makes the identification, assessment and management of the risk, in order to minimize their impact on the project. There are no risk-free projects because there exist an infinite number of events that might have a negative effect on the project. This means that risk management doesn’t eliminate risks, but it identifies, assess and manages risks.

The study made from TzviRaz, Aaron J. Shenhar and DovDvir, in their “Risk management, Project Success, and Technological Uncertainty” R&D Management [8] analyzed the methods of risk management and made some important conclusions. First, they concluded that risk management is not widely used and that projects that made risk management were mainly the ones with a higher risk. Secondly, they concluded that in project where risk management is applied, it positively affects the success of the project. Also, they concluded that the risk management influences the project schedules, cost goals and exerted less influence on project product quality.

However, there are some possible negative events that are more likely to happen in some specific projects. For example, safety risks are more likely to happen in construction projects. Also, changes in the value of local currency mostly affect projects with large international components. Another example is that of road projects and coastal ones, which might experience schedule delays due to the wet or windy weather conditions.

Risks are classified into known and unknown risks. The first ones include events that are identified, and a possible solution is available for them. While the other unidentified risks are called as unknown ones.

Project risks are separate from the organizational risks that are associated with the business purpose of the project.

2.3.2. Risk management

Risk management is one of the most important parts in the process of project management, as it brings about more information for the most unknown part of the whole process.

Risk management is a pivotal instrument that helps us deal with the culling out of various risks, their analysis, and the remedial steps that can be taken to avert them in a particular. A typical risk management process includes the following key steps: risk identification, risk assessment, risk mitigation and risk monitoring.

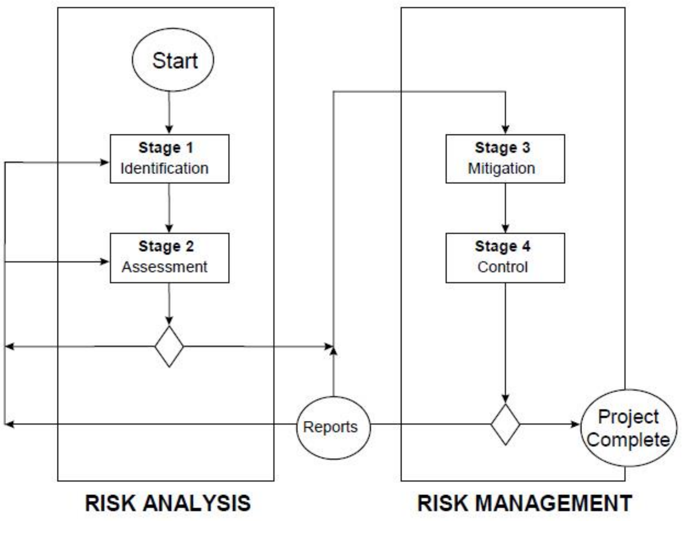


Figure 5 .Stages of risk management in construction projects [9]

2.3.2.1 Risk identification

Task chances are ordered into four unique stages as indicated by the existence pattern of the venture, like investigation of practicality, plan, development and activity. In the attainability interaction chances are for the most part applied to customers and government organizations. The focal point of this cycle is customer need, key outline, and reasonable undertaking possibility study which additionally considers the value vacillation of building material.

The next step is the design process in which designers have the most important role to play in recognizing and fulfilling the desires and needs of clients. Risks in this process relate to the bureaucracy of government, the design fault and the transition that comes from both the client and the contractors.

Once the design has been set, project enters the construction phase, the risks in this phase are likely to correlate with contractors and subcontractors, such as variance of project delay, lack of adequate number of skilled employees, lack of teamwork, and incidence of safety incident.

Just financing for the project operation and difficult government regulation related to facility management, environmental sustainability will result in the potential risks on the final phase after construction work is completed. Overall, many risks occurred during the pre-operation process.

As in this study we are aiming to offer ways of managing risks for the contractor and subcontractors, we will be focusing on risk identification for the construction phase of a project, as this is the part of the project process, in which the risks apply mostly to them [10].

In projects, in particular the following risks occur, which are broken down according to risk types. First, we have quality risks that include defects in interim results, lacking application of project methods or too few controls/ tests. Secondly, risks that might occur include personnel risks, what means lack of skills or disagreements in the team. The third type of risks include cost risks, like planning changes, complicated project conditions or the risk that the consumer will fail to pay. The fourth type of risks are the deadline ones: no handover in good time or the delay of the project. Another type of risks are the ones of the strategic decisions, what means failure to recognize chances and lack of ability to consistently use chances. The final type includes the external risks like natural occurrences, political changes, changes in society, a shift in the market, legal developments, shifts in sectorial trends and technological changes.

2.3.2.2 Risk Analysis

Danger investigation is the interaction that sorts out how likely a danger will emerge in a task. Its examinations vulnerability and what it would mean for the task as far as timetable, quality and expenses if indeed it was to appear. There are two different ways to break down the dangers: subjective and quantitative danger examination.

This part of the project management process is very important as it helps in avoiding potential litigation, address regulatory processes, comply with new legislation, reduce exposure and minimize the impact of each risk on project.

Although there are two ways of risk analysis, it is very important to combine both in order to dig deeper in the project management.

Qualitative risk analysis is the process of prioritizing risks for further analysis or action. It is executed by determining each risks likelihood or probability of occurring, as well as rating its impact on the project. First, to determine the probability of a risk it is used a scale ranging from 0 to 1. It means that, if the likelihood of a risk is 0.5, its chance of occurring is 50 %. On the other hand, the impact scale is measured from 1 to 5, with five being the most impact on the project. By determining the probability and the impact of a risk, we can then categorize it as either source or effect based.

As we can see, qualitative risk analysis is important not only to reduce risks, but also to bring the focus on high-impact risks.

Quantitative risk analysis on the other hand is a numerical or statistical procedure of analyzing the effect of identified risks on overall project objectives. It counts the possible outcomes for the project and figures out the probability of still meeting the project objectives.

2.3.2.3 Risk mitigation and monitoring

As stated by Hillson, risk mitigation and risk response development is often the weakest part of the risk management process.

Risk mitigation and monitor are clearly considered as part of the response to the identified risks. This response can be realized using one or combination of the following strategies: elimination, transference, mitigation or acceptance of the risks.

Risk elimination means eliminating it, so that its effect will no longer be important to the project. Risk transfer means the shift of risk responsibility to another party either by insurance or by contract.

Wang and Chou reported that contractors usually use three methods to transfer risk in construction projects. The first method is that of through insurance-to-insurance companies. The second one is that of subcontracting to subcontractors. The third method is that of modifying the contract terms and conditions to client or other parties.

Mitigation of the risks means the identification of actions that will minimize the impact of risks on project cost, schedule, quality or objectives.

		Modeling and Analysis Suitability				
No	**Technique**	**Risk Group**			**Prominent Uncertainty**	**Tools**
		(A) Organization -Specific	**(B) Global**	**(C) Acts of God**		
1	**Probability**	Very Good	Very Poor	Very Poor	Random (*A*)	DSS
2	**Certainty Factor**	Very Poor	Good	Good	Epistemic (*B* and *C*)	KBS
3	**Dempster_Shaffer Theory of Evidence**	Poor	Good	Good	Epistemic (*B* and *C*)	KBS
4	**Fuzzy Set Theory**	Poor	Very Good	Very Good	Epistemic (B and *C*)	KB-DSS

Figure 6 Techniques of risk analysis based on different risk natures

Acceptance of the risks, on the other hand is generally a viable strategy for high consequence, low likelihood risks, which then must be closely monitored to formulate appropriate responses if the risk does materialize.

2.4 Current techniques of risk analysis

In this study we will focus on analysis of the risk, as the most important part of the process of risk management. The techniques used for risk analysis are different and depend on the type and nature of risks that will be analyzed. They vary from more probabilistic models to numeric ones.

2.4.1. Probabilistic Technique

Historically, probabilistic modelling and analysis have been the prominent way to handle risks regardless of their nature. Such techniques have been regarded as the only effective ones to deal with misunderstanding. Uher and Toakly observed that the ambiguity associated with real risk situations was epistemic rather than spontaneous (a matter of chance). Indeed, the process is mainly based upon experience, assumptions and human judgment.

A branch of mathematics dealing with random phenomena is probability. Probability theory has been widely used to model precisely described, repetitive experiments with observable but uncertain outcomes. The main concept used to express the degrees of belief of the decision-maker is the subjective probability. Individuals with diverse backgrounds are entitled to assess the likelihood of the same events differently, it means that the subjective probabilities given by different individuals for the same risk will be different. We will evaluate the use of probabilistic methods for organization-specific, global risk factors and Act of God type of risks.

Organization specific risks include planning, finance, human resources, and equipment and material logistics. These types of risks can be better evaluated by using probabilistic methods rather than numerical ones. On the other hand, for global risk factors, probabilistic methods pose serious challenges in terms of robustness and validity, if the uncertainty in this group of risks is more epistemic than random. Although the subjective probabilities are more used for the Acts of God category of hazards, as long as these hazards are poorly described and ambiguous in nature, they can not be measured with such high accuracy.

2.4.2. Certainty Theory Analysis Technique

Certainty Theory is mainly a theory for handling uncertainty in knowledge-based systems: KBSs. This theory relies on defining judgmental measures of belief rather than adhering to strict probability estimates. (Baloi, 2012)

The basis of this theory are the certainty factors (CF), which are defined as trust measurements for a piece of evidence. The CFs consist of -1 to +1 numbers and truthful statements (rules). So, if CF=1, it implies that there is complete assurance that a proposition is true; if CF=-1, it implies that there is complete assurance that a proposition is false; whereas if CF=0, it implies that there is no knowledge at all about or no shift of belief.

Using CFs within knowledge-based systems, global risk factors and Acts of God can be modelled in engineering projects, where the following format is common: if A then B with certainty factor CF (CF= rule), where A is the antecedent and B, the consequent. The precedent includes facts (proof) which support the derivation of the resulting evidence (hypothesis). The CF is the net degree of hypothesis confidence, provided that the proof is seen (given). To measure the CF, the formula used is:

$$\boldsymbol{CF}\ [\boldsymbol{h},\boldsymbol{e}] = \boldsymbol{MB}\ [\boldsymbol{H},\boldsymbol{E}] - \boldsymbol{MD}\ [\boldsymbol{H},\boldsymbol{E}] \text{(Equation 1)}$$

The original formula is actually:

$$\boldsymbol{CF}[\boldsymbol{H},\boldsymbol{E}] = (\boldsymbol{MB}[\boldsymbol{H},\boldsymbol{E}] - \boldsymbol{MD}[\boldsymbol{H},\boldsymbol{E}]) : \{\boldsymbol{1} - \boldsymbol{min}(\boldsymbol{MB}[\boldsymbol{H},\boldsymbol{E}], \boldsymbol{MD}[\boldsymbol{H},\boldsymbol{E}])\}$$

(Equation 2)

Where CF[h, e], given the proof E, is the assurance factor of the hypothesis H, MB the degree of confidence, MD the degree of skepticism in h given E. MD and MB values range from 0 to 1.

As described in detail by Shortliffe and Buchanan ***[11]***, the values of MB and MD are calculated:

$$\boldsymbol{MB}\ [\boldsymbol{H},\boldsymbol{E}] = \boldsymbol{1}, \boldsymbol{if}\ \boldsymbol{P}\ [\boldsymbol{H}] = \boldsymbol{1} \qquad \text{(Equation 3)}$$

$$\boldsymbol{MB\ [H, E]\ =\ \{P\ [H\mid E] - P\ [H]\}:\{1 - P\ [H]\},\ \ P\ [H]\ different\ from\ 1}$$

(Equation 4)

$$\boldsymbol{MD\ [H, E] =\ 1, if\ \ \ P\ [H]\ =\ 0}$$ (Equation 5)

$$\boldsymbol{MD\ [H, E]\ =\ \{P\ [H] - P\ [H\mid E]\}: P\ [H], if\ \ P\ [H]\ different\ from\ 1}$$

(Equation 6)

Where P [H] is prior probability of a hypothesis H; P [H, E] is the posterior probability of the hypothesis given some evidence E.

2.4.3. Dempster-Shafer Theory of Evidence Analysis

Dempster-Schafer Theory of proof is normally called epistemic likelihood since it gives an elective model to the evaluation of mathematical levels of conviction. This hypothesis endeavors to recognize vulnerability and obliviousness. It utilizes conviction works rather than likelihood.

This theory is based on two main principles, namely the obtaining of degrees of belief from subjective probabilities for a similar question for one question, and the rule of Dempster to combine certain degrees of belief when based on independent proof.

2.4.4. Fuzzy Set Analysis Technique

The theory of Fuzzy set is a branch of modern mathematics developed by Zadeh to model vagueness inherent in human cognitive processes - humanistic systems. Since then, because of imperfect and imprecise knowledge that characterizes real-world processes, it has been used to tackle poorly described and complex problems. Therefore, it is sufficient for unclear or approximate reasoning requiring intuitive thought of humans. Because of the inherent confusion, it seems that Fuzzy sets are more appropriate than other tools to deal with global risk factors and Acts of God.

The definitions of the linguistic variable and degree of membership are the fundamentals of fuzzy set theory. Because most decision problems in construction engineering are complex and imprecise, linguistic expressions rather than numbers may best explain them. In addition, the transition from one state to another is smooth due to the imprecision inherent in linguistic expressions.

2.4.5. Monte Carlo Simulation as a risk analysis technique

A Monte Carlo simulation is an instrument of computational risk analysis applied to unpredictable or variable circumstances. It is a mathematical way to predict the consequences of a situation or collection of circumstances by presenting a variety of potential results and evaluating the impact of each risk. It is often referred to as the 'Monte Carlo method' or 'probability simulation' and is used in many different applications, such as construction, engineering, finance, project management, insurance, science, transport, etc.

In reference to the principality of Monaco, well known for its casinos, the name is believed to have been devised by scientists working on the atom bomb.

A main feature of a Monte Carlo simulation is that it gives a more accurate image of potential future outcomes by producing a number of possible values, not just a single prediction. It can be used in construction to determine how long a given job will take and its probable impact on the scheduled schedule.

To begin with, using a set of estimates for a specific mission, a mathematical model is developed. A project manager, for example, should consider the time it can take to complete a collection of tasks by:

Considering worst case scenarios (i.e., the maximum expected time values for all variables),

Considering best-case scenarios (i.e., the minimum expected time values for all variables).

Considering the most likely result.

The Monte Carlo simulation, which can be run 500 times, contains these figures. It is possible to measure the probability of a specific outcome by counting how many times it was returned in the simulation and a percentage was generated.

2.4.5. Previous Researches on Risk Analysis of fixed-price design-build contracts

In building projects, there is a shortage of realistic models that could measure risks. Xu [12] introduced an approach to the risk evaluation of the pricing methods of the contractor, while Tummala et al. developed a model of risk management method (RMP) to determine the risks associated with project costs in various phases of the life cycle of the project. Songer et al. propose risk analysis techniques such as Monte Carlo simulation to assess risks in construction projects procured by either design-build (DB), construction management, or methods of operation and transition constructed. Using risk assessment approaches to predict operation and project durations, Dawood developed a simulation model. A survey on the use of risk analysis methods in assessing the contingency allowance in project cost estimation was conducted by Maket al. However, there is no special consideration given to the risks of construction projects of the DB kind.

Over the period from 1960 to 1997, Edwards published a large literature review on risk and risk management [13]. A questionnaire survey of general contractors and project management activities was performed to see if risk analysis and management strategies are used by the industry. They both agreed that, due to a lack of expertise and concerns about the suitability of these methods for construction industry operations, systematic risk analysis and management techniques are seldom used. Although the risks of DB ventures are often not taken into account, it has been shown that realistic risk management strategies and their implementations are missing.

In addition, as the use of this project delivery approach increases, the number of studies relevant to the DB contract framework is growing. During the implementation of such an international contract, he found several issues that could be encountered, including lack of payment, ignoring contract clauses, changes in government, and politics in general. However, in an economic downturn, there is no emphasis on' exchange rate Juctuations/devaluation risk.'

Public sector owners are increasingly identifying new methods of procurement for construction. Changing procurement laws and recorded achievements in the project are motivating owners to try the project procurement system of DB. Using five performance parameters correlated to particular project characteristics, [14].

developed prediction models for public sector DB project selection. Only on the basis of a case study of two related ventures did Ernzen et al. present an overview of the company's labor cost risk. A standard design/bid/build work was one project and a DB job was the other. He believes that the DB project has encountered consistently higher labor cost Juctuations. In their research, they did not jointly consider schedule and cost characteristics.

Rowings et al. asked electrical contractors on several different aspects of DB and how their company is influenced by these variables. The survey showed many significant trends and preferences among electrical suppliers. One field recognized in the survey worthy of notice is that, with their current understanding of the problems, many of the electrical contractors feel ill prepared to embark on DB.

For DB projects, Chan et al. defined a number of project success factors and analyzed the relative contribution of these factors to the outcome of the project. Risk evaluation in DB projects is one of the factors he found to be significant. The number of studies integrating risk analysis/management and DB subjects is still scarce, however. There is also a lack of research on actual case studies that incorporate project price and period estimation using risk management and measurement techniques in fixed-price DB style projects.

In dissecting and surveying the timetable and cost qualities of fixed-value DB development projects, this investigation talks about the materialness and need of the technique for hazard examination. Danger examination cycles might be directed at the assessment and offering phases of fixed-value DB projects as a stage in the undertaking hazard the executive’s structure. This application prompts a more point by point audit of the undertaking chances found and a more exact value proposition with a gauge of venture length. It is currently undisputed that it is generally essential to give a sensible gauge of the last expense and length of the undertaking as ahead of schedule as could be expected. In DB building projects carried out in dangerous locations such as Albania, this necessity transforms into a critical pretender project operation. The case study carried out in this study helps to prove this argument.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The aim of this study is to develop an analytical modeling method to estimate the number of delays in the phase of risk analysis prior to the start of the construction project. This model will tend to give the Project manager the opportunity to see if the critical path of the project will shift from the original one and focus on the tasks that have the more important delays.

For the Monte Carlo simulation to work, we will firstly build an influence diagram that will show the complexity of the problem and represent the logic, in which the simulation will work. The analytical model itself will be created in three phases, using Microsoft Project, Microsoft Excel and an Excel add-inn, Palisade @Risk.

In order to see how successful, the model is, the model will be generated using an existing project completed, and the outcomes will be compared with the results of the project.

3.2 Influence Diagram

For a project manager, an impact diagram is very important, because it is a visual representation of the decision process. An impact diagram is a graphical or visual representation of the decision taken by the project manager, according to Tani and Parnell, 2013. Also, through the influence diagram, the project manager defines the frame of decision, the inputs, uncertainties and decisions of the model. The influence diagram also helps the PM to communicate the structure of the model to other stakeholders, like the owner. (Tani and Parnell, 2013)

An influence diagram is made of different shapes, where each of them represents a specific element of the decision process:

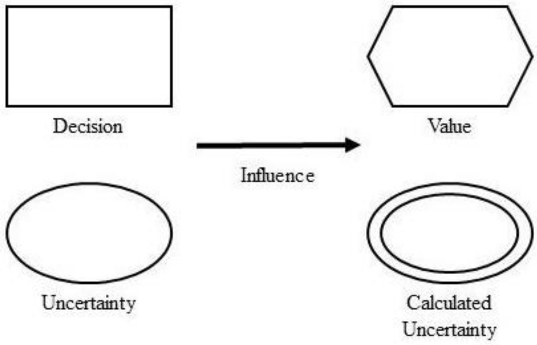


Figure 7 Shapes of influence diagram [15]

The rectangle represents an option based on the complexity of the problem, from a specified group of alternatives, it can be one or more decisions.

The oval shape indicates confusion, which may be continuous or discrete. A continuous uncertainty means a random variable with a value within a specified range of results of any real number, whereas a discrete one is a random variable with a value within a specified range of any countable subset of real numbers, such as a set of integers. An uncertainty can also be scalar (described by a single number value) or vector (values across a time series) [16]

The double oval form is a measured uncertainty, which means that other unknown variables are calculated (decisions, uncertainties, constants). If these other variables are understood, the measured uncertainty will also be recognized.

The octagon reflects a measure of worth, established as a criterion for judgment. This value is a metric that, depending on the desired result to be obtained by the project manager, is maximized or minimized.

The arrow represents a relationship within the influence diagram between two of the other components. It means that between the two related elements there is a probabilistic dependency, where the path of it shows the order of conditionality where the likelihood of an element at the head is conditional on the result of the element at the base.

3.3 Interviews of Subject Matter Experts (SME)

Interviews of Subject Matter Experts are very important for the research in order to understand what the criteria that the developed model should include to be implemented by the project managers. It is very important to know what the stakeholders and project managers think and want of the model, in order to know if it will be implemented by them.

The interviews should also have certain requirements, they should be conducted during different phases of study, with people across history, at all organizational levels and with different levels of expertise.

In this research, we will make some interviews with SME, in order to understand the need of developing an analytical model that can predict potential delays. The questions that will be made to the project managers will be categorized into two types: demographic and project types of questions. Demographic questions will focus on credentials of SME, while project questions will tend to gather information about current methods that project managers use in their companies, their thoughts on implementation of new tools and their thoughts on the developed model.

In order to establish the participation of the SME in the research, we will make a consent agreement with each of them and their full interviews will be published at Appendix A and B.

3.4 Data Collection

With the exception of interviews, each project manager was asked to provide the project manager with details about a project they were working on or any contact information they had. A full list of project plans, a follow-up interview for model confirmation, a task breakdown structure (WBS), an email communication about possible delays, the results of the project and contact details for the project team members were included in the types of information they were required to provide.

3.5 Data Analysis and Model development

In this part of the research, our aim is to build a model in which the Project Manager can input the probabilities of delays for each task on the project schedule. This model is important because it allows for the delays to be exported into Microsoft Project, so that we can see if the critical path will shift from the original one and finally compare it with the original project schedule. This final comparison will validate the model or not.

The model will be built into three main steps, using different software: Microsoft Project, Microsoft Excel and finally an Excel add-in Palisade @Risk.

The first step is that of recreating the original project schedule using Microsoft Project. This will allow to calculate the critical path of the project using the Critical Path Method. The Critical Path of a project is very important because a delay that might happen in it, affects the overall duration of the project itself.

The second step is the transfer of the information from Microsoft Project to Excel. The information that will be transferred include the task number, duration and task name, so that the project manager can put on the model the uncertainty probabilities of delays for each task of the schedule. These probabilities are crucial for the Monte Carlo Simulation that will be made using Palisade @Risk Software.

The Excel add-in Palisade @Risk Software is one of the best software to use because it also produces a detailed statistical report and graphical outputs that the project manager can later use to assess the potential delays and create a plan to ensure the project completion, before the construction phase.

The third step is the transfer of the delay outputs into the original project schedule, so that the analysis can be conducted. The new Critical Path derived from the model is then compared with the original critical path of the project to see if the delays changed the path and how many days the project was delayed. The final comparison is that of the final schedule of the project with the original and model-derived schedule, in order to see which of them is closer to reality.

CHAPTER 4

RESULTS

4.1 Introduction

In this part we will conclude with the final versions of the influence diagram, results of interviews of SME-s, project data, model development and its verification and validation.

4.2 Influence Diagram

As the influence diagram is very important for the visual representation of the decision-making process, the final version of it is represented in *Figure 8*.

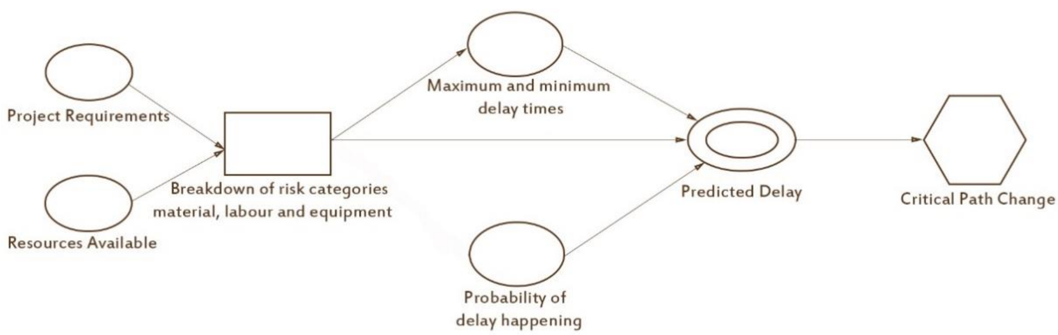


Figure 8 Final version of influence diagram

One of the most important decisions a project manager takes is that of deciding what the number of resources needed for each task is. Considering this, the rectangle in figure 8 represents this decision, which means a breakdown of risk categories for the allocation of material, labor and equipment. The uncertainties affecting this decision include the project requirements and the resources available, therefore there is a dependence connection between them and the decision, represented through an arrow. So, without knowing the project requirements and the resources available, a project manager cannot decide.

The decision that the project manager makes affects another uncertain factor: maximum and minimum delay times. While the calculated uncertainty of predicted delay is depended on both from decision and other uncertainties: maximum and minimum delay times and probability of delay happening. The final value of critical path shift, which is actually the value measure in the influence diagram, is depended on the predicted value; this is why the dependence relation is represented by an arrow ending in it.

The table 1 will present each of the elements of the influence diagram in a detailed description.

Table 1. Detailed description of influence diagram elements

Name	Type	Description
Project Requirements	Uncertainty	Detailed project documents created by the owner, general contractor, and project manager. Ex: schedule, scope, work breakdown structure, resource breakdown schedule, drawings, and contract agreements
Resources Available	Uncertainty	Resources the general contractor and project manager have available for the specific project. Ex: list of subcontractors, shared resources, and contact information for material suppliers to order supplies
Breakdown of risk categories	Decision	The project manager must decide how much of each of the resource categories (labor, materials, and equipment) are needed for each task. Ex: Labor: Assigning subcontractors, number of workers, and the complication of each task Materials: Lumber, steel, cement, piping, drywall, and screws Equipment: Rental equipment, cranes, scissor lift, forklift, and bobcat
Max. and min. delay times	Uncertainty	The estimated maximum and minimum delay times for each task in days. A negative time means the project will be completed faster than expected while a positive time means a delay occurs. Ex: Minimum – -1 days, Maximum – 15 days
Probability of delay happening	Uncertainty	The estimated likelihood of a delay occurring. This is usually based on the project manager's experience with delays for each task. Ex: Event Occurs – 50%, 65%, 80%
Predicted delay	Calculated Uncertainty	The predicted delay for each task, calculated from the likelihood of the delay occurring and the minimum /maximum delay times. Ex: Total Delay - 3 days
Critical path change	Value measure	Input the delays for each task or activity within the original project schedule using the critical path method to determine if the critical path changes. Ex: Task 1 -> Task 3 -> Task 6 -> Task 8 -> Task 9 ->Task 10

4.3 Interviews with SME-s

Before preparing the analytical model for the analysis of the research, we realized interviews with five SME s from different companies, with different years of experience and with involvement in different fields of industry. The method we used to inform them regarding the consent and the questions of the interview was through an email. We have put a copy of the consent and full interview in Appendixes A and B, respectively.

The questions of the inteviews were divided into two categories, demografic and project information. The demografic questions were focused on infromations regarding the SME experience, including the length of their experience, their current job title, the total amount of cost and duration for the actual project and the category of the industry they were currently working on.

In total, the Project Managers interviewed have an experience of 71 years and job titles ranging from Assistant Project Manager to Owner of Contracting Company. This is very important, as it helps see the reaction to the analytical model from different points of view within the firm. As seen from the table, the categories of industries in which the SME s are involved are also different, ranging from residential, commercial, warehouse, healthcare and gaming and hospitality. In total, the length of projects they are currently working is 15 years and the total cost reaches $905,000,000.

In the second part of the interview, we asked the project managers to provide information regarding the methods they currently use to analyse and manage the risks related with resource allocation. So, they were asked on how they manage this category of risks, what type of risks they face in their job mostly, how confident they feel in manging the risks and defining their occurrence probabilities, the method they use to identify risks, how pleased they are with their method and finally if they see benefitial for their company our research and if they were ready to apply it to their companies. The information we gathered from their responses is shown in table below.

__Table 2.__ Project related questions and responses of SME-s

Question	Project Manager nr.1	Project Manage r nr.2	Project Manager nr.3	Project Manager nr.4	Project Manager nr.5
Current method for risk management	Personal Experienc e	Microsof t Excel	Microsoft Excel, Senior professionals	Microsoft Project	Oracle Primaver 6
Type of risks managed	Material risks, finantial, and security	Personne l risks, logistics, and safety	Personnel shortages from subcontractors, resources management	Injuries and personnel shortages	Safety, materials
Confidence level for risk management and probabilities	7/10	4/10	3/10	6/10	4/10
Pleased with the current method?	Yes	No	Yes	No	No
Is this study benefitial for your firm?	Useful if combined with experience	Somewh at useful	Useful because different risk categories can be added	Useful because its results are closer to reality	Useful if probabilities are assigned correctly
Would you apply this	Yes	Yes	No	Yes	Yes

model at your firm?	

As seen from the SME-s responses, the need that the analytical model is user friendly is very important, because their confidence in assigning probabilities of risks is low (4-7). Also, their will to use this analytical model in their firms is motivative for us to develop it and make it usable.

4.4 Data Collection

As mentioned before, the five SMEs chosen to be interviewed were firstly communicated through email in order to be asked to provide information regarding the project they were working on. The model we are going to build in Excel was to be verified in a real project, therefore we asked this information from SME-s. Except for the information for the project, we asked from the managers to provide with their contact information, so a follow up interview could be realized with them, so that they could try the model and verify its usefulness.

Our research aim is a design build project, so only one project provided by the managers fulfilled this requirement. This project was provided by the third SME and it represented the construction of a five-star hotel from the beginning, located in Rinas, Kruje. The original Project Schedule is shown in Appendix 1; it is originally produced in Microsoft Project.

The building is a one and four story commercial residential building without underground parking level. It is built to serve as a 5-star hotel consisting of different types of rooms: barrier-free room, double room, double-deluxe room, family room, long-stay room and suite. The total built area is 9000 square meters with an original timeline of 443 days. According to the original schedule, the start date is 29 January of 2019 and the finish date 22 July 2020. The total number of tasks is 617 and a part of the tasks is shown in (*Figure 9)*

D		Task Mode	Task Name	Duration	Start	Finish
1			**MK Hotel Tirana**	**447 days?**	**Tue 1/29/19**	**Wed 7/22/20**
2			Presenting of Design; construction documents	1 day?	Fri 3/15/19	Fri 3/15/19
3			preliminary building permit	1 day?	Tue 3/26/19	Tue 3/26/19
4			**Tender procedures**	**371 days?**	**Tue 1/29/19**	**Wed 4/8/20**
5			**Tender temporaly site works**	**39 days?**	**Tue 1/29/19**	**Mon 3/25/19**
6			Preparation of tender documens escavation	10 days	Tue 1/29/19	Tue 2/12/19
7			Inviting of bidders	2 days	Tue 2/12/19	Thu 2/14/19
8			Oferring process	7 days	Thu 2/14/19	Mon 2/25/19
9			Negotiation prices works materials	14 days	Mon 2/25/19	Fri 3/15/19
10			Negotiation of contract	5 days	Fri 3/15/19	Fri 3/22/19
11			Signing of contract for escavation works	1 day?	Fri 3/22/19	Mon 3/25/19
12			**Tender temporaly elektrical works**	**39 days?**	**Thu 2/21/19**	**Sat 4/13/19**
13			Preparation of tender documens escavation	10 days	Thu 2/21/19	Thu 3/7/19
14			Inviting of bidders	2 days	Thu 3/7/19	Mon 3/11/19
15			Oferring process	7 days	Mon 3/11/19	Wed 3/20/19
16			Negotiation prices works materials	14 days	Wed 3/20/19	Sun 4/7/19
17			Negotiation of contract	5 days	Sun 4/7/19	Fri 4/12/19
18			Signing of contract for escavation works	1 day?	Fri 4/12/19	Sat 4/13/19
19			**Tender escavation works**	**41 days?**	**Wed 2/13/19**	**Tue 4/9/19**
20			Preparation of tender documens escavation	10 days	Wed 2/13/19	Wed 2/27/19
21			Inviting of bidders	2 days	Wed 2/27/19	Fri 3/1/19
22			Oferring process	7 days	Fri 3/1/19	Tue 3/12/19
23			Negotiation prices works materials	14 days	Tue 3/12/19	Mon 4/1/19
24			Negotiation of contract	7 days	Mon 4/1/19	Mon 4/8/19
25			Signing of contract for escavation works	1 day?	Mon 4/8/19	Tue 4/9/19
26			**Tender rough structure**	**60 days?**	**Mon 2/4/19**	**Sun 4/21/19**
27			Preparation of tender documens rought structure	10 days	Mon 2/4/19	Mon 2/18/19
28			Inviting of bidders	2 days	Mon 2/18/19	Wed 2/20/19
29			Oferring process	10 days	Wed 2/20/19	Wed 3/6/19

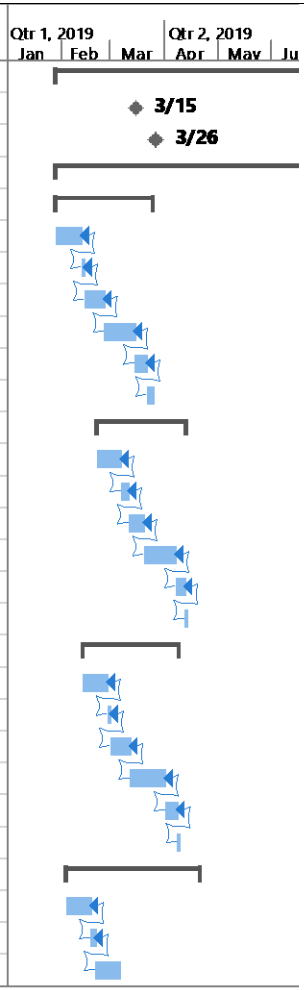
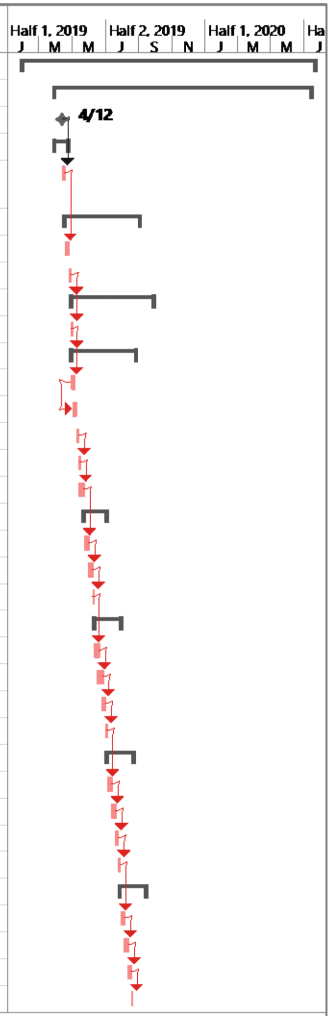


Figure 9 Original Project Schedule (tasks 1-29)

The original schedule built in Microsoft Project has some advantages, because from there a project manager can easily find out the remaining tasks of the project, but also get the critical path of the project through the Critical Path Method. The critical path of the project is shown in (Figure 10).

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1			**MK Hotel Tirana**	**447 days?**	**Tue 1/29/19**	**Wed 7/22/20**		
194			**Site works**	**400 days?**	**Thu 3/28/19**	**Wed 7/15/20**		
195			building permit	1 day?	Fri 4/12/19	Fri 4/12/19		
196			**Temporary works / site organization**	**24 days**	**Thu 3/28/19**	**Mon 4/22/19**		
201			Excavation of top soil only building area and temporay roads	3 days	Sat 4/13/19	Mon 4/15/19	200,195	
207			**Escavation works**	**140 days**	**Tue 4/16/19**	**Mon 9/2/19**		
208			Escavation	7 days	Tue 4/16/19	Mon 4/22/19	3,201	
209			backfilling with gravel level of foundation	5 days	Wed 4/24/19	Sun 4/28/19	468FS-1 day	
213			**Rough structure**	**154 days**	**Sun 4/28/19**	**Sat 9/28/19**	**209FS-1 day**	
214			blinding concrete	2 days	Sun 4/28/19	Mon 4/29/19	209FS-1 day	
215			**Rough structure up to ground level**	**119 days**	**Tue 4/30/19**	**Mon 8/26/19**	**214**	
216			formwork for foundation slab	5 days	Tue 4/30/19	Sat 5/4/19	214	
217			reinforcement 1st level of foundation slab	6 days	Thu 5/2/19	Tue 5/7/19	216SS+2 days	
218			reinforcement upper level of foundation slab	6 days	Wed 5/8/19	Mon 5/13/19	469FS-1 day	
219			concrete for foundation slab	2 days	Tue 5/14/19	Wed 5/15/19	218	
221			columns up to level 1 between axes A-O and 1-8	8 days	Tue 5/14/19	Tue 5/21/19	219FS-2 days	
229			**Rough structure up to level 1 +4,90**	**44 days**	**Wed 5/22/19**	**Thu 7/4/19**		
230			formwork for slab at level 1	10 days	Wed 5/22/19	Fri 5/31/19	221	
231			reinforcement of slab level 1 incl. staircase	8 days	Thu 5/30/19	Thu 6/6/19	230FS-2 days	
232			Concrete for slab at level 1 incl. staircase	2 days	Fri 6/7/19	Sat 6/8/19	231	
235			**Rough structure up to level 2 +8,40**	**50 days**	**Mon 6/10/19**	**Mon 7/29/19**		
237			walls up to level 2	9 days	Tue 6/11/19	Wed 6/19/19	232FS+2 days	
238			formwork for slab at level 2	10 days	Sun 6/16/19	Tue 6/25/19	236FS-4 days,23	
239			reinforcement of slab level 2 incl. staircase	8 days	Mon 6/24/19	Mon 7/1/19	238FS-2 days	
240			Concrete for slab at level 2 incl. staircase	2 days	Tue 7/2/19	Wed 7/3/19	239	
242			**Rough structure up to level 3 +11,90**	**50 days**	**Thu 7/4/19**	**Thu 8/22/19**		
244			walls up to level 3	9 days	Fri 7/5/19	Sat 7/13/19	240FS+1 day	
245			formwork for slab at level 3	10 days	Wed 7/10/19	Fri 7/19/19	243FS-4 days,24	
246			reinforcement of slab level 3 incl. staircase	8 days	Thu 7/18/19	Thu 7/25/19	245FS-2 days	
247			Concrete for slab at level 3incl. staircase	2 days	Fri 7/26/19	Sat 7/27/19	246	
249			**Rough structure up to the roof +15,40**	**50 days**	**Sun 7/28/19**	**Sun 9/15/19**		
251			walls up to the roof	9 days	Mon 7/29/19	Tue 8/6/19	247FS+1 day	
252			formwork for slab at the roof	10 days	Sat 8/3/19	Mon 8/12/19	250FS-4 days,25	
253			reinforcement of roof slab	8 days	Sun 8/11/19	Sun 8/18/19	252FS-2 days	
254			Concrete for roof slab incl. staircase	2 days	Mon 8/19/19	Tue 8/20/19	253	



ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
256		dismantling of formwork	5 days	Wed 9/11/19	Sun 9/15/19	254FS+21 days	
257		**Masonry**	**61 days**	**Tue 7/30/19**	**Sat 9/28/19**		
261		Masonry Level 3	15 days	Sat 9/14/19	Sat 9/28/19	256FS-2 days	
264		**Finishing works**	**324 days?**	**Sat 6/8/19**	**Tue 7/7/20**		
301		**Fasade**	**125 days**	**Sat 7/27/19**	**Tue 12/10/19**		
308		**windows**	**107 days**	**Sat 7/27/19**	**Thu 11/14/19**		
311		windows fasade Nort - East	15 days	Fri 9/27/19	Fri 10/11/19	303,261FS-2 day	
312		windows fasade South - East	12 days	Sat 10/12/19	Wed 10/23/19	261,304,311	
313		windows fasade Nort - West	9 days	Thu 10/24/19	Fri 11/1/19	261,305,312	
314		windows fasade South - West	9 days	Mon 11/4/19	Thu 11/14/19	306,261,313	
341		**Dry walls**	**62 days**	**Fri 11/15/19**	**Mon 2/10/20**		
345		dry walls Level 3 structure and unilaterally gypsymboard	8 days	Fri 11/15/19	Tue 11/26/19	487,491,314	
349		dry walls Level 3 closing with gypsymboard and preparing for painting	15 days	Wed 12/18/19	Tue 1/7/20	438,459,495,506	
350		**Ceilings**	**103 days**	**Wed 1/15/20**	**Fri 6/5/20**		
352		Ceiling at level 1	20 days	Wed 3/11/20	Tue 4/7/20	576,353	
353		Ceiling at level 2	20 days	Wed 2/12/20	Tue 3/10/20	577,354	
354		Ceiling at level 3	20 days	Wed 1/15/20	Tue 2/11/20	578	
357		**acoustic layer**	**43 days**	**Wed 2/12/20**	**Fri 4/10/20**		
358		acoustic layer level 1	3 days	Wed 4/8/20	Fri 4/10/20	352	
361		**screed**	**66 days**	**Thu 2/13/20**	**Thu 5/14/20**		
365		screed in level 1 rooms and coridors	5 days	Thu 4/9/20	Wed 4/15/20	358FS-2 days	
368		**waterproofing in bathrooms**	**63 days**	**Thu 2/27/20**	**Mon 5/25/20**		
370		waterproofing in bathrooms level 1	4 days	Thu 4/23/20	Tue 4/28/20	365FS+5 days	
373		**Wall tiles**	**131 days**	**Tue 12/24/19**	**Tue 6/23/20**		
376		Wall tiles level 1	20 days	Thu 4/30/20	Wed 5/27/20	370FS+1 day	
379		**Floor tiles**	**69 days**	**Thu 3/19/20**	**Tue 6/23/20**		
382		Floor tiles level 1 rooms and servise rooms	10 days	Thu 5/14/20	Wed 5/27/20	376SS+10 days	
389		**painting**	**65 days**	**Fri 3/20/20**	**Thu 6/18/20**		
391		painting rooms and coridors level 1	15 days	Fri 5/15/20	Thu 6/4/20	382SS+1 day,352	
397		**Doors**	**75 days**	**Thu 3/19/20**	**Wed 7/1/20**		
400		Doors for rooms level 1	10 days	Thu 6/4/20	Wed 6/17/20	391FS-1 day	
404		**Vinil Floring**	**58 days**	**Fri 4/17/20**	**Tue 7/7/20**		
407		Vinil level 1	8 days	Tue 6/16/20	Thu 6/25/20	400FS-2 days,49	
460		**Electrical works**	**371 days**	**Mon 4/22/19**	**Tue 7/7/20**		
467		**Electrical distribution network 0.4kV**	**363 days**	**Mon 4/22/19**	**Thu 6/25/20**		
468		grounding works stainless stell mesh	3 days	Mon 4/22/19	Wed 4/24/19	208FS-1 day	
469		Graunding works in foundation level	2 days	Tue 5/7/19	Wed 5/8/19	217FS-1 day	
495		Panels and cabeling dry walls Level 3	15 days	Wed 11/27/19	Tue 12/17/19	345	
564		**HVaC works**	**286 days**	**Fri 7/12/19**	**Wed 7/1/20**		
569		Horisontal ducts level 3	8 days	Wed 11/27/19	Fri 12/6/19	345,565	
574		horizontal distribution pipe network in level 3 incl. test	10 days	Wed 12/4/19	Tue 12/17/19	569SS+5 days,34	
578		Instalation and conection of FCU in Level 3	7 days	Mon 1/6/20	Tue 1/14/20	349FS-2 days	
611		**Furniture**	**58 days**	**Tue 4/28/20**	**Thu 7/16/20**		
613		Furniture level 1	10 days	Tue 6/23/20	Mon 7/6/20	407FS-3 days	
616		**Comisioning**	**20 days**	**Tue 6/23/20**	**Mon 7/20/20**	613SS	
617		**Optaining of permit**	**2 days**	**Tue 7/21/20**	**Wed 7/22/20**	616	

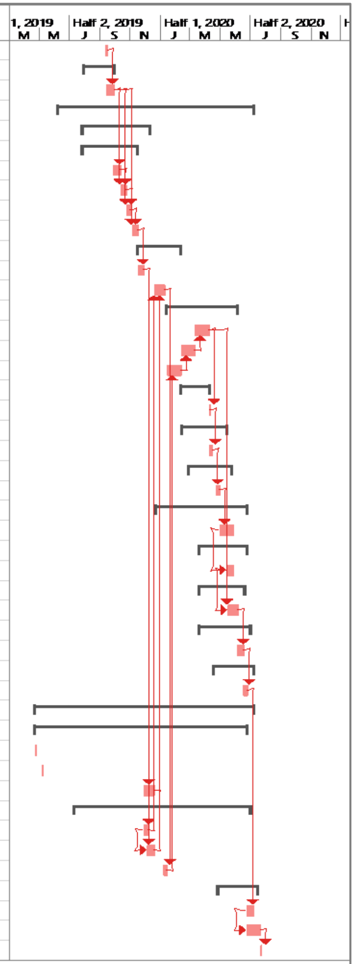


Figure 10 Critical Path of the original schedule

4.5 Data Analysis

The logical model we will construct will utilize the Microsoft Excel Software, along with include programming called Polisade @Risk to run the Monte Carlo Simulation. The model will incorporate two tabs inside an Excel exercise manual. The main tab will be named Model Results, where we will show the deferrals for each assignment along with the complete number of postponements for the undertaking. The subsequent tab will be entitled Risk Calculations, and this is the place where the examination will be made.

The model we are going to build will first have a color-coding system, which we will show at the Risk Calculations tab through a legend. This color-coding system will make it easier for the Project Manager to understand the model and use it. The system of colors we are creating will have a total number of 6 colors, as shown in *(Figure 11)*.

Legend
Input
Calculation
Objective
Input from MS Project
Constant
Average no. of delays

Figure 11 Legend of Color-coding system for the analytical model

The six colors we have used include the dark red color, the orange, light red, grey white and dark orange. The dark red color is showing the input values that the project manager must fill manually according to his experience. These values are to be put in four columns: probability of delay occurring or P [True], the minimum delay, the maximum delay and total number of delays of each task in an output table, for each of resource categories: labor, material and equipment.

The orange color represents the calculated values, which are calculated automatically after the input values are filled by the project manager. The calculated values will be put in four columns: the probability of event not occurring or P [false]

Event Occurrence, which is the statistical distribution for each risk category, Average Delay which means the statistical distribution of the average delay, and the Delay time which is the total delays.

The light red color represents the objective of the function that means the total number of delays for each task.

The grey color shows the input values taken from Microsoft Project, respectively the Task number, task name and duration.

The dark orange color represents the total and average number of delays calculated by the Monte Carlo simulation. While the white color is a constant value which doesn’t change for every task. The firs constant column is the one showing the task number and task name, while the second one is the columns showing the values of True and False. So, if the delay probability is False, it will have the value of 0, while if it is True, its value will be 1. In the *Figure 12* we will use the model that will be repeated for every task.

Task Number			Event Chance Calculation (Discrete/Bernoulli Distribution)				Monte Carlo Distibutions	Delay Calculation (Triangular Distribution)			Monte Carlo Distibutions	Delay Occurrence	Objective
Task Number	Duration	Task Name	FALSE	TRUE	P[False]	P[True]	Event Occurrence	Minimum	Base	Maximum	Average Delay	Delay Time	Delay Time per task
195	1	Building Permit											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	0%	100%	1	0	0	0	0	0	0
		Material	0	1	100%	0%	0	0	0	0	0	0	0
		Total				100%							0
201	3	Excavation of top soil only building area and temporay roads											
		Equipment	0	1	0%	100%	1	-5	0	10	1.666666667	1.666666667	1.666666667
		Labor	0	1	100%	0%	0	0	0	0	0	0	0
		Material	0	1	100%	0%	0	0	0	0	0	0	0
		Total				100%							1.666666667
208	7	Escavation											
		Equipment	0	1	10%	90%	1	-5	0	10	1.666666667	1.666666667	1.666666667
		Labor	0	1	90%	10%	0	-5	0	10	1.666666667	0	0
		Material	0	1	100%	0%	0	0	0	0	0	0	0
		Total				90%							1.666666667
209	5	Backfilling with gravel level of foundation											
		Equipment	0	1	40%	60%	1	-5	0	8	1	1	1
		Labor	0	1	80%	20%	0	-3	0	3	0	0	0
		Material	0	1	80%	20%	0	-2	0	3	0.333333333	0	0
		Total				60%							1
214	2	Blinding concrete											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	20%	80%	1	-2	0	2	0	0	0
		Material	0	1	80%	20%	0	-2	0	3	0.333333333	0	0
		Total				80%							0
216	5	Formwork for foundation slab											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	5	1	1	1
		Material	0	1	60%	40%	0	-4	0	1	-1	0	0
		Total				60%							1
217	6	Reinforcement 1st level of foundation slab											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
218	6	Reinforcement upper level of foundation slab											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0

		Total				60%							0.333333333
219	2	Concrete for foundation slab											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
221	8	Columns up to level 1 between axes A-O and 1-8											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
230	10	Formwork for slab at level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
231	8	Reinforcement of slab level 1 incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
232	2	Concrete for slab at level 1 incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
237	9	Walls up to level 2											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
238	10	Formwork for slab at level 2											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
239	8	Reinforcement of slab level 2 incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
240	2	Concrete for slab at level 2 incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333

		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
244	9	Walls up to level 3											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
245	10	Formwork for slab at level 3											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
246	8	Reinforcement of slab level 3 incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
247	2	Concrete for slab at level 3incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
251	9	Walls up to the roof											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
252	10	Formwork for slab at the roof											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
253	8	Reinforcement of roof slab											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
254	2	Concrete for roof slab incl. staircase											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	40%	60%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	60%	40%	0	-4	0	2	-0.666666667	0	0
		Total				60%							0.333333333
256	5	Dismantling of formwork											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0

		Labor	0	1	0%	100%	1	-3	0	4	0.333333333	0.333333333	0.333333333
		Material	0	1	100%	0%	0	0	0	0	0	0	0
		Total				100%							0.333333333
261	15	Masonry Level 3											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	30%	70%	1	-5	0	7	0.666666667	0.666666667	0.666666667
		Material	0	1	70%	30%	0	-2	0	1	-0.333333333	0	0
		Total				70%							0.666666667
311	15	Windows fasade Nort - East											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	80%	20%	0	-3	0	5	0.666666667	0	0
		Material	0	1	20%	80%	1	-1	0	10	3	3	3
		Total				80%							3
312	12	Windows fasade South - East											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	80%	20%	0	-3	0	5	0.666666667	0	0
		Material	0	1	20%	80%	1	-1	0	10	3	3	3
		Total				80%							3
313	9	Windows fasade Nort - West											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	80%	20%	0	-3	0	5	0.666666667	0	0
		Material	0	1	20%	80%	1	-1	0	10	3	3	3
		Total				80%							3
314	9	Windows fasade South - West											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	80%	20%	0	-3	0	5	0.666666667	0	0
		Material	0	1	20%	80%	1	-1	0	10	3	3	3
		Total				80%							3
345	8	Dry walls Level 3 structure and unilaterally gypsymboard											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	10	1.666666667	1.666666667	1.666666667
		Material	0	1	50%	50%	0	0	0	10	3.333333333	0	0
		Total				50%							1.666666667
349	15	Dry walls Level 3 closing with gypsymboard and preparing for painting											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	7	0.666666667	0.666666667	0.666666667
		Material	0	1	50%	50%	0	0	0	10	3.333333333	0	0
		Total				50%							0.666666667
352	20	Ceiling at level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	7	0.666666667	0.666666667	0.666666667
		Material	0	1	50%	50%	0	0	0	10	3.333333333	0	0
		Total				50%							0.666666667
353	20	Ceiling at level 2											

		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	7	0.666666667	0.666666667	0.666666667
		Material	0	1	50%	50%	0	0	0	10	3.333333333	0	0
		Total				50%							0.666666667
354	20	Ceiling at level 3											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	7	0.666666667	0.666666667	0.666666667
		Material	0	1	50%	50%	0	0	0	10	3.333333333	0	0
		Total				50%							0.666666667
358	3	Acoustic layer level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	100%	0%	0	0	0	0	0	0	0
		Material	0	1	0%	100%	1	0	0	7	2.333333333	2.333333333	2.333333333
		Total				100%							2.333333333
365	5	Screed in level 1 rooms and coridors											
		Equipment	0	1	60%	40%	1	0	0	2	0.666666667	0.666666667	0.666666667
		Labor	0	1	70%	30%	0	-4	0	6	0.666666667	0	0
		Material	0	1	70%	30%	0	0	0	3	1	0	0
		Total				40%							0.666666667
370	4	Waterproofing in bathrooms level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	60%	40%	0	-5	0	4	-0.333333333	0	0
		Material	0	1	40%	60%	1	0	0	5	1.666666667	1.666666667	1.666666667
		Total				60%							1.666666667
376	20	Wall tiles level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	30%	70%	1	-5	0	10	1.666666667	1.666666667	1.666666667
		Material	0	1	70%	30%	0	0	0	10	3.333333333	0	0
		Total				70%							1.666666667
382	10	Floor tiles level 1 rooms and servise rooms											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	30%	70%	1	-5	0	10	1.666666667	1.666666667	1.666666667
		Material	0	1	70%	30%	0	0	0	10	3.333333333	0	0
		Total				70%							1.666666667
391	15	Painting rooms and coridors level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	0%	100%	1	-3	0	4	0.333333333	0.333333333	0.333333333
		Material	0	1	100%	0%	0	0	0	0	0	0	0
		Total				100%							0.333333333
400	10	Doors for rooms level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	80%	20%	0	-2	0	4	0.666666667	0	0
		Material	0	1	20%	80%	1	0	0	10	3.333333333	3.333333333	3.333333333
		Total				80%							3.333333333

407	8	Vinil level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	60%	40%	0	-4	0	3	-0.333333333	0	0
		Material	0	1	40%	60%	1	0	0	5	1.666666667	1.666666667	1.666666667
		Total				60%							1.666666667
468	3	Grounding works stainless stell mesh											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	30%	70%	1	-2	0	2	0	0	0
		Material	0	1	70%	30%	0	-2	0	3	0.333333333	0	0
		Total				70%							0
469	2	Graunding works in foundation level											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	30%	70%	1	-2	0	3	0.333333333	0.333333333	0.333333333
		Material	0	1	70%	30%	0	-2	0	3	0.333333333	0	0
		Total				70%							0.333333333
495	15	Panels and cabeling dry walls Level 3											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	6	0.333333333	0.333333333	0.333333333
		Material	0	1	50%	50%	0	0	0	3	1	0	0
		Total				50%							0.333333333
569	8	Horisontal ducts level 3											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	60%	40%	0	-5	0	6	0.333333333	0	0
		Material	0	1	40%	60%	1	0	0	3	1	1	1
		Total				60%							1
574	10	Horizontal distribution pipe network in level 3 incl. test											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	6	0.333333333	0.333333333	0.333333333
		Material	0	1	50%	50%	0	0	0	3	1	0	0
		Total				50%							0.333333333
578	7	Instalation and conection of FCU in Level 3											
		Equipment	0	1	70%	30%	0	0	0	0	0	0	0
		Labor	0	1	60%	40%	0	-5	0	6	0.333333333	0	0
		Material	0	1	40%	60%	1	0	0	3	1	1	1
		Total				60%							1
613	10	Furniture level 1											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	50%	50%	1	-5	0	6	0.333333333	0.333333333	0.333333333
		Material	0	1	50%	50%	0	0	0	3	1	0	0
		Total				50%							0.333333333
616	20	Comisioning											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	0%	100%	1	0	0	10	3.333333333	3.333333333	3.333333333
		Material	0	1	100%	0%	0	0	0	0	0	0	0

		Total				100%							3.333333333
617	2	Optaining of permit											
		Equipment	0	1	100%	0%	0	0	0	0	0	0	0
		Labor	0	1	0%	100%	1	0	0	10	3.333333333	3.333333333	3.333333333
		Material	0	1	100%	0%	0	0	0	0	0	0	0
		Total				100%							3.333333333
		Total Average Delay											52.33333333

Figure 12 Applied model for our case study

The steps that a project manager must follow to analyse risks are shown in figure 13.

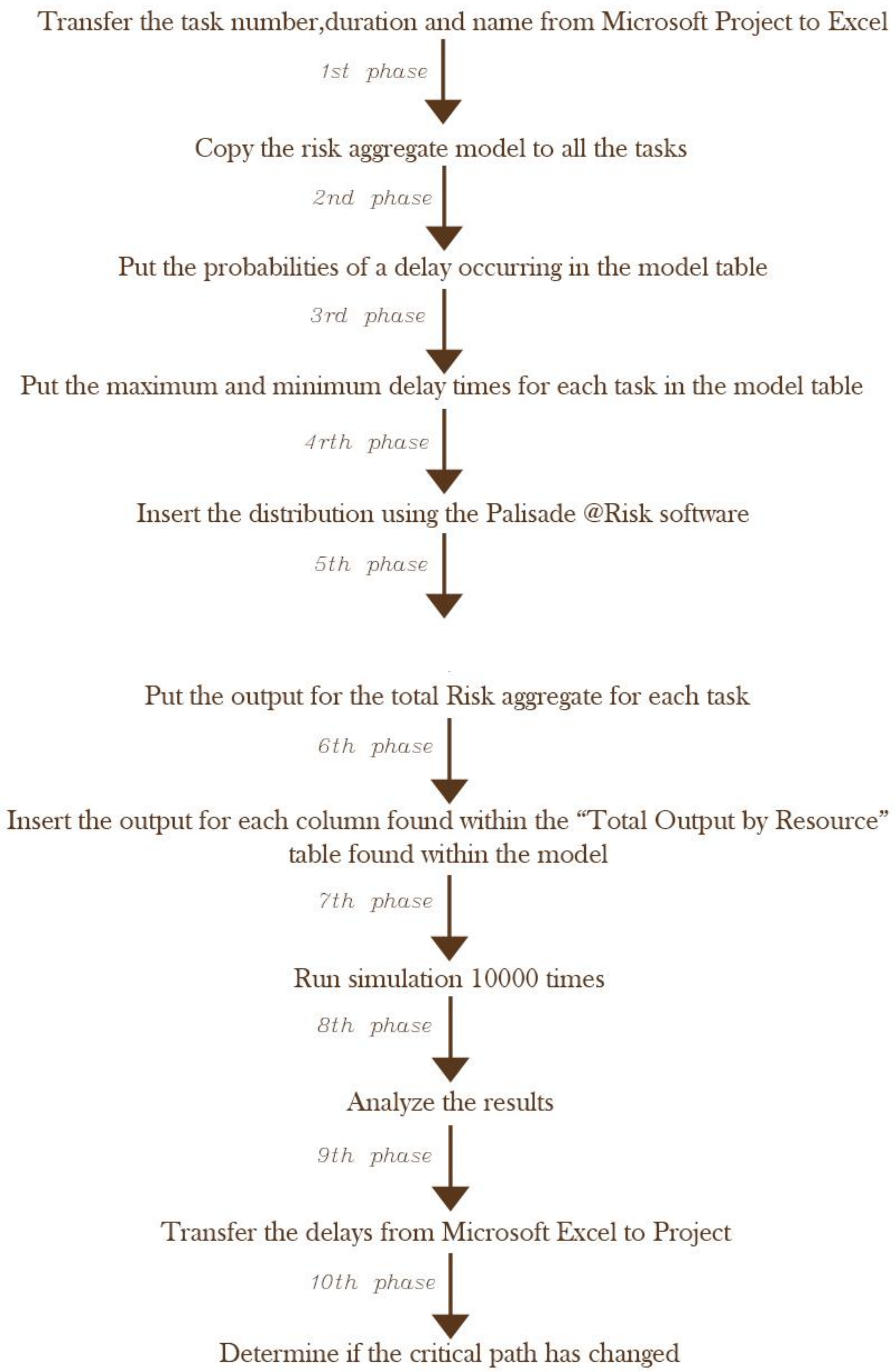


Figure 13 Steps that a project manager follows to analyze risks

4.6 Model Verification

Before the analysis is conducted, the model will be verified using another verified and validated project. So, the verification is made using the analsysis from research team of [17] which used the PERT method to identify and calculate the critical path. The tasks of the analyzed project and duration of them is shown in *table 2*.

The visual representation of the analyzed project from Wang and Huang is shown in *Figure 12*. As we can see from the visual representation, the critical path of the project is 1-3-6-8 or B, F and J. As seen from *Figure 12*, the maximum duration of the project is 108 days and the minimum is 92, while the most likely duration is 100 days.

Table 3. Original Duration for each activity

Activity (i, j)	**Estimated Duration days**		
	Maximum	most likely	Minimum
A (1,2)	42	36	30
B (1,3)	44	40	36
C (1,4)	50	40	30
D (2,5)	50	40	30
E (2,6)	13	10	7
F (3,6)	42	40	38
G (4,6)	12	10	8
H (4,7)	44	32	20
I (5,8)	26	20	14
J (6,8)	22	20	18
K (7,8)	30	20	10

As we can see from the AOA, the used method from Wang and Huang is the PERT method to calculate the critical path.

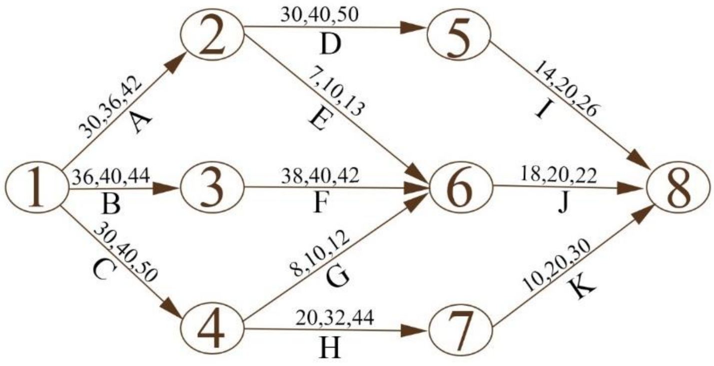


Figure 14 Original Activity-on-Arc (AOA) Diagram

After building the AOA, we will put the values of this model in Microsoft Project, as the model we are building uses the CPM algorithm. From the *Table 2*, we are taking only the most likely values, while the maximum and minimum durations are used in the analysis we will conduct. The schedule will be recreated using these most likely values and setting a starting date randomly. The software will automatically generate the dates for each task using the predecessors finish date and duration of each activity. The final form of the project schedule built in Microsoft Project is shown in *Figure 15*

	ⓘ	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			A(1,2)	36 days	Wed 12/13/17	Wed 1/31/18	
2			B(1,3)	40 days	Wed 12/13/17	Tue 2/6/18	
3			C(1,4)	40 days	Wed 12/13/17	Tue 2/6/18	
4			D(2,5)	40 days	Thu 2/1/18	Wed 3/28/18	1
5			E(2,6)	10 days	Thu 2/1/18	Wed 2/14/18	1
6			F(3,6)	40 days	Wed 2/7/18	Tue 4/3/18	2
7			G(4,6)	10 days	Wed 2/7/18	Tue 2/20/18	3
8			H(4,7)	32 days	Wed 2/7/18	Thu 3/22/18	3
9			I(5,8)	20 days	Thu 3/29/18	Wed 4/25/18	4
10			J(6,8)	20 days	Wed 4/4/18	Tue 5/1/18	5,6,7
11			K(7,8)	20 days	Fri 3/23/18	Thu 4/19/18	8

Figure 15 Project Schedule in Microsoft Project

After building the model in Microsoft Project, the next step of the model verification is that of transferring the data to the model we have created in Excel. The data that we have transferred include the task number, name and duration. The Whang and Huang model have not divided the risks into categories, therefore we have considered equipment as the only risk category causing delays, so the probability of delay occurring is 100 % for the equipment risk category, while for the other categories it is 0 %. The maximum and minimum delays are taken from the model of Whang and Huang, considering the maximum delay as the most pessimistic value of duration minus the most likely value, while the minimum delay is calculated as the most optimistic value minus the most likely one. We have copied the previous built excel model for each of the tasks as in figure 16.

Task Number			Event Chance Calculation (Discrete/Bernoulli Distribution)				Monte Carlo Distibutions	Delay Calculation (Triangular Distribution)			Monte Carlo Distibutions	Delay Occurrence	Objective
Task Number	**Duration**	**Task Name**	FALSE	TRUE	P[False]	P[True]	Event Occurrence	Minimum	Base	Maximum	Average Delay	Delay Time	Delay Time per task
1	36												
		Equipment	**0**	**1**	0%	100%	1	-6	**0**	6	0	0	0
		Labor	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Material	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Total											0
2	40	B(1,3)											
		Equipment	**0**	**1**	0%	100%	1	-4	**0**	4	0	0	0
		Labor	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Material	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Total											0
3	40	C(1,4)											
		Equipment	**0**	**1**	0%	100%	1	-10	**0**	10	0	0	0
		Labor	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Material	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Total											0
4	40	C(1,4)											
		Equipment	**0**	**1**	0%	100%	1	-10	**0**	10	0	0	0
		Labor	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Material	**0**	**1**	100%	0%	0	0	**0**	0	0	0	0
		Total											0

Figure 16 The analytical model for the first 4 tasks of the project

I order to find out if our model is valid, we simulated the values in Monte Carlo, in order to compare it to the results from Whang and Huang model. The calculations we made produced the minimum, maximum and average delays of the project, using several iterations of 10000 times. The results were used to see if the critical path changed from that calculated by the model. The way we used to compare the results was that of calculating the durations for each of the possible paths of the project, and see which of them has the longest duration, to define the critical path.

Table 4. Duration for each possible path

Possible Paths	Named Path	Duration	Average Delay	Min Delay	Max Delay
1 – 2 – 5 – 8	**A- D-I**	96	0	-21.83	21.81
1 – 3 – 6 – 8	**B-F-J**	100	0	-7.92	7.93
1 – 4 – 7 – 8	**C-H-K**	92	0	-31.64	31.72
1 - 2 – 6 – 8	**A-E-J**	66	0	-10.90	10.86
1 – 4 – 6 – 8	**C-G-J**	70	0	-13.83	13.84

As we can see from the calculated results from Monte carlo, the difference between maximum and minimum delay times is very small, avering to 0, thus proving that the most likely durations of activities are the ones from Whang and Huang model. Also, the critical path from the Monte Carlo calculations in our model is not changing, what means that our model is verified in this way.

4.7 Model Validation

The model we created does not only need to be verified but also validated through the use of a real project. The project we are using to validate the model is the

5-star hotel in Rinas, Tirane, part of the Tirana Bussines Park Complex. The schedule of the project contains a number of 617 tasks, so the analysis will be conducted only for the task included in the critical path of the schedule. As explained before, the model table is copied for each of the tasks and then the input values of it were filled by the project manager, dependeng on his experience.

According to the values filled by the project manager, the Monte Carlo simulation was then conducted for each of the values of average delays. The number of itarations in the Monte Carlo simulation was 10000 as given by the model from Whang and Huang. The final value of the average delay for each task is taken as a maximum of the delays caused by each of the resources: equipment, labour and material. In the table below are given the total averages for each task, as calculated by the Monte Carlo simulation.

Table 5. Average Durations for each of tasks

Task Number	**Task Name**	**Total Average Delay**
195	Building Permit	0
201	Excavation of top soil only building area and temporay roads	2
208	Escavation	2
209	Backfilling with gravel level of foundation	1
214	Blinding concrete	0
216	Formwork for foundation slab	1
217	Reinforcement 1st level of foundation slab	0
218	Reinforcement upper level of foundation slab	0
219	Concrete for foundation slab	0
221	Columns up to level 1 between axes A-O and 1-8	0
230	Formwork for slab at level 1	0
231	Reinforcement of slab level 1 incl. staircase	0
232	Concrete for slab at level 1 incl. staircase	0
237	Walls up to level 2	0
238	Formwork for slab at level 2	0
240	Concrete for slab at level 2 incl. staircase	0
244	Walls up to level 3	0

Task Number	Task Name	Total Average Delay
245	Formwork for slab at level 3	0
246	Reinforcement of slab level 3 incl. staircase	0
247	Concrete for slab at level 3incl. staircase	0
251	Walls up to the roof	0
252	Formwork for slab at the roof	0
253	Reinforcement of roof slab	0
254	Concrete for roof slab incl. staircase	0
256	Dismantling of formwork	0
261	Masonry Level 3	1
311	Windows fasade Nort - East	3
312	Windows fasade South - East	3
313	Windows fasade Nort - West	3
314	Windows fasade South - West	3
345	Dry walls Level 3 structure and unilaterally gypsymboard	3
349	Dry walls Level 3 closing with gypsymboard and preparing for painting	3
352	Ceiling at level 1	3
353	Ceiling at level 2	3
354	Ceiling at level 3	3
358	Acoustic layer level 1	2
365	Screed in level 1 rooms and coridors	1
370	Waterproofing in bathrooms level 1	2
376	Wall tiles level 1	2
382	Floor tiles level 1 rooms and servise rooms	3
391	Painting rooms and coridors level 1	0
400	Doors for rooms level 1	3
407	Vinil level 1	2
495	Panels and cabeling dry walls Level 3	1
569	Horisontal ducts level 3	1
574	Horizontal distribution pipe network in level 3 incl. test	0
578	Instalation and conection of FCU in Level 3	1
613	Furniture level 1	0
616	Comisioning	3
617	Optaining of permit	3

The total number of delays is the sum of delays for each task, which in this case is a total of 57 days. The calculated number of delays effects the whole project duaration, as long as the tasks calculated are in the critical path of the project.

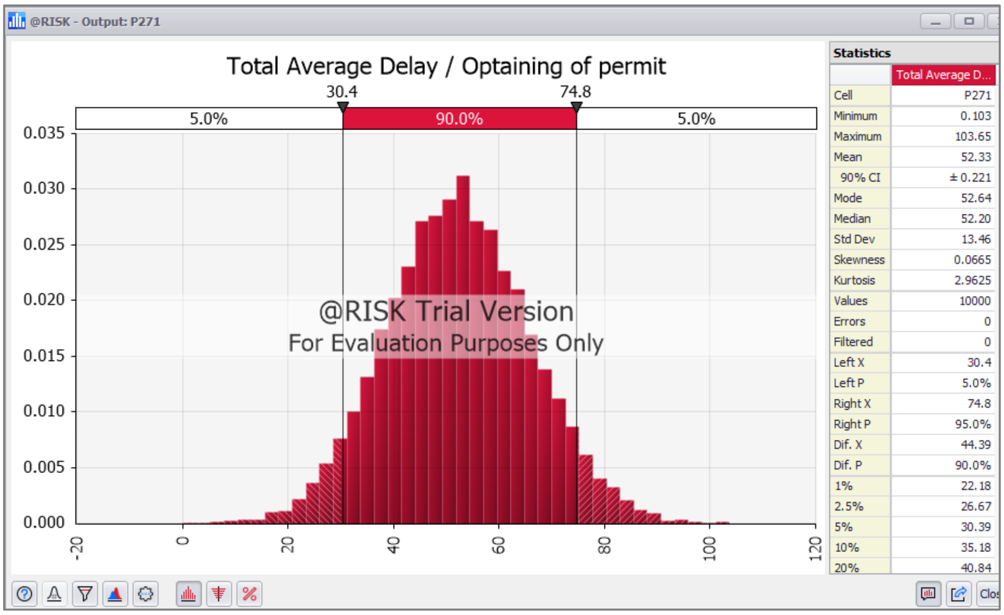


Figure 17. Total Average Delay, Probabilistic Distribution

From the Monte Carlo simulation and Palisade @Risk software, the project manager can get a number of charts and analysis diagrams. For example, if all the tasks of the project were included in the analysis, we could get a total number of delays for each of the resource categories, which could help in the risk mitigation plan of the project manager, because in that way he might be able to focus on the category causing the largest number of delays. However, from the tasks we have analysed, we get the average number of total delays diagram, where the project manager can see the minimum and maximum duration of the project.

As seen from the Probabilitstic Distribution of the total average delay, the mean value of the delays is about 52 days, while the minimum delay is 1 and the maximum 104 days. The delays distribution is 90 % between the values 30 and 75 days, what means that there is a probability of 90 % that the project will be completed within these values of delays.

Another chart that the project manger gets from the simulation is that of tornado diagram, which shows the number of effects that the input tasks have on the output of the project.

As seen from the Tornado Diagram, there are two tasks which are mostly affecting the output mean: Dry walls Level 3 structure with the risk aggregate of labor

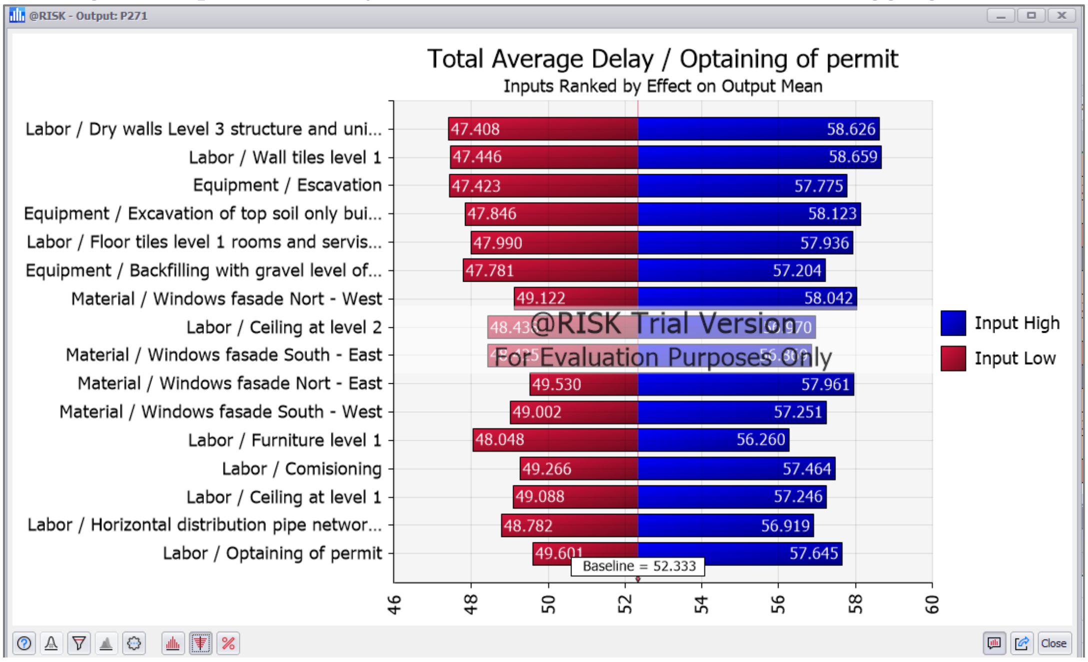


Figure 18. Total delay - Tornado diagram output Mean

and wall tiles level 1 with the risk aggregate of labor. Both of these tasks are causing an effect of 47 to 58 days to the output mean. Of the 16 tasks listed in the tornado diagram, 9 of them have the risk aggregate of labor, which is considered as normal, as long as during recent years Albania is experiencing a loss in the labor resources, because of the economic emigration. This diagram is considered to be very important in directing the project manager in focusing on these tasks for the risk mitigation plan.

Another diagram produced by the simulation is that of tornado diagram Contribution to variance, which shows the percentage of the effect of tasks on the output mean. The project manager can use in combination the first tornado diagram with this one, in order to better understand the effect of the tasks on the output mean and plan a strategy for managing them.

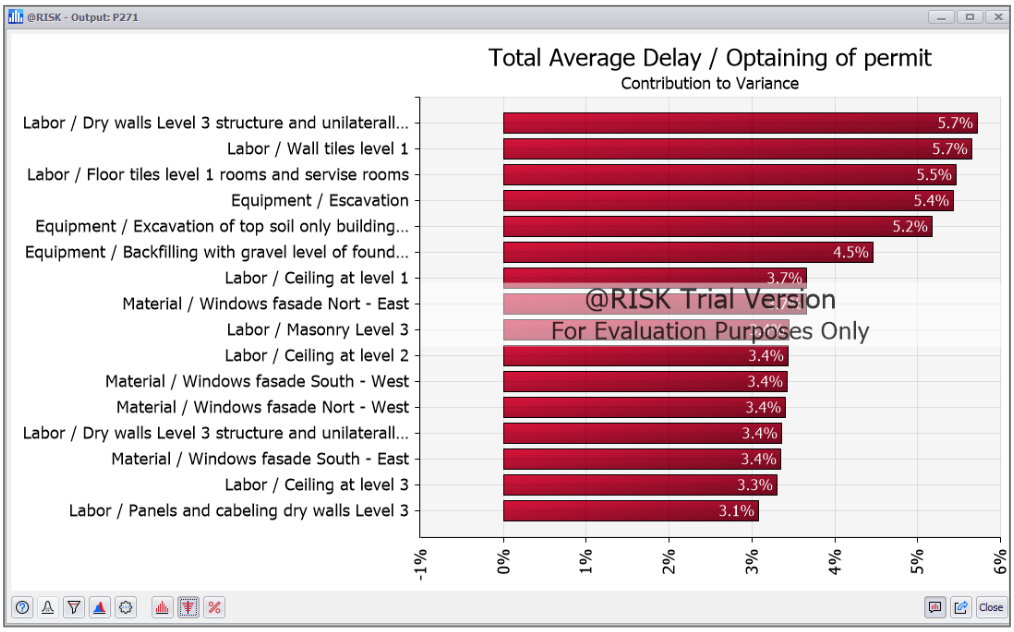


Figure 19. Total Delay, Tornado Diagram Contribution to Variance

From the Tornado Diagram Contribution to Variance, we can see that there are 16 tasks contributing mostly to the output, with the highest percentage of 5.7 % and the lowest of 3.1 %. Nine of the tasks have the risk aggregate of labor, thus directing the project manager for his risk mitigation plan. As the most difficult part of the risk mitigation strategy is that of identifying the risks and tasks contributing mostly to the final result of the project, the tornado diagrams play an important role in giving the project management team directives on this.

After the analysis has been conducted, the other step is inserting the calculated delays on the original project schedule in Microsoft Project and see how the final end date of the project will be changed according to the delays.

ID		Task Mode	Task Name	Duration	Start	Finish	Pr	Re Na	Critical
1									
2			**MK Hotel Tirana**	**504 days?**	**Mon 1/21/19**	**Thu 10/1/20**			**Yes**
3			Presenting of Design; construction documents	16 days?	Mon 1/21/19	Fri 3/15/19			No
4			preliminary building permit	6 days?	Mon 1/28/19	Tue 3/26/19			No
5			**Tender procedures**	**406 days?**	**Tue 1/29/19**	**Wed 5/27/20**			**No**
195			**Site works**	**435 days?**	**Thu 3/28/19**	**Wed 9/2/20**			**No**
196			building permit	1 day?	Fri 4/12/19	Fri 4/12/19			Yes
197			**Temporary works / site organization**	**26 days**	**Thu 3/28/19**	**Wed 4/24/19**			**No**
198			Temporary Fence along B05 and B07	5 days	Thu 3/28/19	Wed 4/3/19	4F		No
199			Demolution works bilboard; concrete foundtions	3 days	Wed 4/17/19	Fri 4/19/19	19		No
200			Temporary Fence on site	5 days	Tue 4/2/19	Sat 4/6/19	19		No
201			Temporary road in front of the site	3 days	Thu 4/4/19	Sat 4/6/19	19		No
202			Excavation of top soil only building area and temporay roads	5 days	Sat 4/13/19	Wed 4/17/19	20		Yes
203			Temporary road at the site	3 days	Thu 4/18/19	Sat 4/20/19	20		No
204			Temporary el power, cables, boards, lights	14 days	Sun 4/7/19	Sat 4/20/19	20		No
205			Car wash structure	4 days	Sun 4/21/19	Wed 4/24/19	20		No
206			Temporary containers for staff; supervisor	3 days	Sun 4/21/19	Tue 4/23/19	20		No
207			Temporary toilets	3 days	Sun 4/21/19	Tue 4/23/19	20		No
208			**Escavation works**	**143 days**	**Thu 4/18/19**	**Sat 9/7/19**			**Yes**
209			Escavation	9 days	Thu 4/18/19	Fri 4/26/19	4,		Yes
210			backfilling with gravel level of foundation	6 days	Sun 4/28/19	Fri 5/3/19	46		Yes
211			backfilling with gravel between foundations axes F-O and 8-14	5 days	Thu 5/23/19	Mon 5/27/19	22 da		No
212			backfilling with gravel between foundations up to ground level	7 days	Sat 7/20/19	Fri 7/26/19	23		No

Figure 20. New Project Schedule with the delays added for each task

In the Figure 20 is shown the new project schedule (a part of it), with the delays added as calculated by the Monte Carlo simulations. As the tasks we have calculated are all included in the critical path, they will all affect the duration of the whole project. The new critical path is shown in the figure below.

ID		Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	Critical
2			**MK Hotel Tirana**	**504 days?**	**Mon 1/21/19**	**Thu 10/1/20**			**Yes**
195			**Site works**	**435 days?**	**Thu 3/28/19**	**Wed 9/2/20**			**No**
196			building permit	1 day?	Fri 4/12/19	Fri 4/12/19			Yes
197			**Temporary works / site organization**	**26 days**	**Thu 3/28/19**	**Wed 4/24/19**			**No**
202			Excavation of top soil only building area and temporay roads	5 days	Sat 4/13/19	Wed 4/17/19	20		Yes
208			**Escavation works**	**143 days**	**Thu 4/18/19**	**Sat 9/7/19**			**Yes**
209			Escavation	9 days	Thu 4/18/19	Fri 4/26/19	4,		Yes
210			backfilling with gravel level of foundation	6 days	Sun 4/28/19	Fri 5/3/19	46		Yes
214			**Rough structure**	**155 days**	**Fri 5/3/19**	**Fri 10/4/19**	**21**		**Yes**
215			blinding concrete	2 days	Fri 5/3/19	Sat 5/4/19	21		Yes
216			**Rough structure up to ground level**	**119 days**	**Sun 5/5/19**	**Sat 8/31/19**	**21**		**Yes**
217			formwork for foundation slab	6 days	Sun 5/5/19	Fri 5/10/19	21		Yes
218			reinforcement 1st level of foundation slab	6 days	Tue 5/7/19	Sun 5/12/19	21		Yes
219			reinforcement upper level of foundation slab	6 days	Mon 5/13/19	Sat 5/18/19	47		Yes
220			concrete for foundation slab	2 days	Sun 5/19/19	Mon 5/20/19	21		Yes
222			columns up to level 1 between axes A-O and 1-8	8 days	Sun 5/19/19	Sun 5/26/19	22		Yes
230			**Rough structure up to level 1 +4,90**	**44 days**	**Mon 5/27/19**	**Tue 7/9/19**			**Yes**

ID		Task Mode	Task Name	Duration	Start	Finish	Pr	Resource Names	Critical
231			formwork for slab at level 1	10 days	Mon 5/27/19	Wed 6/5/19	22		Yes
232			reinforcement of slab level 1 incl. staircase	8 days	Tue 6/4/19	Tue 6/11/19	23		Yes
233			Concrete for slab at level 1 incl. staircase	2 days	Wed 6/12/19	Thu 6/13/19	23		Yes
236			**Rough structure up to level 2 +8,40**	**50 days**	**Sat 6/15/19**	**Sat 8/3/19**			**No**
238			walls up to level 2	9 days	Sun 6/16/19	Mon 6/24/19	23		Yes
239			formwork for slab at level 2	10 days	Fri 6/21/19	Sun 6/30/19	23		Yes
240			reinforcement of slab level 2 incl. staircase	8 days	Sat 6/29/19	Sat 7/6/19	23		Yes
241			Concrete for slab at level 2 incl. staircase	2 days	Sun 7/7/19	Mon 7/8/19	24		Yes
243			**Rough structure up to level 3 +11,90**	**50 days**	**Tue 7/9/19**	**Tue 8/27/19**			**No**
245			walls up to level 3	9 days	Wed 7/10/19	Thu 7/18/19	24		Yes
246			formwork for slab at level 3	10 days	Mon 7/15/19	Wed 7/24/19	24		Yes
247			reinforcement of slab level 3 incl. staircase	8 days	Tue 7/23/19	Tue 7/30/19	24		Yes
248			Concrete for slab at level 3incl. staircase	2 days	Wed 7/31/19	Thu 8/1/19	24		Yes
250			**Rough structure up to the roof +15,40**	**50 days**	**Fri 8/2/19**	**Fri 9/20/19**			**No**
252			walls up to the roof	9 days	Sat 8/3/19	Sun 8/11/19	24		Yes
253			formwork for slab at the roof	10 days	Thu 8/8/19	Sat 8/17/19	25		Yes
254			reinforcement of roof slab	8 days	Fri 8/16/19	Fri 8/23/19	25		Yes
255			Concrete for roof slab incl. staircase	2 days	Sat 8/24/19	Sun 8/25/19	25		Yes
257			dismantling of formwork	5 days	Mon 9/16/19	Fri 9/20/19	25		Yes
258			**Masonry**	**62 days**	**Sun 8/4/19**	**Fri 10/4/19**			**No**
262			Masonry Level 3	16 days	Thu 9/19/19	Fri 10/4/19	25		Yes
265			**Finishing works**	**358 days?**	**Thu 6/13/19**	**Mon 8/31/20**			**No**
302			**Fasade**	**137 days**	**Fri 8/2/19**	**Fri 1/3/20**			**No**
309			**windows**	**119 days**	**Fri 8/2/19**	**Tue 12/10/19**			**No**
312			windows fasade Nort - East	18 days	Thu 10/3/19	Sun 10/20/19	30		Yes
313			windows fasade South - East	15 days	Mon 10/21/19	Wed 11/6/19	26		Yes
314			windows fasade Nort - West	12 days	Thu 11/7/19	Fri 11/22/19	26		Yes
315			windows fasade South - West	12 days	Mon 11/25/19	Tue 12/10/19	30		Yes
342			**Dry walls**	**65 days**	**Wed 12/11/19**	**Tue 3/10/20**			**Yes**
346			dry walls Level 3 structure and unilaterally gypsymboard	11 days	Wed 12/11/19	Wed 12/25/19	48		Yes
350			dry walls Level 3 closing with gypsymboard and preparing for painting	18 days	Fri 1/17/20	Tue 2/11/20	43		Yes
351			**Ceilings**	**112 days**	**Thu 2/20/20**	**Fri 7/24/20**			**Yes**
353			Ceiling at level 1	23 days	Fri 4/24/20	Tue 5/26/20	57		Yes
354			Ceiling at level 2	23 days	Tue 3/24/20	Thu 4/23/20	57		Yes
355			Ceiling at level 3	23 days	Thu 2/20/20	Mon 3/23/20	57		Yes
358			**acoustic layer**	**51 days**	**Tue 3/24/20**	**Tue 6/2/20**			**No**
359			acoustic layer level 1	5 days	Wed 5/27/20	Tue 6/2/20	35		Yes
362			**screed**	**72 days**	**Wed 3/25/20**	**Thu 7/2/20**			**No**
366			screed in level 1 rooms and coridors	6 days	Mon 6/1/20	Mon 6/8/20	35		Yes
369			**waterproofing in bathrooms**	**69 days**	**Wed 4/8/20**	**Mon 7/13/20**			**No**
371			waterproofing in bathrooms level 1	6 days	Tue 6/16/20	Tue 6/23/20	36		Yes
374			**Wall tiles**	**137 days**	**Mon 2/3/20**	**Tue 8/11/20**			**No**
377			Wall tiles level 1	22 days	Thu 6/25/20	Fri 7/24/20	37		Yes
380			**Floor tiles**	**75 days**	**Wed 4/29/20**	**Tue 8/11/20**			**No**
383			Floor tiles level 1 rooms and servise rooms	13 days	Thu 7/9/20	Mon 7/27/20	37		Yes
390			**painting**	**71 days**	**Thu 4/30/20**	**Thu 8/6/20**			**No**
398			**Doors**	**83 days**	**Thu 5/7/20**	**Mon 8/31/20**			**No**
401			Doors for rooms level 1	13 days	Thu 7/30/20	Mon 8/17/20	39		Yes
405			**Vinil Floring**	**64 days**	**Mon 6/1/20**	**Thu 8/27/20**			**No**
408			Vinil level 1	10 days	Fri 8/14/20	Thu 8/27/20	40		Yes
461			**Electrical works**	**402 days**	**Fri 4/26/19**	**Tue 8/25/20**			**Yes**
468			**Electrical distribution network 0.4kV**	**394 days**	**Fri 4/26/19**	**Thu 8/13/20**			**Yes**
469			grounding works stainless stell mesh	3 days	Fri 4/26/19	Sun 4/28/19	20		Yes
470			Graunding works in foundation level	2 days	Sun 5/12/19	Mon 5/13/19	21		Yes
496			Panels and cabeling dry walls Level 3	16 days	Thu 12/26/19	Thu 1/16/20	34		Yes
565			**HVaC works**	**316 days**	**Wed 7/17/19**	**Wed 8/19/20**			**No**
579			Instalation and conection of FCU in Level 3	8 days	Mon 2/10/20	Wed 2/19/20	35		Yes
612			**Furniture**	**66 days**	**Mon 6/8/20**	**Mon 9/7/20**			**No**
617			**Comisioning**	23 days	Tue 8/25/20	Thu 9/24/20	61		Yes
618			**Optaining of permit**	5 days	Fri 9/25/20	Thu 10/1/20	61		Yes

Figure 21. New Critical Path of the project

As seen from the new Critical Path, where the deferrals were added, the end date of the task was determined to be delayed from 22 July of 2020 from the first undertaking timetable to 1 October of 2020, as indicated by the recreations. After the comparison of the calculated critical path with the original one, we organized a meeting with the project manager of the project and discussed the outcomes of the analysis with the real ones. According to the project manager, the real end date of the project was March of 2021, with an added period of delay of 3 months due to the pandemic situation of 2020. As long as there was a forced 3 months period of non working site because of the pandemic situation, the project was delayed more than predicted. In these conditions, the calculations from our analytical model were closer to the real results of the project then the original schedule by the project manager. Asked about this fact, the managing team admitted that the use of this model could be very benefitial if used before the construction period.

CHAPTER 5

Conclusions and Future Work

5.1 Summary of Research Goals and Objectives

The purpose of this research study was to develope an analytical model which could help project managers analyse the risks before the construction phase and create a mitigation plan to manage these risks. But this model was validated using only one real project, so there is needed future works on other real projects, before final results and conclusions are made. So, we can say that the specific objective of this research was developing a model which could help pjoject scheduling in terms of resource risk allocation for design build fixed price types of contract, by using Monte Carlo simulation software by:

- conducting information regarding the existing contract types, payment methods, risk management methods, monte carlo simulation and previous researches on risk management.

-Developing an anlutical model easy to be used bu the project manager, where he can input probabilities and maximum and minimum duration for each task.

-Interviewing five project managers in order to find out the current metods for risk management and the flexibility of them to use new and different methods.

-Defining each of the resource risk categories as: equipment, materials and labor.

-Verifying if the model is correct by comparing with a project with previous analyzed data.

-Conducting analysis and simulations with the data of a real project in order to validate the model developed.

-identifying future works that can be done further to this research.

5.2 Outcomes from Literature Review

The literature review regarding current contract and payment methods, risk definition and management, previous researches on risk management of fixed-price design- build type of contracts found out there is a lack of research on existing literature in the following directions:

-effects of a project managed with a schedule software like Microsoft Project or Oracle Primavera

-analytical modeling tool or software that a project manger ca use

-risk management with the use of Monte Carlo simulation

Research being conducted by investigators from the Construction Industry Institute

(CII) didn’t focus on the specific causes of the delays, and this allows for the development of a model which takes into account resource risk categories.

5.3 Observations from the Data Collections

As explained from the section of Interviews to Project managers, we asked from them to provide full data package from the project they were currently working on. From five project managers, only one could provide this full set of data and the others were unwilling to provide such information. The reason for this is linked with the way these companies secure their profit based on the first bid they offer and the way they manage time and cost durin the project. So, collecting information from them was a real challenge.

Except for this, the interview with project managers waa linked with another challenge, because most of them were considering the interview as a time cost, as long as it had two parts, before and after the conduct of the analysis. In order for the model to be validated, we needed to make another interview with the project manager, in order to compare the analysis results with the real project results. For this reason, most of them didn’t accept to make a follow up interview.

5.4 Results from the Data Analysis

The results of the research project were developed after comparing the analysis outcomes with the original project schedule and te real outcomes of the project:

-The construction of a five-star Hotel in Rinas, Tirana, Albania was used as a case study.

-An interview was made with five project managers in order to give real insights into the actual situation of risk management in Albania.

-The original project schedule provided a start date of 29 January of 2019 and the finish date 22 July 2020 with a duration of 443 days.

There exist many factors affecting the time schedule of the project. At our case study we have analysed the most three important factors as Resources, Materials and Manpower.

Reffering to the resources, it has delayed the schedule with one week. Lack of machines for excavation and backfilling works is a factor. It delayed the starting of the upcoming activities like rough structure and finishing works.

Late delivery of materials is one of the most affected factor. In this projects it was a huge delay in delivering bitumen membrane, aluminium windows, curtain walls etc. which occurred a postpone in time of starting activities like dry walls, plastering, all finishing works inside building.

Lack of Manpower is another important factor which delayed the timeschedule more than 3 weeks. Manpower fenomen is known in all construction sites which is a factor to be considered for each activity. In this case the manpower caused problems in most of the activities, but the most delayed ones are masonry brickwall, screed, drywalls, HVAC works etc.

-The delays predicted by the model include a total number of 52 days.

-The final end date of the project was calculated to be 1 October of 2020

After the anlysis was conducted, another interview was made with the project manager, where he said that the project is not yet finished, because of the pandemic situation of Covid-19. Therefore, our model is closer to reality.

According to the experience gained from different projects, every project manager knows the minimum and maximum delays of each activity.

With application of this model helps the project manager to predict the delay of timeschedule and consider it before finalizing. Project manager has to put the minimum and maximum delays in the model and it will simulate the delays foer each task of the project.

5.5 Future Work

Future work recommendations will focus on three main things. The first one includes a further consideration of cost in the development of the risk management. In our project we didn’t consider the effect of cost in the risk management because a project manager needs to consider the effects of a delay related to the cost too.

Another area this study can be developed in future works include the software that should be used to conduct the analysis. We have used Monte Carlo and Palisade@Risk Software, but the model should also be developed using a software that can be accessed by all the project managers.

The last thing the future works should consider is the spread of the model and its adaptation in other areas or fields of industry, as long as risk management is very important in all the types of industry where project management plays an important role.

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APPENDIX

Appendix A: Implied Consent Agreement Form

20/12/2020

To Who It May Concern:

My name is Edvaldo Picari and I at present am an alumni understudy at the Epoka Univerity seeking after my MS in Civil Engineering. My exploration center is around the impacts of inappropriate danger the executives on the asset assignment measure checking whether we can anticipate expected risks before they happen utilizing Monte-Carlo Simulation inside the development business. One of my fundamental advantages inside designing is to improve the task the board cycle by executing new innovation or strategies to help project chiefs in finishing projects on time and inside spending plan.

You are welcome to partake in an organized meeting where you will respond to a couple of inquiries in the connected document in regards to the examination. You were chosen as a potential member in this examination in light of your skill and your obligation regarding different undertaking information and venture the board imperative to my investigation.

In the event that you choose to take part in this deliberate investigation and meeting, we will continue with talking about the connected arrangement of inquiries. By consenting to be talked with, you have inferred your agree to take an interest in this investigation. Record of this meeting will be kept as manually written or composed notes for the length of this investigation. Sound and video recording of the meeting won't be utilized. Anytime you can decide to not answer a question or pull out from partaking in this meeting. No advantages gather to you for addressing the inquiries in this meeting, yet your reactions will be utilized to help comprehend the effect of the investigation inside the development business.

Any data that is gotten regarding this meeting and that can be related to you will stay private and won't be unveiled. Any recognizable data will be held secret to the degree permitted by law and University strategy.

In the event that you have any inquiries, concerns, or protests about this investigation or meeting, you maycontact the essential scientist at this location:

Edvaldo Picari

Department of Civil Engineering

Epoka University

epicari09@epoka.edu.al

We appreciate your willingness to participate. Thank you for your time.

Sincerely,

Edvaldo Picari

Appendix B: Complete List of Interview Questions

Demographic Information:

1. How long have you functioned in the development business?

2. How long have you functioned for your present organization?

3. What is your present place of employment title?

4. What industry are the sorts of undertakings you are dealing with, e.g., medical care, stockroom, producing, places of business, private, or other?

5. What is the size of the undertaking you are at present chipping away at regarding absolute expense, number of staff, absolute work hours, and undertaking length?

Undertaking Information:

1. How is hazard the executives asset portion right now dealt with in your organization?

2. What are the essential sorts of danger that you oversee, i.e., cataclysmic events, assets deficiencies, faculty?

3. How agreeable would you say you are distinguishing and appointing hazard probabilities?

4. How might you recommend separating the dangers utilized for examination for example utilizing an totals/classification or deciding the main/vital dangers for an undertaking?

5. In the event that you use totals/classifications, what classes would you us for example hardware, materials, work, and so forth?

6. How would you think the development business is moving to embrace new programming or apparatuses to uphold?

7. Would the business embrace apparatuses utilized in this examination?

8. Should this examination be investigated with extra activities?

9. It is safe to say that you are happy with your present procedure?

10. How helpful was this examination in applying it to your present organization?

11. Are there any traps to a product or device like the one utilized in the investigation?

12. Do you have any proposals in improving the examination?

13. Would you think about utilizing this apparatus on future ventures?