A COMPARATIVE STUDY OF RISK ASSESSMENT BETWEEN PREFABRICATED AND TRADITIONAL RESIDENTIAL CONSTRUCTION IN TANZANIA

by

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ABSTRACT

A COMPARATIVE STUDY OF RISK ASSESSMENT BETWEEN PREFABRICATED AND TRADITIONAL RESIDENTIAL CONSTRUCTION IN TANZANIA

Residential buildings have been the most marketable sector in the construction industry in Tanzania. Considering the elevated risks in the traditional method of construction currently in Tanzania, a modern method of construction is required. In this study, two different methods of construction are analyzed; Prefabricated Construction (PFC) and Traditional Method of Construction (TMC). A comparative risk assessment between PFC and TMC in Tanzania is conducted by using Analytic Hierarchy Process. Moreover, in this study the most important risks are obtained in both construction methods showing how the PFC can have more manageable risks compared to the TMC. The findings resulted to most of the significant risk factors for the PFC's investment in Tanzania being owner, economic and political related, whereas most of the significant risk factors for the TMC in Tanzania being owner and nature related. The analysis results suggest that in order for efficiently managing the significant risk factors for the PFC, a close relation between the government and the investing companies on the PFC is required. This contribution provides an insight to the construction industry in Tanzania and the investors around the world to consider the deployment of PFC in the residential building market in Tanzania. Furthermore, the management of significant risk factors in other similar East African countries is also discussed.

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ÖZET

TANZANYA’DA PREFABRİK VE GELENEKSEL KONUT YAPIMI ARASINDAKİ RİSK DEĞERLENDİRMESİ İLE KARŞILAŞTIRMALI İNCELEME

Konut binaları, Tanzanya'daki inşaat sektöründe en kolay pazarlanabilen sektörü oluşturmaktadır. Şu anda Tanzanya'da geleneksel inşaat yönteminde artan riskler göz önüne alındığında, sektörde modern inşaat yöntemlerinin kullanılması zaruri bir hal almaktadır. Bu çalışma kapsamında iki farklı inşaat yapım yöntemi incelenmiştir; Prefabrik Yapım (PFY) ve Geleneksel İnşaat Yapım (GİY) yöntemleri. PFY ve GİY uygulamalarının Tanzanya özelinde karşılaştırmalı risk değerlendirmesi, Analitik Hiyerarşi Süreci kullanılarak gerçekleştirilmektedir. Bu çalışma ile her iki inşaat yapım yönteminde karşılaşılan en önemli riskleri elde etmenin yanı sıra, PFY'nin GİY'ye kıyasla nasıl daha yönetilebilir risklere sahip olduğu da gösterilmektedir. Bulgular, Tanzanya'daki GİY için önemli risk faktörlerinin çoğunun, işveren ve doğa olayları ile ilişkili olmasına rağmen, PFY ile ilgili önemli risk faktörlerinin çoğunun ekonomi, işveren ve hükümetle alakalı olduğunu göstermektedir. Analiz sonuçları, PFY için önemli risk faktörlerini etkin bir şekilde yönetebilmek için, PFY alanında yatırım yapan şirketler ve hükümet arasında yakın bir ilişki kurulması gerektiğini göstermektedir. Bu katkı, Tanzanya'daki inşaat endüstrisine ve dünyadaki yatırımcılara, Tanzanya'daki konut pazarı için prefabrike inşaat yapım yöntemini tercih etmenin sağlayacağı imkânlar hususunda ışık tutmaktadır. Ayrıca, diğer benzer Doğu Afrika ülkeleri için de önemli risk faktörlerinin yönetimi tartışılmaktadır.

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LIST OF SYMBOLS

[C]	Criteria Comparison Matrix
n	Number of criteria
$\{W_s\}$	Weight sums vector
{W}	Criteria weight
$\sum$	Summation
λ	Average of the elements of {Consistency}

LIST OF ACRONYMS/ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
CI	Consistency Index
CR	Consistency Ratio
CV	Coefficient of Variation
GDP	Gross Domestic Product
LS	Least Significant
MODEX	Modularization Expert
MS	Moderate Significant
NBS	Tanzania National Bureau of Statistics
PFC	Prefabricated Construction
PMBOK	Project Management Book of Knowledge
PMI	Project Management Institute
RAND	Research and Development
RI	Random Index
RMP	Risk Management Process
ROI	Rate on Investment
SS	Slightly Significant
TMC	Traditional Methods of Construction
UAE	United Arab Emirates
UK	United Kingdom
URT	United Republic of Tanzania
USA	United States of America
VS	Very Significant

1. INTRODUCTION

1.1. Background of the Research

Construction industry all over the world has been playing a significant role in determining the development and progress of a nation. The global construction industry contributes to around 9% of the world's Gross Domestic Product (Horta *et al.*, 2013). Therefore, this sector is among the highly providing employment in most countries, speeds up economic growth and contributes to providing solutions to the culture, weather and energy challenges. The Pricewaterhousecoopers, a multinational consultant company, released a report for Global Construction 2030 foreseeing the global construction will increase by 85% to $15.5 trillion worldwide by 2030. It's identified that United States, China and India will be the leading nations for this major change to up to 57% globally (Perspectives and Economics, 2015). This shows that how the population of a country is directly proportional to the demand in construction activities. An international competitiveness evaluation study for global construction conducted in 2014 (Han *et al.*, 2015) revealed United States and China have high attractiveness and Italy especially has a high level of corporate competitiveness. Canada, India and Denmark illustrated a low attractiveness due to lack of competitiveness in construction and design. Turkey, Portugal, Greece and Ireland lack nation's industry competitiveness where Japan, Australia, Korea and Netherlands need market stability to boost the construction market.

Global construction industry has incurred changes towards sustainability, the European Union stated that the building sector is responsible for approximately 40% of primary energy use, 50% of all extracted materials and 30% of carbon emissions and thus, adopting long-term efforts towards enforcing the energy reduction is highly expected (Tsimplokoukou *et al.*, 2014). Study conducted in Hong Kong revealed that construction waste reduction is one of the major benefits when using prefabrication compared with conventional construction. The average wastage reduction level was about 52% (Jaillon *et al.*, 2009). Similar findings were found out in terms of environmental, economic and social benefits of using prefabrication when compared to conventional construction methods in dense urban environment (Jaillon and Poon, 2008). Lean construction resulted in a significant reduction of material waste by 64%, a significant reduction or eliminating key safety hazards and a significant economic effect by reducing production hours by 31% (Nahmens and Ikuma, 2011). Work flow showing the construction process stages is presented in (Figure 1.1).

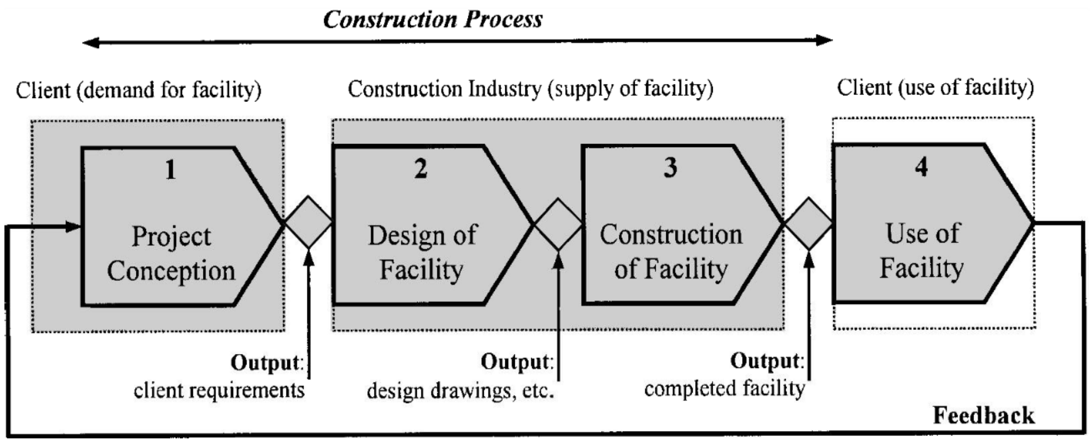

Figure 1.1. Simplified Model of the Construction Process (Kamara *et al.*, 2002).

The construction industry similar to other industries face local and international competition in terms of its market. Competitiveness in the construction industry is defined as the capability of pleasing the interests of companies, clients and societies under free and fair trade and market conditions disclosed to an international environment (Henricsson *et al.*, 2004). This competition is high when the number of construction companies exceeds the number of existing projects.

According to the European commission which is European Union's politically independent executive arm responsible for drawing up proposals for new European legislation, and implementation of the decisions of the European Parliament and Council; the competitiveness in the construction industry comes with benefits such as:

- produces buildings and infrastructure adapting to changing social and economic needs
- meets global challenges like energy security and climate change
- Provides an attractive sector to work in, equipped with excellent opportunities for career development, good payment, and improved health and safety.

Most of the construction companies face competitive challenges, thus arising a need to strategize their organization for a successful uphold of their market. Some of the strategies include proper risk management; improving the design services in engineering; use of modern technology; partnership with other parties and enhancing of human resources (Ozorhon and Demirkesen, 2014). This competitiveness is severe for the construction companies in developing countries. The globalization lead to various advantages and disadvantages to the construction sector of the developing countries (Table 1.1).

Table 1.1. Advantages and Disadvantages of Construction Sector of Developing Countries (Ofori, 2000).

Advantages	**Disadvantages**
Involvement of international finance made way to implementation of various projects, such as those of major infrastructure.	Local construction companies lack enough funds to engage in private projects.
Foreign investment in projects leads to increase in construction works, creating more work opportunities to local firms.	Local construction firms lack of technical and managerial capacity to attain foreign-funded projects.
Competition among foreign companies lowers the costs of projects to developing countries.	Possibility of local firms to be restricted from growing.
International firms assist in the technology transfer to the local firms and upgrade in the sector	Local construction companies may not be able to utilize the expert skills attained from the technology transfer.

1.2. Problem Determination

Most of the innovation practices in Africa have been sluggish since not enough emphasis is implemented in the innovation practice. Narrowing down the construction industry to East Africa, Tanzania being precise, the construction industry accounted for 5% of the nation’s GDP (Jason, 2008) which rose to 8.3% of the nation’s GDP in 2013 (National Bureau of Statistics – NBS; Ministry of Works). In the 2015, Tanzania National Bureau of

Statistics (NBS) enlisted the growth of Tanzanian construction sector being 17.6% then followed by a decline in the growth to 6.9% in 2016, caused by pull out of some of the investments in the year (Figure 1.2).

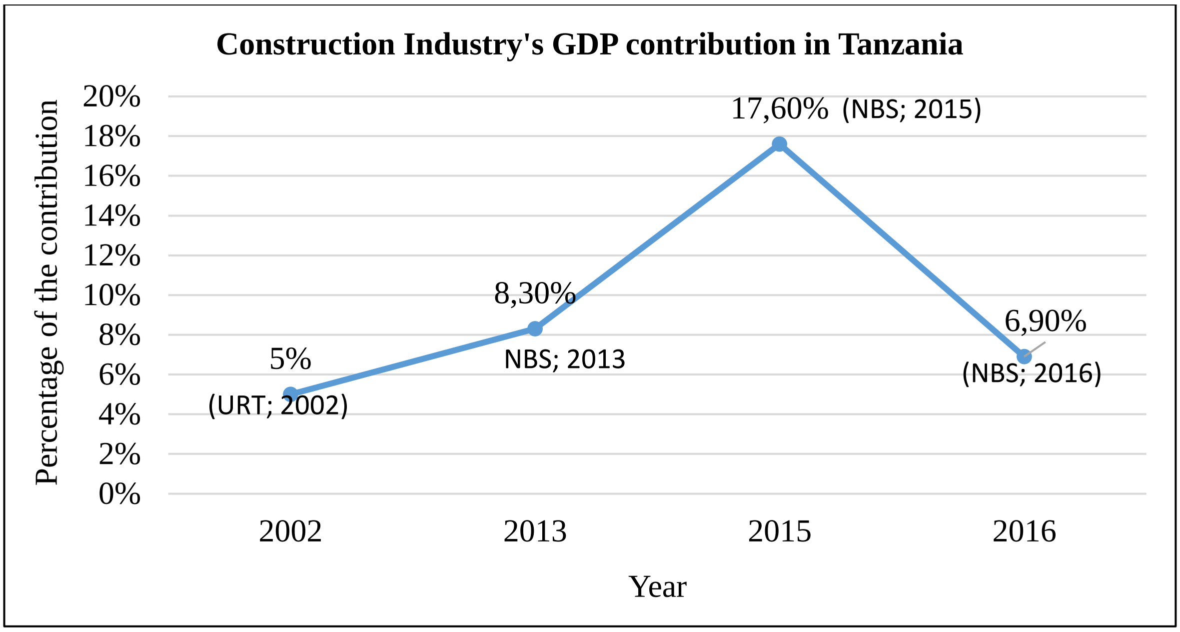

Figure 1.2. Construction Industry's GDP Contribution in Tanzania.

1.3. Problem Statement

Contractors registration board in Tanzania stated how 97% of the contractors being locals in the construction sector, despite this, 96% of the market in construction is foreign owned leaving only 4% to the local construction companies (Chileshe and Kikwasi, 2014). As Tanzania is on its developing phase, the construction industry is of a vital importance and proper care is needed to ensure it does have a positive impact on the growth and not a barrier to it. The residential units in Tanzania has been struggling. According to 2001 housing figures published by the Tanzanian Ministry of Lands and Habitat Development, there is a demand for 600,000 housing units in the major urban areas (Mehta and Bridwell, 2005). Since then the population of the country has risen from 35 million to 56.8 million (United Nation estimate July 1st, 2017) increasing the demand of the housing units. In 2014, the below data on housing condition was obtained from the Basic Demographic and Socio-Economic Profile Report (Tanzania Mainland) published by the ministry of finance and national bureau of statistics.

Table 1.2. Distribution of Housing Ownership Condition in the Tanzania Mainland (Source: Tanzania Mainland-Basic Demographic & Socio-Economic Profile 2014).

		Rural	**Urban**	**Total**
	Total No. of Households	6,054,641	2,972,144	9,026,785
%	Owned by Household	87.8	46.9	74.3
	Living without paying rent	4.0	4.7	4.2
	Rented privately	6.3	43.6	18.6
	Rented by employer	0.5	1.5	0.8
	Rented by government at subsidized rent	0.4	1.7	0.8
	Owned by Employer (Free)	0.9	1.1	1.0
	Owned by Employer (Rent)	0.2	0.4	0.3

Despite most of the people owning their own houses, there exists problems in rural and urban housing. Increasing the quality of life in developing countries requires the optimal utilization of resources. This include the reliance on local natural resources and labor skills instead of imported construction materials. This will lead to more affordability of the housing units for workers and middle class (Mehta and Bridwell, 2005).

There exist a number of causes of delays and disruptions to the construction project in Tanzania leading to great effects on the performance of the industry (Kikwasi, 2013). Construction sectors face predictable and non-predictable factors during the project execution. The predictable factors should be anticipated during the initial stage of the project whereas the non-predictable factors involve uncertainties; this should also be predicted for the successful completion of the project because these risks will affect the cost, time, quality of the project (Renuka *et al.*, 2014).

1.4. Related Studies

Risks in construction project deliver a crucial role in the development of construction industry. Risks are different for every construction project depending on its size and nature (Subramanyan *et al.*, 2012). Studies have been conducted in different parts of the world including Malaysia, Turkey and Tanzania. For example, the Malaysian construction industry is also challenging like many other countries, due to a number of reasons in the area such as lack of improvement in the operations, lack of research and development, unskilled human resources, low technology, environmental pollution and occupational safety and health (Razak Bin Ibrahim *et al.*, 2010).

For a fast-developing country like Turkey, a study conducted in 2012 stated different factors from financial, labor-based, managerial, owner-based, project-based, resources-based and environmental. All these factors have a significant effect to the time overruns in the construction projects (Kazaz *et al.*, 2012). Another study on causes and effects of delays in construction projects in Tanzania identified 21 different risk factors affecting the construction projects ranking them in terms of their priority (Kikwasi, 2013). The studies concerning the risks and delays in the construction industry in Tanzania are considering the Traditional Method of Construction (TMC) currently existing, leaving a gap of imposing Prefabricated Construction (PFC) as an offsite production method in the analysis.

1.5. Aim and Objectives of the Thesis

The aim of this thesis is to evaluate the major risk factors of TMC and PFC in the Tanzania's current construction era. Despite both methods being used globally, PFC has brought a substantial change in worldwide development of construction industries over the last few decades (Wong *et al.*, 2003). A major reason posited for the reluctance among clients and contractors to adopt the offsite production is that they have difficulty determining the benefits that such an approach would add to a project (Pasquire and Gibb, 2002). Since every client or construction company is seeking a less risky project with a less risky technique, this approach will be used in showing how the PFC is better compared to the TMC.

Since Tanzania uses the TMC, the data about the TMC usage will be obtained from Tanzania. The later data for the PFC is obtained from Turkey since PFC is not present in Tanzania. The reason for selection of Turkey as a key comparison, is for its strengths in the construction sector domestically and their international competitiveness constituting of low cost, strong sub-sectors and high efficiency of labor (Ozorhon and Demirkesen, 2014).

The risks are obtained from a number of literatures and counterchecked with academicians and professionals with experience in their field of work, then the ratings are established by using AHP to obtain an arguable result. These information are taken from professionals in both, the TMC and the PFC sector. This is so that variation between the two methods could be analyzed. The risks rating are affected by the attitude of the professionals to the commitment of the arising problem (Bu-Qammaz *et al.*, 2009) thus more experienced professionals is an important key in the data collection. In order for the aim of this thesis to be fulfilled, core objectives are raised:

- To evaluate and rank the risk factors impacting the TMC and the PFC
- To check the manageability of the major risk factors impacting the TMC and the PFC
- Make recommendations to the construction industry and the public on how the construction industry in Tanzania can be improved.

1.6. Scope and Limitations

This thesis plays a great role in identifying and evaluating the risk factors for two different construction methods; TMC and PFC. Since the construction industry continues to be the most hazardous industry around the world, many studies to date have covered the risk factors in different phases of the project. These risk factors include misunderstanding the client, miscalculation and choosing incompetent consultants in the pre-project phase, lack of cooperation between project actors, shortage of resources, problems with design and gap of knowledge in the planning and design phase, incompetent contractors in the contractor selection phase, lack of knowledge of the contractor and delays in the construction schedule in the project operation phase (Gajewska and Ropel, 2011).

This study focuses on Tanzania where limited literatures have covered the risks in the construction field. Moreover, the existing studies in the literatures only examine the TMC risks. Therefore, this study aims to fill this gap in the literature by conducting a comparative risk assessment between TMC and PFC method in the Tanzanian residential construction industry.

1.7. Organization of the Thesis

In the coming chapters, the background section covers the history of the TMC and PFC. Additionally, a thorough review on the PFC is reviewed in order to give a distinct expression on how it affects the construction industry. This include the review of the advantages and barriers of the PFC method. In the 3rd chapter, a descriptive way of the method used will be explained step by step, starting with the risk identification section to coming up with the risk groups, followed by detailed explanations of the risk factors obtained from the existing studies. Further in the methodology, a decision tool is used to analyze the data collected from experts both in Turkey and Tanzania in order to evaluate the risk factors. In the decision process, the Analytical Hierarchy Process (AHP) will be discussed, accompanied with the SUPERDECISION tool.

The methodology section will also give insight on the professionals that participated in the data collection, their role in the construction industry and their years of experience. Following the methodology chapter, the results and findings section will display the results obtained in this study. In the discussion section, comparisons will be conducted among the results of the TMC and PFC. Further discussion will be made with a comparison of results of this study and previous studies done. A conclusion will be presented instating the completion of the aim and objectives of this study, together with recommendations for future studies and improvements in the construction industry.

2. BACKGROUND

2.1. History of Methods of Construction

TMC dates to before 12000 BC, since then there has been various changes in both the construction materials and its methods of execution. Construction industry experienced many innovations in terms of materials and processes from the use of stone, mud, clay and timber to iron, glass, masonry and cemented chipboards. This innovative transition lead to PFC. Innovation is elucidated in different ways, as stated by the Department of Trade and Industry; innovation is "the successful exploitation of new ideas" (Dale, 2007). Furthermore, innovation is an improvement of product, process or system, all of which, is unique to the organization establishing it (Blayse and Manley, 2004). Innovation can also be categorized in various groups: incremental, modular, architectural and radical innovations (Henderson and Clark, 1990). All these differ according to the level of change from incremental changes to radical changes (Slaughter, 1998). Considering these changes in the construction industry occurring to date, the construction industry being a sector with the less innovation slope compared to other industries such as chemical, electronic and automobile (Kulatilake, 2016). This stagnation and slow progress of the innovation in construction has been due to a bounded amount of resources of the majority of the members in the industry (Blayse and Manley, 2004; McFallan, 2002).

Apart from the techniques and machinery innovation in the TMC that has been used for the past centuries, the PFC has been also developed. PFC is one of the modern methods of construction which is defined by the UK government as "the innovations in house-building from the construction site to the factory" (Pan *et al.*, 2007). Offsite fabrication is changing the whole concept of construction from a site dependent work to an offsite, well-monitored construction work (Rahman, 2013). The Construction Industry Institute from the USA, defined prefabrication "as a manufacturing process that takes place at a particular facility", where preassembly "is a process whereby prefabricated components are joined together at a remote location". The Construction Industry Institute also defined offsite fabrication as "the practice of preassembling or fabricating of parts/components at an area apart from the installation area". Currently, modern construction have less devotees as less known on how the PFC works and its advantages with respect to the TMC. Adopting the PFC could be the breakthrough we have all been looking for in the construction sector for making housing units affordable.

2.2. Prefabricated Construction

Prefabrication is defined as a manufacturing process that occurs in a specialized facility to which different materials are combined together to establish a component of final installation (Gibb, 1999). Prefabricated construction as a method of construction where the components of manufacturing process takes place in a specialized facility then taken to a site for final installation. Recently, prefabrication has been reviewed in many studies in the literature (e.g. Comparative Study on Prefabrication Construction with Cast In-Situ Construction of Residential Buildings (Dineshkumar and Kathirvel, 2015), Prefabricated Building Construction Systems Adopted in Hong Kong (Wong *et al.*, 2003), Towards adoption of prefabrication in construction (Tam *et al.*, 2007)). The adoption of PFC was analyzed in different literatures whether it's beneficial or not. Seven benefits were found out: (i) frozen design at the initial, (ii) enhanced controlling on quality improvement, (iii) construction cost reduction, (iv) less construction time, (v) incremental of environmental performance, (vi) integrity on the building design and finally (vii) construction, and artistic issues on the building (Tam *et al.*, 2007). A different study also remarks similar benefits of PFC; (i) less construction time, (ii) higher quality, (iii) more consistent product, (iv) reduced snagging and defects, (v) increase the value, (vi) increased sustainability, (vii) less initial cost, (viii) increased flexibility, (ix) more customization options and finally (x) increased component life (Goodier and Gibb, 2007).

In these studies, PFC is indicated as a great degree of importance compared to traditional (on-site) construction. Not all countries have been preferring the PFC but the number has been increasing in the recent years due to the increase incomprehensive knowledge of PFC. A study to reveal the advantages of prefabricated elements when compared to the traditional (on-site) in terms of their processes in the Hong Kong construction industry was conducted and presented in (Table 2.1).

Table 2.1. Advantages of PFC Compared to TMC (Wong *et al.*, 2003).

Factor	Prefabrication	On-site
Quality	Climate-controlled environment using modern equipment operated by trained personnel.	Uncertain weather may result low quality in construction.
Speed	Fast process (approximately 70% less)	Time consuming, can be caused by climate or schedule conflicts.
Cost	More control on manufacturing products, reducing the possibility of cost exceedance.	Uncontrollable factors such as climate and schedule can increase the construction cost.
Versatility	Less	More
Site space	Panels arrive on a flat-bed trailer and are installed with sufficient listing plants.	Larger space is needed. Scaffolding necessity during installation increase the cost.
Site refuse	Less waste is produced at the site.	A high amount of waste is generated, increasing the cost for its removal.

Despite having a vast advantage list of PFC compared to the TMC, many barriers exist related with its operation. These drawbacks/barriers constitute of factory-related, clients, labor, contractors and suppliers-related. Since the PFC is a collective process, whichever party delays, it leads to a delay of the entire construction process. Barriers of PFC were also revealed by studies conducted (Tam *et al.*, 2007; Goodier and Gibb, 2007; Wong *et al.*, 2003).

Table 2.2. Barriers of PFC.

Wong *et al.* (2003)	**Goodier & Gibb (2007)**	**Tam *et al.* (2007)**
Design and planning consumes time.	High cost	Inflexible for design changes
Time required for production	Longer lead-in times	Higher initial construction cost
More demanding planning and management	Client opposition	Lack of research knowledge
Huge working space is required for working.	Lack of guidance & information	Time consuming
Extra working space for storage	Few codes/standards available	Standard method
Installation requires careful planning	More risks	Restricted site space
The handling and assembly of heavy precast components	Negative image	Leakage problems
Complications in assessing working positions.	Materials locally unavailable	Lack of experience
Complications in installation	Lack of personal usage experience	Uniform in aesthetics
Defective connections reduce quality	Difficulty in obtaining finance	Low market of prefabrication
	Insufficient trained workers	
	Less quality	
	Restricted regulations	

A study conducted in the management of PFC revealed how developed countries (USA, Sweden and Australia) are the main contributors, where contribution of developing countries (Turkey and China) is anticipated to increase (Li *et al.*, 2014). Despite these contribution in the PFC, this thesis is aimed at revealing how the risks related to the PFC are more manageable compared to TMC in Tanzania’s construction industry.

3. RISK MANAGEMENT IN CONSTRUCTION

Risk management is a critically important aspect used in different industries, from information technology related business, automobile, pharmaceutical industry, to the construction sector (Gajewska and Ropel, 2011). In the risk management field, two key concepts are mostly confused, risk and uncertainty. Despite this confusion, a number of literatures have distinguished the difference between these two concepts. Over the years the definitions have changed but the concepts of all the definitions in the literature are convergent in a single meaning and a specific difference between them.

3.1. Risk Definition

There are a number of risk definitions and risk management studies related to the construction industry. According to the 5th Edition of the PMBOK® Guide, project risk is "an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, or quality". As Lifson and Shaifer described, the definition of risk is elusive and its measurement is controversial (Al-Bahar and Crandall, 1990). Risk is also defined as "a situation that contains valuable knowledge on what the result might be, either a positive or a negative one depending on the situation present", whereas uncertainty is defined as "a situation where an individual has no information on the result of it" (Webb, 2003). The lack of information on the situation faced is what determines whether it's a risk or an uncertainty. The definition was simplified more stating risk to be "the disclosure of uncertainty" (Cooper, 2005), which means that as the information is known on the uncertainty then it changes from being an uncertainty to a risk.

Studies also provided the explanation on risk with a slight modification from the previously explained. Risk occurs when there is several information about the event, a decent amount of information to declare the event might happen (Smith *et al.*, 2009). In 2010, a rather short but meaningful definition of risk where they stated it being "a possibility of loss or injury in any given situation" (Darnall and Preston, 2010). All these definitions have something in common, they all state an occurrence of an event from a situation depending whether any information is known which separates risk from uncertainty. Risk is generally related with coming up with decisions where the aftermath are not certain. Uncertainty emerges when decisions are apprehended towards the future where their sources are normally lack of information.

The risks can be generally categorized into two; controllable and uncontrollable risks (Zolkafli *et al.*, 2012) as presented in Table 3.1. Most of the controllable risks are internal risks, a vast amount of these risks are easily controlled but some can be challenging. The most challenging part is the recognition of the risks. Uncontrollable risks are the risks that occur despite any precautions. These risks can contribute to least and massive impact to the project. Examples of controllable and uncontrollable risks are in Table 3.1. Uncontrollable risks' effects can be reduced or averted by the use of insurances for the specific sector involved. For instance, price of commodities and foreign currencies can be hedged against any changes by the use of financial derivative mechanisms (Rebeiz, 2011).

Table 3.1. Controllable and Uncontrollable risks (Zolkafli *et al.*, 2012).

Controllable Risks	**Uncontrollable Risks**
Inadequate planning	Weather
Poor quality control	Natural disasters
Poor leadership	Fire
Errors in cost and time estimates	Strikes
Ineffective communication	War

3.2. Risk Management Process

PMBOK defined Risk Management Process (RMP) as "the process used to identify, analyze, and respond to a risk by identifying, analyzing, and prioritizing risks". Given the fact that not all risks can be controlled as stated before, but recognizing the risk is a crucial part in the risk management process. It's the crucial part of the whole process, knowing what the organization is up against. The risk management process involves the systematic application of management policies, procedures of establishing the context, identifying, analyzing, assessing, treating, monitoring and communicating risks (Cooper, 2005).

3.2.1. Risk Identification

Risk identification is the first and the most important step of risk management process describing the competitiveness conditions and the clarification of risk and uncertainty factors (Zavadskas *et al.*, 2010). Risks can be hard to eradicate, but when they have been identified, it is easier to take actions and have control over them (Gajewska and Ropel, 2011). Risk identification is of considerable importance since the processes of risk analysis and response management can only be performed on identified potential risks (Al-Bahar and Crandall, 1990). The purpose of risks identification is to obtain a list with potential risks to be managed in a project (Guide, 2004).

For risk identification there are various methods that can be employed. For example, brainstorming is the most common used technique for the risk identification, where a group of experts are asked to come up with the possible risks. The goal for this technique is to obtain an extensive risk list that can be implemented in the qualitative and quantitative risk analysis (PMBOK, 2000). The size of the group involved in the brainstorming process will have a direct significance to the reliability of the list obtained from it (Chapman, 1998). Brainstorming has its advantages and its shortcomings as a risk identification technique. One of the main advantages using the brainstorming technique is the easiness, time and cost saving technique. It also involves a number of professionals which help in exchanging their ideas on the matter in hand and can lead to recognize extra risks that may have not been anticipated by a single individual. Not only does the method contain advantages but it can have a shortcomings, the members in the brainstorming technique can be manipulated and some risks can be ignored due to unorganized nature of the technique (Kıral *et al.*, 2014).

The other risk identification technique that comes right after brainstorming is the checklist, by this method of risk identification, a risk list is developed based on previous historical information and knowledge acquired in different similar projects. This method is a time saving and easy to conduct. The most important aspect of the risk identification is making sure the list is updated from time to time and reviewing of the list after every project so as to integrate any new information acquired by the project. In spite of this, this method is not suitable for project specific and unique risks (Kıral *et al.*, 2014). The method is also lacking group thinking which could act as a disadvantage when it comes to new projects.

Apart from these two methods, there exists a more technical way of identifying risks known as Delphi technique. The history Delphi method dates back to 1950's when Norman Dalkey of RAND Corporation first came up with it for a U.S military project. It has then undergone several other modifications for knowledge creation in the literature starting from Information Technology to the construction industry. The use of Delphi Method could increase the efficiency of risk identification stage (Kıral *et al.*, 2014). Despite this method being adaptable and straightforward, the user needs to consider many design constraints in order to use it successfully (Skulmoski *et al.*, 2007). Using this method in risk identification involves a number of steps:

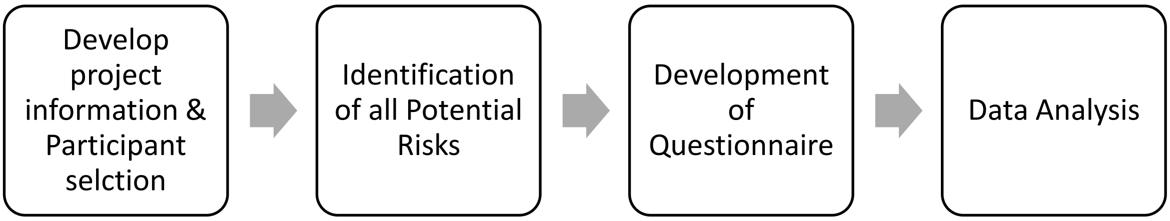

Figure 3.1. Method in Risk Identification.

The development of questionnaire part may take several trials since in the end, a consensus must be obtained before the list is finalized. To ensure that the judgments made by the experts are consistent, the data set are subjected to consistency tests which were conducted separately for each expert's data (Lam and Chin, 2005). The consistency is defined by the relation between the entries, thus the quality of the output has a relation to the consistency of the comparison judgments (Görener, 2012). However perfect consistency rarely occurs in practice but whenever the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency (Triantaphyllou and Mann, 1995).

Risk identification methods found in the literatures can be categorized in three groups: (i) information gathering methods, (ii) documentation and (iii) research (Gajewska and Ropel, 2011). The risk identification tools and techniques are categorized into three main categories considering the degrees of involvement of people: (i) identification by expert, (ii) one-to-one interview and (iii) working group led by analysts (Rostami, 2016). Failure in the identification of risks can lead to inadequacy in the whole process, which can in turn critically affect the progress of the sector. The consequences include economic losses/gains, injuries, physical damages, time and cost savings/overrun (Al-Bahar and Crandall, 1990).

3.2.2. Risk Analysis

Risk analysis is conducted after the identification stage. The aim of this stage in the risk management process is to know the importance of the assigned factors, the probability of them to happen and their effect after it has occurred (Dziadosz and Rejment, 2015). In this part of the risk management there are two types of analysis that can be conducted: (i) Qualitative Analysis and (ii) Quantitative Analysis. In the risk analysis, the main goal is to enable managers to reduce the level of uncertainty and focus on the high priority risks.

Qualitative risk analysis acquires the ranking of the listed risks with the consideration of its likelihood of occurring (probability). This includes the effects of the risk in terms of cost, time and quality. There shouldn’t be any sort of biasness in the analysis part of the risks. Qualitative risk analysis is a fast and cost deduction way of running the risk analysis for response selection. After qualitative risk analysis, if necessary, quantitative risk analysis can be conducted. Qualitative risk analysis needs the probability and effects of the risks be evaluated with qualitative analysis methods (PMBOK, 2000). These methods include risk probability and assessment, probability/impact risk rating matrix, risk categorization and risk urgency assessment (Gajewska and Ropel, 2011). Unlike qualitative research handling non-numeric information and interpretation based on human opinion and subjectivity. Quantitative research deals with numerical data and statistical interpretations in a logical and strictly objective criterion (Leung, 2015). The techniques that are used in conducting the quantitative risk analysis process include Monte Carlo simulation, sensitivity analysis, fault tree analysis and event tree analysis (Gajewska and Ropel, 2011).

3.2.3. Risk Response

Risk response is a way of which the project management team use, as a reaction to the risk factors they are facing in any kind of project. The risk responses are of different types depending on the situation of risk event being faced. The efficiency of the risk response selected will be a determining factor that the risk will increase or decrease (PMBOK, 2000). PMBOK 2000, indicated 4 types of risk response. These include avoiding the risks (risk avoidance), transferring the risks (risk transfer), mitigating the risks (risk mitigation) or accepting the risks (risk acceptance).

3.3. Risks in Construction Projects

Construction industry is among the sectors that faces many risks since it involves site and offsite activities. The site and offsite activities of the construction industry leads to natural and human risk factors. These risks not only account by their large in number but also they have a significant impact to the project when unsupervised, resulting to inefficient project. The process of risk management should be conducted at the initial phase of the project for an effective risk management process. Most of the construction companies tend to refrain from this process as it requires time and money. A proper risk identification analysis is essential since risks depend on the project scope (Gajewska and Ropel, 2011). The compensation of cost and time acquired by the risk management process lead to its various advantages (Schieg, 2006). The figure below explains the impact of using risk management on project cost (Figure 3.2).

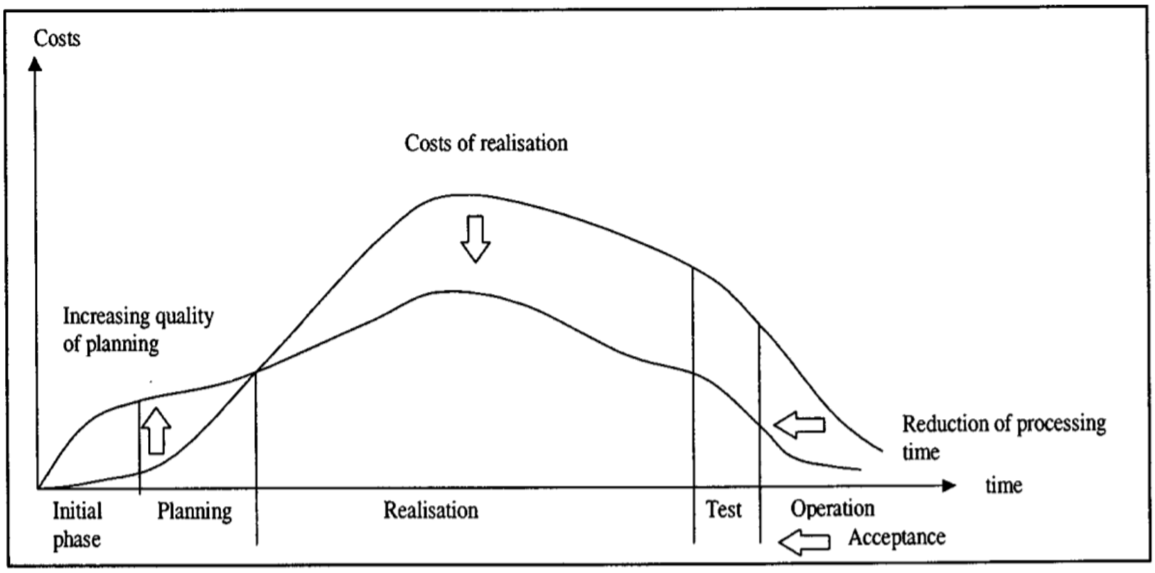

Figure 3.2. Risk Management Capability in Construction Industry (Schieg, 2006).

As it can be seen in the figure, the use of risk management in a construction project cause a high initial cost but also it increases the quality of the planning phase followed by a reduction of the cost in the realization phase. This is due to accounting of the various risk in all the construction activities. This results to a reduction in time to the entire project including the testing and operation phase.

The construction sector has undergone innovation of the TMC to the PFC. The major difference between the methods of construction is the construction process is the type of construction in the two methods. TMC involves construction in situ and PFC involves construction in a controlled environment. The prefab industry is the backbone for the development of new ideas in construction business (Dineshkumar and Kathirvel, 2015). In the construction field, prefabrication is regarded as the first level of industrialization, followed by mechanization, automation, robotics, and reproduction (Richard, 2005).

3.3.1. Risks in the TMC

Traditional methods of construction is the construction technique that involves activities that are based on the site. Different methodologies were conducted in different literatures to find out the risks that are present in various construction projects in different places. A descriptive study including clients, consulting firms, regulatory boards and construction firms from Tanzania was conducted. Results obtained indicated seven high ranked causes of the delays: (i) changes in design, (ii) delays in payment to contractors, (iii) information delays, (iv) funding problems, v) poor project management, (vi) compensation issues and (vii) disagreement on work valuation. Other medium ranked causes are: (i) conflicts among the involved parties, (ii) change in project schedule, (iii) supply / procurement problems, (iv) bureaucracy, (v) multiple projects by contractors and (vi) unqualified contractors. Some of these causes were identified in countries (Kikwasi, 2013).

A construction risk management system to assist the contractors in the systematic identification and analyzation of the project risks was developed. This lead to acts of God, physical risks, financial and economic, political and environmental, design and construction related risks risk factors (Al-Bahar and Crandall, 1990). Similarly, a study utilizing AHP for risk management for overseas construction projects was conducted. This resulted to 10 risk factors from a list of 21, with high probability and impact level. The risk factors are as follows: high inflation, bureaucracy, low social security, corruption, lack of education facility nearby, lack of transportation facility nearby, tax rate changes, exchange rate fluctuation, lack of legal system and lack of communication facility nearby (Zhi, 1995).

In 1997, a questionnaire survey to attain knowledge on the project management practices and the usage of risk analysis and management technique was conducted. This concluded that risk management is essential to construction activities to reduce the losses and enhancing the profit. The study found out how risk analysis and management in construction depend highly on intuition, judgement and experience (Akintoye and MacLeod, 1997). The table lists the risk categories that were identified in the literatures. The risks obtained in the studies have been summarized in Table 3.2.

Table 3.2. Risks of the TMC (a).

Al-Bahar *et al.* (1990)	**Zhi H. (1995)**	**Akintoye *et al.* (1997)**
Acts of God	high inflation	Environmental (e.g. weather)
Physical risks	bureaucracy	Political, Social & Economic (e.g. inflation)
Financial and Economic	low social security	Contractual agreement (e.g. responsibilities)
Political and Environmental	lack of education facility nearby	Financial
Design	lack of transportation facility nearby	Construction (productivity, injury, safety)
Construction related	tax rate changes	Market/industry (availability of workload)
	exchange rate fluctuation	Company (corporate)
	lack of legal system	Development in IT
	lack of communication facility nearby	Project (design information)

Revolutionizing of the construction industry lead to a need to study the risks for major projects. A survey about risk and its management determining that risk analysis technique in Kuwaiti’s construction industry was conducted. The research further determined financial failure being the major cause of delay in construction, followed by delayed payment, labor and material availability, defective design and coordination with sub-contractors (Kartam and Kartam, 2001).

A fuzzy approach was administered to construction project risk assessment showing the relationship and consequences of the risks. This methodology represents the risk exposure in equivalent to the time, cost, quality and safety. A hierarchical risk breakdown structure is described in the research for a qualitative risk assessment. A risk management system was then developed using Microsoft visual basic and operates under Microsoft windows 95/98 or NT4 to support this framework (Carr and Tah, 2001). Similarly, fuzzy decision framework is utilized to model global risk factors affecting the construction cost performance. Major global risk factors affecting cost were identified through a thorough literature review and preliminary discussions with contractors. It is necessary to determine the significant global risk factors, and build the knowledge base on a fuzzy decision support system to successfully model, assess and manage the risks (Baloi and Price, 2003).

Various risks from related literatures were used, then a survey was prepared to come up with risk allocated for Public/Private Partnership or Private Finance Initiative. The risk allocation was based on the nature of the relationship to projects. Macro level risks include political and government policy, macroeconomic, legal, social and natural. Meso level risks include project selection, project finance, residual risk, design, construction and operation. Micro level risks include: relationship and third party risks (Bing *et al.*, 2005). The risks obtained in the studies have been summarized in Table 3.3.

Table 3.3. Risks of the TMC (b).

Kartam & Kartam (2001)	**Carr *et al.* (2001)**	**Baloi & Price (2003)**	**Bing *et al.* (2005)**
Contractor	Labor risk	Estimator related	Macro level risks
Owner	Plant risk	Design related	Meso level risks
Shared	Material risk	Level of competition related	Micro level risks
Undecided	Sub-contractor risk	Fraudulent practices related	
	Site risk	Construction related	
		Economic related	
		Political related	

Focusing on Indian construction projects, a survey is conducted having fifty five factors emerging with seven factors affecting cost performance in the specified country. The critical success factors obtained are: (i) project manager's competence, (ii) top management support, (iii) coordination among project managers and leadership skills, (iv) monitoring and feedback by the participants, (v) coordination among project participants and (vi) owner's competence and favorable climatic condition. Factors affecting the cost performance of projects were obtained to be: (i) conflict among project participants, (ii) ignorance and lack of knowledge, (iii) presence of poor project specific attributes and non-existence of cooperation, (iv) hostile socio economic and climatic condition, (v) reluctance in timely decision (vi) aggressive competition at tender stage and (vii) short bid preparation time. (Iyer and Jha, 2005).

Data collected from contractors, consultants and owners in the United Arab Emirates in order to figure out the top ranked risks. A total of 124 claims were used ranking each type of claims in groups. These groups included changes claims, extra-work claims, delay claims, different site conditions claims, acceleration claims and contract ambiguity claims. Further ranking were done for each cause of claims and the top 5 are: changes or variation of orders, delay caused by owners, oral change by owner, delay in payment by owner and low prices of contract due to competition (Zaneldin, 2006). The six steps of risk management process include identifying risks, analyzing the risks, assessing the risks, controlling the risks, monitoring the risks and controlling goals of the project (Schieg, 2006). International construction projects risks are rated resulting to cost increase using fuzzy risk assessment method. The study stated the cost increase is affected by the specific country risk and specific project risk (Dikmen *et al.*, 2007). The risks obtained in the studies have been summarized in Table 3.4.

A research with 7 allocated risks and fuzzy knowledge transforms the linguistic principles and experiential expert knowledge into a more usable and systematic quantitative-based analysis. This provides an explicit and systematic framework in risk allocation practice rather than a subjective approach based on individual's professional judgement. The research provided insight on the risk allocation decision, whether it should be to the contractor, owner or shared among them. Capability, contractual and legal, economic, physical, political and societal risk events were considered in the research (Lam *et al.*, 2007).

Table 3.4. Risks of the TMC (c).

Lyer and Jha (2005)	**Zaneldin E.K (2006)**	**Schieg M. (2006)**	**Dikmen *et al.* (2007)**
Conflict among the project participants	Change or variation of orders	Quality risks	Country risk
Ignorance and lack of knowledge	Delay caused by owner	Personnel risks	Construction risk
Presence of poor project specific attributes	Oral change by owner	Cost risks	Project risk
Hostile socio economic and climatic condition	Delay in payment by owner	Deadline risks	
Reluctance in timely decision	Low price of contract due to competition	Risks of strategic decisions	
Aggressive competition at tender stage		External risks	
Short bid preparation time			

A questionnaire obtaining data from project executives in Vietnam to determine the major project risks. A total of 59 risks were evaluated and the top 10 risks were obtained. The top 10 risks are: bureaucratic government system and delayed project approval, poor design, incompetence of project team, inadequate tendering, late internal approval process from the owner, inadequate project organization structure, improper project feasibility study, inefficient and incompetent contractors, improper project planning and budgeting and design changes (Van Thuyet *et al.*, 2007). A modification to the Analytical hierarchy process termed as fuzzy, can be utilized to rank risk factors. The advantages of this method include (i) handling expert knowledge, engineering judgement and the historical data for risk assessment consistently (ii) the risk can be evaluated directly using linguistic terms employed in risk assessment; and (iii) the introduction of factor index enables decision makers to perform a risk analysis of the underlying construction environment to obtain more reliable results. A case study of risk assessment conducted in this study resulted to, human, site, material and equipment related factors (Zeng *et al.*, 2007).

A study to identify and assess the important risk factors in the UAE construction industry via questionnaire of experts in the construction industry is conducted. The study reveals that economic risks such as inflation and sudden changes in prices, shortage in material and labor supply are significant. Other significant risks include owner risks such as improper construction scheduling, improper intervention and design change. Political, social and cultural risks are found to be insignificant. All the risk factors in the research were simplified into 2 groups: Internal risks and External risks (El-Sayegh, 2008). The summary of the risks obtained from the studies are illustrated in Table 3.5.

Table 3.5. Risks of the TMC (d).

Lam *et al.* (2007)	**Thuyet *et al.* (2007)**	**Zeng *et al.* (2007)**	**El-Sayegh (2008)**
Capability	Bureaucratic government system and delayed project approval	Human factors	Owners
Contractual & legal	Poor design	Site factors	Designers
Economic	Incompetence of project team	Material factors	Contractors
Physical	Inadequate tendering	Equipment factors	Sub-Contractors
Political and societal	Late internal approval process from the owner		Suppliers
	Inadequate project organization structure		Political
	Improper project feasibility study		Social & Cultural
	Inefficient and incompetent contractors		Economic
	Improper project planning and budgeting		Natural
	Design changes		Others

Furthermore, a risk related literature to the construction projects in China is reviewed. The data was collected by using a questionnaire and a comparative study was conducted. The key risks were grouped in 5 groups: cost related risks, time related risks, quality related risks, environment related risks and safety related risks. The study also concluded that clients, designers and government bodies should take the responsibility to manage their relevant risks (Zou *et al.*, 2007). Risks can be obtained based on checklist and utilized by making use of graphical user interface for scenario generations. The scenario generations assist in planning the starting time of activities and brings awareness of the events that face high disruption cost (Schatteman *et al.*, 2008).

A survey via questionnaire to obtain the most important causes of delays. The overall results revealed that the most important causes are; financing by contractor during construction, delayed payment by owner to contractor, design changes by owner at the construction phase, partial payments during construction, and non-utilization of professional construction/contractual management (Abd El-Razek *et al.*, 2008). Finally a case study in Sri Lanka to identify the risk responsibilities and finding ways to improve the risk handling methods. The findings from the research show Sri Lanka road construction projects' are exposed to many risks assigned by parties via contract clauses. The risks in road construction in the study are found to be: technical and contractual risks; economic, financial and political risks; managerial risks; external and site condition risks. (Perera *et al.*, 2009) Summarized findings of the studies are presented in Table 3.6.

Table 3.6. Risk of the TMC (e).

Zou *et al.* (2007)	**Schatterman *et al.* (2008)**	**Abd El-Razek *et al.* (2008)**	**Perera *et al.* (2009)**
Cost related risks	Environment	Financing by contractor during construction	Technical and contractual risks
Time related risks	Organization	Delays in contractor's payment by owner	Economic, financial and political risks
Quality related risks	Customer goods	Design changes by owner	Managerial risks
Environment related risks	Workforce	Partial payments	External and site condition risks
Safety related risks	Machines	Non-utilization of contractual management	
	Sub-contractor		

3.3.2. Risks in the PFC

PFC is one of the modern methods of construction as a part of the latest way of construction. This method aims to simplify the construction industry and increase the quality of the structures. Thus offsite construction becomes a priority to remove human errors and increases a constant quality check in the facility being produced. Despite the change to reduce human errors, there are various risks that are embedded with utilizing this method of construction. One of the pioneers to conduct a study on the modular construction was in 1993. A type of modern construction methods involving contacting the experts and developed modularization expert framework (MODEX) for decision making. This framework contains 3 steps: prescreening, detailed feasibility study and economic study. Prescreening requires less information for a weighing the factors and determining the initial feasibility. Detailed feasibility is a detailed study to determine the advantageous design and method of construction. The final stage is the economic study that presents the answer regarding cost and time savings. The system performs feasibility analysis of 5 influencing factors: plant location, environmental and organization, plant characteristics, labor consideration and project risks (Murtaza *et al.*, 1993).

Case studies from web-search, workshops and interview surveys were developed to acquire the most important risks. Lack of skills and sufficient offsite manufacture knowledge are generally the greatest problems facing offsite manufacture in Australia. The future of Australia adapting to offsite manufacture has to be followed by the better understanding of the construction process and its associated costs (Arif *et al.*, 2009). A study involving site visits and interviews were conducted with professionals on the relevant field. The case study revealed the drivers and constraints of the offsite construction. The drivers include: cost saving, time saving, high quality construction, better health and safety in construction, a higher sustainability. The constraints included site restrictions, limitation of the process and procurement problems. For a successful future of the offsite manufacture to residential construction, the industry and all the stakeholders involved need to accept the change and understand the benefits it can generate in terms of economic, social and environmental criteria (Boyd *et al.*, 2012).

In recent years an integrated model was developed for managing risk in lean manufacturing where Delphi method was also used in this case study based in Indonesia. 19 potential risks were identified and grouped into 10 risk events and 9 risk agents. The top 3 risk events concluded were: unable to achieve key Performance targets, unable to finalize action plan on schedule and unable to deliver lean manufacturing training to employees (Widiasih *et al.*, 2015). Summarized findings of the studies are presented in Table 3.7. The 9 risk agents included:

- Lack of top management commitment
- Lack of supporting facilities
- Lack of knowledge
- Lack of communication
- Unqualified human resources
- Collecting data manually
- Lack of data due
- Lack of budget
- Difficult to change work culture.

Table 3.7. Risk of the PFC.

Murtaza *et al.* (1993)	**Arif *et al.* (2009)**	**Boyd *et al.* (2012)**	**Widiasih *et al.* (2015)**
Plant location	Industry knowledge	Site	Unable to achieve Key Performance Index target.
Environmental and Organization	Cost, value and productivity	Process	Unable to finalize action plan on schedule
Plant characteristics	Industry and market culture	Procurement	Unable to deliver lean manufacturing training/knowledge to employees
Labor consideration	Skills		
Project risks	Quality		

4. METHODOLOGY

The aim of this thesis is to evaluate the risk factors of TMC and PFC in the Tanzania's current construction era and provide insight to the parties in the construction sector and public. Furthermore, the risks are weighted and ranked to obtain the major, intermediate and least significant risk factors. To accomplish this, a literature review is conducted. Data is then collected from experts. Finally a decision making software called SUPERDECISION is used in the study to conduct the data evaluations and calculates weights and rankings using AHP technique. Further in the methodology, a link of the background and the method adopted will be constructed to make justification from previous literatures.

4.1. Risk identification

The risk identification in this study is based on literature review from previous studies conducted on the construction industry. 23 peer-reviewed manuscripts are examined. The selected studies are not limited to a particular country, instead various countries are examined. Furthermore, 23 studies are selected focusing on both TMC and PFC; 19 of them are related with the onsite construction and 4 of them are on the offsite construction. Initially, the risk factors from all the selected studies are listed. Different studies tend to have similar risks thus a frequency column is created to attain the similarity between the selected studies.

This frequency reveals the most common risks in the construction industry. Some risks are important but have a less frequency since they had different names in the literatures reviewed. Hence a new and general risk factor is generated that fit numerous minor risks in it and create a large frequency for it to be selected. Some of the risk factors that also have passed the selection are merged with similar risk factors to reduce the complications in the next phase of the study. The 23 selected studies reveal a total of 141 risk factors obtained from the literature review. The frequency of each risk category is calculated and weather/climate condition has the highest frequency (16 out of 23 selected studies). Availability of materials, lack of training/skills and management & communication have the second highest frequency (13 out of 23 selected studies). These results are presented in Table 4.2, Table 4.3 and Table 4.4.

Table 4.1. Literatures Covered in the Risk Identification.

No	Title	Author	Year
1	Application of a Fuzzy Based Decision making Methodology to Construction Project Risk Assessment.	Zeng *et al*.	2007
2	Methodology for Integrated Risk Management and Proactive Scheduling for Construction.	Schatterman *et al*.	2008
3	Modelling Global Risk Factors Affecting Construction Cost Performance.	Baloi *et al*.	2002
4	Risk Assessment and Allocation in the UAE Construction Industry.	Sameh Monir El-Sayegh	2007
5	Risk Analysis and Management in Construction.	Akintoye *et al*.	1997
6	Risk Management in Construction Project Management.	Martin Schieg	2006
7	Risk Management in Oil and Gas Construction Projects in Vietnam.	Thuyet at al	2007
8	Risk Management in Road Construction the Case of Sri Lanka.	Perera *et al*.	2009
9	Using Fuzzy Risk Assessment to Rate Cost Overrun Risk in International Construction Projects.	Dikmen *et al*.	2006
10	A Fuzzy Approach to Construction Project Risk Assessment and Analysis Construction Project Risk Management System.	Carr *et al*.	2001
11	Construction Claims in United Arab Emirates Types Causes and Frequency.	Essam K. Zaneldin	2006
12	Factors Affecting Cost Performance Evidence from Indian Construction Projects	Iyer *et al*.	2005
13	Modelling Risk Allocation Decision in Construction Contracts.	Lam *et al*.	2007
14	Risk Management for Overseas Construction Projects.	He Zhi	1995
15	Systematic Risk Management Approach for Construction Projects.	Al-Bahar *et al*.	1990
16	Development of Integrated Model for Managing Risk in Lean Manufacturing Implementation in an Indonesian Manufacturing Company Case Study.	Widiasih *et al*.	2015
17	Drivers, Constraints and the Future of Offsite Manufacture in Australia.	Blismas *et al*.	2008
18	Causes of Delay in Building Construction Projects in Egypt.	Abd El-Razek *et al*.	2008
19	Knowledge-Based Approach to Modular Construction Decision Support	Murtaza *et al*.	1993
20	Off-Site Construction Of Apartment Buildings	Boyd *et al*.	2013
21	The Allocation of Risk in PPP PFI Construction Projects in the UK.	Bing *et al*.	2004
22	Risk and its Management in the Kuwaiti Construction Industry a Contractors Perspective.	Kartam *et al*.	2001
23	Understanding the Key Risks in Construction Projects in China.	Zou *et al*.	2007

Table 4.2. Risk Factors with their Frequencies.

No	Risk Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Freq.
1	Weather / climate conditions		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓			✓	✓		✓	✓		16
2	Availability of materials	✓	✓		✓			✓	✓	✓	✓	✓			✓				✓	✓		✓	✓		13
3	Lack of training / skills	✓	✓		✓		✓	✓		✓							✓	✓	✓	✓	✓		✓	✓	13
4	Management & communication	✓	✓		✓		✓	✓				✓	✓		✓				✓	✓		✓	✓	✓	13
5	Accidents (safety)		✓		✓	✓					✓	✓		✓	✓	✓		✓	✓	✓				✓	12
6	Delays/lack of formalities/permits		✓		✓			✓	✓					✓		✓			✓			✓	✓	✓	10
7	Inflation			✓	✓	✓		✓	✓						✓	✓						✓	✓	✓	10
8	Availability & condition of construction equipment	✓	✓		✓			✓	✓					✓		✓		✓		✓		✓			10
9	Site condition, constraints and access	✓		✓	✓			✓						✓				✓		✓	✓	✓			9
10	Work scheduling (work boundaries + definition)	✓	✓		✓			✓				✓			✓		✓			✓	✓	✓			10
11	Quality of materials	✓	✓		✓		✓	✓							✓			✓		✓	✓	✓			10
12	Changes in plan/design		✓		✓	✓	✓		✓							✓			✓			✓	✓	✓	10
13	Defective/poor design							✓	✓	✓		✓		✓	✓	✓			✓				✓		9

Table 4.3. Risk Factors with their Frequencies (Cont.).

No	Risk Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Freq.
14	Labor disputes, strikes & fatigue			✓	✓						✓		✓	✓		✓				✓		✓	✓		9
15	Instability of political condition + war threats			✓	✓					✓			✓	✓	✓							✓	✓		8
16	Delayed payment				✓		✓		✓	✓		✓							✓			✓		✓	8
17	Inaccurate estimation of duration		✓				✓		✓			✓	✓		✓						✓			✓	8
18	Sudden bankruptcy/ availability of finance				✓	✓		✓							✓							✓	✓	✓	7
19	Geological / foundation conditions			✓							✓			✓	✓				✓				✓		6
20	Government relations / stability			✓				✓				✓			✓							✓		✓	6
21	Attitudes and motivations	✓		✓						✓			✓				✓								5
22	Acts of God (force majeure)								✓							✓						✓	✓		4

Table 4.4. Risk Factors with their Frequencies (Cont.).

No.	**Risk Factors**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**Freq.**
23	Insecurity & criminal acts		✓	✓	✓										✓	✓									5
24	Project complexity			✓		✓	✓	✓		✓															5
25	Changes in laws and regulations				✓									✓		✓		✓					✓		5
26	Change or variation orders											✓								✓		✓		✓	4
27	Market conditions / culture			✓			✓								✓			✓					✓		5
28	Slow delivery of materials			✓														✓	✓		✓			✓	5
29	Corrupt & bribery practices			✓	✓	✓		✓							✓										5
30	Exchange rate fluctuation			✓	✓										✓	✓									4
31	Interest rates fluctuation			✓				✓							✓								✓		4
32	Taxation changes			✓				✓							✓								✓		4

Minor risks are merged to a major group to provide a high frequency risk factor. For instance, availability of competent labor and training/skills are combined to form “lack of training/skills”. Communication (disagreement/incompetence within team) and management (organization structure) are merged resulting to “management & communication problems”. Site constraints and access (logistics and site operations) and unexpected site conditions (working environment) are combined to form “site condition, constraints and access”. Availability of construction equipment (increase of cost) and condition of construction equipment (equipment productivity + failure), are also merged forming “availability and condition of construction equipment”. Labor disputes & strikes and labor fatigue / productivity are melded together creating “labor disputes, strikes & fatigue”. Finally, civil disorder losses (instability of political condition) and war threats are also melded creating “instability of political condition + war threat” (Table 4.5).

Table 4.5. Merging Minor Risks to Resulting Risk Factor.

Minor Risks Merged	**Resulting Risk Factor**
Availability of competent labor	Lack of training / skills
Training / skills	
Communication	Management & communication problems
Management (organization structure)	
Site constraints and access (logistics and site operations)	Site condition, constraints and access
Unexpected site conditions (working environment)	
Availability of construction equipment	Availability and condition of construction equipment
Condition of construction equipment	
Labor disputes & strikes	Labor disputes, strikes & fatigue
Labor fatigue / productivity	
Civil disorder losses (instability of political condition)	Instability of political condition + war threat
War threats	

Apart from the merging of the risk factors to eliminate the confusion of similar risk factors, new risk factors are formed from different minor risk factors. For instance "change or variation orders caused by owner". This risk factor comprised of 5 other risk factors that had similar concept: change orders negotiations (by owner) (Zaneldin, 2006; Kartam and Kartam, 2001), change or variation orders by client/owner (Zaneldin, 2006; Zou *et al.*, 2007), willingness to live with design constraints (Murtaza *et al.*, 1993; Boyd *et al.*, 2012), excessive bureaucracy in project owner operation (Abd El-Razek *et al.*, 2008) and owner receptivity to modularization (Murtaza *et al.*, 1993).

The risk factors with a frequency more than 4 are then separated and groups are established to fit the relevant risks. In total 32 critical risk factors are identified and they are enlisted into 9 sub-groups and 2 main groups. The main groups are given as internal and external risks. This is followed by sub-groups: owner, designer, contractor/company, suppliers, political, social & cultural, economic, natural and site. From these sub-groups, several risk factors are listed accordingly.

4.2. Critical Risk Factors

An intense literature review of 23 academic papers that were published in the years between 1993 and 2015 are examined. All the selected papers are related with the construction industry. The papers are on a global scale, and the literatures cover both traditional and prefabricated methods. The papers reviewed to provide the final risks in this study are obtained by searching the following key words: "Risk in construction", "Risk in modular construction", "Risk in Prefabricated construction" and "Risk in Offsite construction". 23 selected papers are examined to identify the risk factors. The risk factors with frequency of four or more are used to conduct this study. This lead to a total of 32 risk factors existing in at least four academic papers. These risks are used to undergo further evaluation and evaluated to obtain the ranking of the very significant risk factors in the TCM and PFC. The 32 risks are grouped into 9 sub-groups: Owner, Designer, Contractor/ Company, Suppliers, Political, Social and Cultural, Economic, Natural and Site. These sub-groups are then further grouped into two main groups; Internal and External.

4.2.1. Internal Risks

The internal risks in the construction industry focuses on the factors that are affecting the industry from within the construction sector. The internal risks are those uncertainties acquired by the companies involved or determined by the project's own nature (Zhi, 1995). The sub-categories are further explained in detailed with their risk factors. The risk factors in the sub-categories differ. The internal risks comprises of:

- Owners Risks,
- Designers Risks,
- Contractor/Company Risks and
- Suppliers Risks.

<u>4.2.1.1. Owners Risks.</u> The owner is one of the internal risks since the owner has a direct influence to the project. The owner can be an individual, a company or the government. The owner related risks consists of 2 risk factors; Delayed Payment and Changes or Variation of Orders. The payment to the contractors or subcontractors by the owner can lead to a stagnation to the commencing or proceed with other phases of the project. Payments for a construction project from the owners are the main source of fund for construction contractors. Whenever the owners delay payments to contractors, a financial burden is placed on the contractors. Moreover, owners often tend to rush projects for time and money leading to changes or variation of the orders when the construction is underway (El-Sayegh, 2008). Delays in payment to the contractors covers both, full and partial payments delayed for any particular reason (Abd El-Razek et al., 2008). The owner can decide to alter the initial order. This alteration if done after the construction has begun, can lead to extra costs and time overruns. The change of order will require replacement of the current sent order to the site incurring extra cost and time.

4.2.1.2. Designers Risks. Among the important internal risks is the designer related risks, as any given project cannot begin without an approved design attained from the design team. The designer risks are broken down into three categories; Changes in Plan Design, Defective/Poor Design and Project Complexity. The design changes also tend to occur after approvals of previous designs. The earlier this occurs, the lesser the impacts to the project (Van Thuyet *et al.*, 2007). The risk of defective design and scope change cannot be underestimated because this would lead to poor performance of the project (Perera *et al.*, 2009). Poor design work is a part of the designer related risks since the design work is done at the early stage in the project life cycle, and the quality of earlier stage work often has strong impact on the total project. Complex specifications used in the drafted design will have impact to the project since the design will undergo reviews resulting to additional time spent until the designer and contractor’s team come to a mutual understanding. Thus the increasing of the size and complexity of construction projects adds to the risks of time overruns (El-Sayegh, 2008).

4.2.1.3. Contractor/Company Risks. The contractor makes the company efficient by applying the management and communication system effectively. The contractors/company risks involve a number of sub-categories such as: Lack of Training/Skills, Management & Communication Problems, Availability and Condition of Construction Equipment, Inaccurate Scheduling and Labor Disputes, Strikes & Fatigue. Lack of skills is a major problem in the fields of construction and project management where modern skills are required. This is caused by the movement of talented staff searching for better opportunities. The cooperative the management team, in terms of management and communication, the more successful the project can be. Similarly to clients, contractors are acknowledged to have extensive influences on the project objectives (Zou *et al.*, 2007). Availability and condition of construction equipment is considered as a significant risk factor to be observed. The less and worse condition equipment will eventually lead to a slow progress of the work causing time overruns. The contractors/company’s team are responsible for scheduling of the projects. Any miscalculations will lead to time overruns. Labor strikes and disputes can disrupt construction activity and have negative impact to the project objectives. (El-Sayegh, 2008). The Labor strikes and disputes may lead to litigation causing more time spent and extra costs for the legal system procedures.

4.2.1.4. Suppliers Risks. The suppliers play a significant role in terms of determining the riskiness of an existing project. The suppliers' risks contains 3 risk factors. These include: Availability of Materials, Quality of Materials and Slow Delivery of Materials. Availability of materials and quality, are important to the contractors unlike the project management practices because these risks are related to construction process on site (Akintoye and MacLeod, 1997). The absence of the materials at a close distance will require transporting them from a far location, resulting to extra time and cost. Supplier's risks are mostly caused by the large number and size of new projects imposing constraints on material suppliers. The quality is of great importance in terms of suppliers. Therefore, when the quality provided by the supplier is low this leads to low quality of work. Some materials can require the importation of goods, hence any problems that will arise in the transportation process will lead to slow delivery of materials ordered (El-Sayegh, 2008).

Table 4.6. Internal Risks with its Sub-Groups.

Internal Risks			
Owners	**Designers**	**Contractor / Company**	**Suppliers**
Delayed payment	Changes in plan/design	Lack of training / skills	Availability of materials
Change or variation of orders	Defective/poor design	Management & communication problems	Quality of materials
	Project complexity	Availability and condition of construction equipment	Slow delivery of materials
		Inaccurate scheduling	
		Labor disputes, strikes & fatigue	

4.2.2. External risks

Additionally to the internal risks, there’s also a classification of external risks. These risks have a considerable impact to the overall project with an indirect effect compared to the internal risks. The external risks are those changeable factors that relate to the national/regional market or the local construction industry which have significant impacts on the project (Zhi, 1995). The external risks are further categorized to 5 sub-groups:

- Political Risks,
- Social and Cultural Risks,
- Economic Risks,
- Natural Risks and
- Site Risks.

4.2.2.1. Political Risks. Political risks is one of the major part of the external risk. This sub-category attain even more importance when the undergoing project is owned by the government. The political risks consist of 5 risk factors. These include: delays/lack of formalities/permits, instability of political condition + war threat, government relations / stability, changes in laws and regulations and corrupt & bribery practices. The delays of the permits and regulations in the sector are external risks since the projects are required to obtain permits from third parties for them to commence (Perera *et al.,* 2009). The delays in formalities/permits in addition to the bureaucracy is not because the government bodies are not efficient but generally due to the large number and sizes of ongoing projects (El-Sayegh, 2008). Delays of formalities have various consequences including: claims and disputes, delays, stoppages of work, inflated costs (Akintoye and MacLeod, 1997). Instability and war threat is significant as this leads to a halt of entire project resulting to cost and time overruns. The presence of heavy bureaucracy shows that the governmental agencies’ major influences are concerned with project cost, time and sustainability (Zou *et al.*, 2007). The bureaucracy can be as a result of bad government relations with the companies. Changes in laws like change in labor acts, could require the salaries of laborers to be increased leading to extra cost. Depending on the country, corruption and bribes is considered as a significant risks. The corruption and bribery practice lead to extra costs that was not accounted for.

4.2.2.2. Social and Cultural Risks. Social and cultural risks are an important sub-category in the construction sector, since the social and cultural traits vary from one place to another. This study has three risk factors in the social and cultural sub-category. These include: attitudes and motivations (undisciplined employee), insecurity & criminal acts and market conditions / culture. Attitudes and motivations is an important factor since having undisciplined employees will create problems in the project execution leading to delays. Criminal acts by the locals in the area of the project execution will lead to extra cost in attaining replacement of the damaged or stolen equipment. Investors have to understand the cultural differences to be able to live, attain projects and efficiently work in foreign nations (El-Sayegh, 2008). Social environment problems are most likely to be caused by language barriers, religious differences, cultural differences, crime and lack of security, and informal relationships and brotherhood (Zhi, 1995).

4.2.2.3. Economic Risks. In every construction project, the cost and profit generation is of great importance, thus making the economic situation a part of external risks. Price inflation of construction material is a global risk and it is not directly related to a project stakeholder. Nevertheless, all project team members including the client, designers, contractors, subcontractors and suppliers should assist to administer the issue (Zou *et al.*, 2007; Akintoye and MacLeod, 1997). The availability of funds is crucial especially when there is a dependence on foreign funding, creating a limited amount of fund (Perera *et al.*, 2009). The absence of materials for construction locally requires importing them. In this process, exchange rate becomes an important key factor and its fluctuation causes a crucial economic risk to the construction process. The economic and financial risks may arise from a local economy crisis (such as an abrupt decreasing Gross National Product), critical under-development (such as an incompatibly low Gross National Product per capita), interest rate fluctuations, rising inflation, foreign currency exchange rate fluctuations, and rising tax rates (Zhi, 1995).

4.2.2.4. Natural Risks. The construction processes have a natural related factor that has a significant effect to the overall project completion. Acts of God and weather condition may have an impact to the construction activities. Bad weather condition can cause schedule delays in a construction project (Zhi, 1995). This can include excess rain and wind conditions resulting to impossible labor working condition causing time overruns. Acts of God like Tsunami and earth slips may have the construction activities halted for a few days. The materials can be washed away and work in progress affected by the unexpected rainfall (Perera *et al.*, 2009).

4.2.2.5. Site Risks. Construction industry mainly consists of projects conducted on site. Despite having offsite construction, assembling of the components would involve the site. The site risks includes accidents which are directly related to the safety precautions taken, site condition and constraints. Site safety and site condition are one of the site related risks. They are important to the contractors unlike the project management practices because these risks are related to construction process on site (Akintoye and MacLeod, 1997). Any accidents that the workers will encounter on site will lead to time overruns for the assessment of the safety conditions and cost overruns for compensation cost. Work scheduling is a factor to be taken into account since it involves deciding the resources, cultivating procurement management and payment plans, deciding the labor power needed, cash flows together with the allocation of contractors and sub-contractors. Ground conditions are important at the construction stage, and are typically borne by contractor (Bing *et al.*, 2005). Bad ground conditions after the construction process has commenced, results to extra costs and time overruns.

These external risk factors have been summarized in the Table 4.7 where the various sub-category of the major risk factor are enlisted. This is followed by provision of the risk factors of each sub-category. Political and economic sub-category contains a total of 5 risk factors, whereas site sub-category consist of 4 risk factors. Social and cultural sub-category contains 3 risk factors whereas natural sub-category containing a total of 2 risk factors. This illustrates the majority of the risks being in the political and economic sub-category.

Table 4.7. External Risks with its Sub-Groups.

External Risks				
Political	**Social & Cultural**	**Economic**	**Natural**	**Site**
Delays/lack of formalities/permits	Attitudes and motivations (undisciplined employee)	Inflation	Weather / climate conditions	Accidents (safety)
Instability of political condition + war threat	Insecurity & criminal acts	Sudden bankruptcy/ availability of finance	Acts of God (force majeure)	Site condition, constraints and access
Government relations / stability (policies/bureaucracy)	Market conditions / culture	Exchange rate fluctuation		Work scheduling (work boundaries)
Changes in laws and regulations		Interest rate fluctuation		Geological / foundation conditions
Corrupt & bribery practices		Taxation changes		

4.3. Analytical Hierarchy Process (AHP)

This multi-criteria decision method was first introduced by Thomas Saaty in 1980. Saaty defined AHP as “a decision making model that aids us in making decisions in our complex world” (Saaty, 1988). As the name states, it involves hierarchy of the goal to the alternatives linking them. Fundamentally the AHP works by establishing priorities for alternatives and criteria used to judge the alternatives (Saaty, 2001). The AHP has various uses for the decision maker (Saaty, 1988): assist in designing a form that represents a complex problem, measure priorities and choose among alternatives, measure the consistency, predict a cost analysis, formulate a cost analysis, design forwards and backward planning, analyze conflict resolution and develop resource allocation.

The most essential task in making decision is to select the factors that are important for the particular decision. This study utilizes AHP for the ranking performed by the experts. The risk factors involved in this study included owner, designer, contractor/company, supplier, political, social & cultural, economic, natural and site. AHP is utilized in this study since there is not any direct dependencies between natural and owner risk factors, designer and site, contractor/company and economic, social & cultural and site, political and natural, political and site or supplier and political. The other reason leading to the selection of the AHP technique for this study is because AHP has the higher general awareness. Its hierarchical structure is intuitively more understandable for inexperienced users and because of its simplicity it is more suitable for an illustration and evaluation of group aggregation techniques (Ossadnik *et al.*, 2016). Considering Tanzanian and Turkish experts' first encounter to this data collection technique and ranking, AHP technique in the risk analysis emerged as a convenient technique to collect a reliable data from the experts.

Furthermore, 232 different papers published between the years 2005 and 2009 were reviewed (Sipahi and Timor, 2010). They developed a table that illustrates how often the AHP, ANP, Fuzzy AHP and Fuzzy ANP were used in the examined papers (Table 4.8). From the table, manufacturing and construction industry are taken into account together as they represent prefabricated and traditional method respectively. Table 4.8 shows that manufacturing industry having 45 out of 76 studies conducted utilizing AHP compared to 23 out of 76 for Fuzzy AHP. Whereas in the construction industry, despite having less studies reviewed, 8 out of 11 showed the use of AHP method following 1 out of 11 for ANP and Fuzzy AHP. For these reasons, AHP technique is concluded to be a widely used and convenient method for this research that involves both, a construction and manufacturing industry.

Table 4.8. Literature Review of Areas with the Corresponding Decision Making Tool Utilized (Sipahi and Timor, 2010)

Area	**AHP**	**ANP**	**AHP & ANP**	**Fuzzy AHP**	**Fuzzy ANP**	**Fuzzy AHP & Fuzzy ANP**	**Total**
Manufacturing industry	45	2	4	23	1	1	76
Environmental management and agriculture	24	-	1	1	-	-	26
General decision problems	12	2	1	3	1	-	19
Power and energy industry	14	-	-	1	-	-	15
Transportation industry	12	1	-	2	-	-	15
Construction industry	8	1	1	1	-	-	11
Health	10	-	-	-	-	-	10
Others	44	3	2	11	-	-	60
Total	169	9	9	42	2	1	232

The AHP arrange the selected factors in a hierarchy structure first undergo priority derivation for the performance of the alternatives. The priorities are then derived based on pairwise assessments using judgment. Finally a weighting and adding process is used to attain the overall priority for the alternatives to the goal (Saaty, 2001). The pairwise assessments is normally conducted by the aid of a matrix. The matrix set up will contain a diagonal of 1's since when comparing similar criteria, they definitely will have a same importance (Table 4.9).

Table 4.9. Matrix of Importance Relationship between the Criteria.

	n1	**n2**	**n3**	**n4**
n1	1	….	….	….
n2	….	1	….	….
n3	….	….	1	….
n4	….	….	….	1

(i) Conducting of a pairwise comparison of every criteria using the ranking below:

Table 4.10. AHP Fundamental Scale (Source: Saaty, 1977).

Intensity of Importance	**Definition**
1	Equal importance
3	Moderate importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute/Extreme importance
2, 4, 6, 8	Intermediate values

If an activity “i” has one of the above intensity of importance (non-zero numbers) assigned in when compared to activity “j”, then “j” has the reciprocal value when in comparison to “i” (Saaty, 1977). The upper part of the matrix is basically the reciprocal of the lower part of the Criteria Comparison matrix, C.

(ii) Sum up elements of every column

Table 4.11. Summation of the Columns of the Criteria Comparison Matrix.

	n1	**n2**	**n3**	**n4**
n1	1	….	….	….
n2	….	1	….	….
n3	….	….	1	….
n4	….	….	….	1
Sum Columns	∑ (column 1)	∑ (column 2)	∑ (column 3)	∑ (column 4)

(iii) Normalize the Criteria Comparison Matrix

This step involves the division of the elements importance in every column, obtained in step 3, dividing it with the sum of the respective column. This will result to a Normalized Criteria Comparison Matrix. To know that the data is correct, the updated matrix (Normalized Criteria Comparison Matrix) should give a sum of 1.

Table 4.12. Normalized Criteria Comparison Matrix.

	∑ (column 1)	∑ (column2)	∑ (column3)	∑ (column4)
Normalized Criteria Comparison Matrix				
	n1	**n2**	**n3**	**n4**
n1	1/∑(column1)	../∑(column2)	../∑(column3)	../∑(column4)
n2	../∑(column1)	1/∑(column2)	../∑(column3)	../∑(column4)
n3	../∑(column1)	../∑(column2)	1/∑(column3)	../∑(column4)
n4	../∑(column1)	../∑(column2)	../∑(column3)	1/∑(column4)
Sum Columns	1	1	1	1

(iv) Finding the mean of the Rows of the Normalized Criteria Comparison Matrix.

As stated by Saaty, AHP aids us in making decisions in our complex world, determination of the criteria weights is significant. The higher the criteria weight the more significant the criteria is considered to be. These criteria weights are calculated by the mean of the normalized criteria comparison matrix.

Table 4.13. Normalized Criteria Comparison Matrix with the Criteria Weights.

	∑ (column 1)	∑ (column2)	∑ (column3)	∑ (column4)	**Criteria Weights (W)**
Normalized Criteria Comparison Matrix					
	n1	**n2**	**n3**	**n4**	
n1	1/∑(column1)	../∑(column2)	../∑(column3)	../∑(column4)	**Mean_1**
n2	../∑(column1)	1/∑(column2)	../∑(column3)	../∑(column4)	**Mean_2**
n3	../∑(column1)	../∑(column2)	1/∑(column3)	../∑(column4)	**Mean_3**
n4	../∑(column1)	../∑(column2)	../∑(column3)	1/∑(column4)	**Mean_4**
Sum Columns	1	1	1	1	

(v) Checking the consistency ratio of the ranking. The consistency ratio (CR) of a pairwise comparison matrix is the ratio of its consistency index μ to the corresponding Random Index (RI) (Saaty, 2004).

$$(Ws) = [C]\ (W) \tag{3.1}$$

$$\text{Dot product (Consistency)} = (Ws) \bullet \left(\frac{1}{W}\right) \tag{3.2}$$

$$CI = \frac{(\lambda - n)}{(n - 1)} \tag{3.3}$$

$$\text{Consistency ratio (CR)} = \frac{CI}{RI} \tag{3.4}$$

where:

Ws = Weight sums vector.
C = Normalized Criteria Comparison Matrix.
W = Criteria Weights.
n = number of criteria.
λ = Average of the elements of (Consistency).
RI = Random Index.
CI = Consistency Index

Maintaining the consistency is considered to be a priority. Saaty (1988) gave the inconsistency magnitude split of 90% and 10% (Saaty, 1988). This means, the consistency ratio obtained has to be less than 10% (0.01) for the data to be consistent. Saaty (2004) stated things to be done when the consistency ratio is higher than desired. These include:

(i) Find the most inconsistent judgement in the matrix.
(ii) Determine the range of values to which that specific judgement can be changed for improvement of the inconsistency.
(iii) Ask the decision maker to consider changing his judgement to a value of the more appropriate value in the range.

Shortly, the AHP generally has a trend in terms of its procedure starting with construction of hierarchy of criteria from the available information. Then integrating the information by normalization to obtain the relative rankings. Information from qualitative and quantitative section are then compared and weights and priorities are acquired. In this method, the groups are considered independent to each other, as the factors in a single group are not to be thought to have any sort of inter-relationship with another group. This being said, the goal node is only affected by the 2nd level of the hierarchy whereas this level is only affected by the 3rd level and subsequently the alternatives are affected by the 3rd level (Vayvay *et al.*, 2012). The progressive usage of decision making tools lead to Thomas Saaty's team seeking to invent a software to conduct the ranking. The software invented is called SUPERDECISION.

4.4. Super Decision Software

Following the increase use of AHP technique discovered by Thomas L. Saaty, SUPERDECISION software was developed by his research team. The software was fully sponsored by Creative Decisions Foundation which was set up in 1996 by Thomas L. Saaty and his wife. Thomas L. Saaty is currently holding the title of distinguished university professor at Pitt Business School, Pennsylvania, USA. Creative Decision Foundation is privately owned with the aim of providing education to people globally on how to make rational decisions. The foundation provide sponsorship to education, researches together with software development in advanced decision-making methods using AHP and ANP. Since the AHP has a couple of steps, this program provides a User Interface that can integrate all the data and calculate the required values needed for the assessment and decision making.

The basic SUPERDECISION model consist of a goal cluster that holds the goal element, criteria cluster holding the criteria elements and alternatives cluster that is equipped with the alternative elements. These clusters are linked together and the pairwise comparison is conducted. This goal cluster for this study is the very significant risk factors in the method of construction. Criteria cluster contains the internal and external risks. Sub-criteria is added in this study to enclose the owner, designer, contractor/company, supplier, political, social and cultural, economic, natural and site. Finally the alternatives is made for each sub-criteria. The data fed into the SUPERDECISION software is obtained from professionals who are experts on TMC or PFC. The use of small sample (10 or below) in AHP analysis has been adopted by abundant researchers (Lam and Chin, 2005). Therefore, getting data from 20 experts, 10 for each construction method is a reasonable approach. These professionals have different roles and years of experiences in their field.

The aim of this thesis is to evaluate the risk factors of TMC and PFC in the Tanzania's current construction era. The pairwise comparison for risk factors associated with each construction technique is conducted separately. TMC experts involved are from Tanzania. Considering PFC is an unfamiliar technique in Tanzania, experts from Turkish Prefabricated industry with international construction experiences in Africa including Tanzania are selected. Table 4.14 and Table 4.15 shows the experts' current position and their number of years of experience.

Table 4.14. Experts' Information from PFC.

PREFABRICATED CONSTRUCTION PROFESSIONALS		
PROFESSIONAL	**POSITION**	**YEARS OF EXPERIENCE**
1	General Manager	18
2	General Manager	20
3	Factory Director	18
4	Production Manager	18
5	Project Manager	11
6	Planning Director	11
7	Civil Engineer	7
8	Senior Corporate Sales Manager	19
9	Corporate Sales Manager	7
10	Sales Manager	3

Table 4.15. Experts' Information from TMC.

TRADITIONAL CONSTRUCTION PROFESSIONALS		
PROFESSIONAL	**POSITION**	**YEARS OF EXPERIENCE**
1	Chief Engineer (Civil Eng.)	39
2	Managing Director (Architect)	35
3	Managing Director (Civil Eng.)	28
4	Managing Director (Civil Eng.)	33
5	Architect	20
6	Civil Engineer	20
7	Civil Engineer	20
8	Civil Engineer	6
9	Project Supervisor	4
10	Site Engineer	3

The average years of experience of the experts who work in prefabricated construction is 13 years. Most of the professionals work at the production, planning, sales and management sector since these sectors are the crucial and most important ones in the prefabricated construction. The prefabrication construction's professionals were selected from four different privately owned companies in Turkey. The traditional method of construction's professionals have an average of 19 years of experience with most of them being civil engineers and architects from different companies. Similarly, the professionals also work in privately owned construction companies in Tanzania.

The rating that were used by the professionals were on a 1-9 scale which was invented by Saaty (Saaty, 1977). The SUPERDECISION software provides a various ways to input the data obtained from the experts. There is a questionnaire, matrix, direct, verbal and graphical input methods. All these methods provide a pairwise comparison of the risk factors. The experts conducted a pairwise comparison for the sub-criteria and the alternatives.

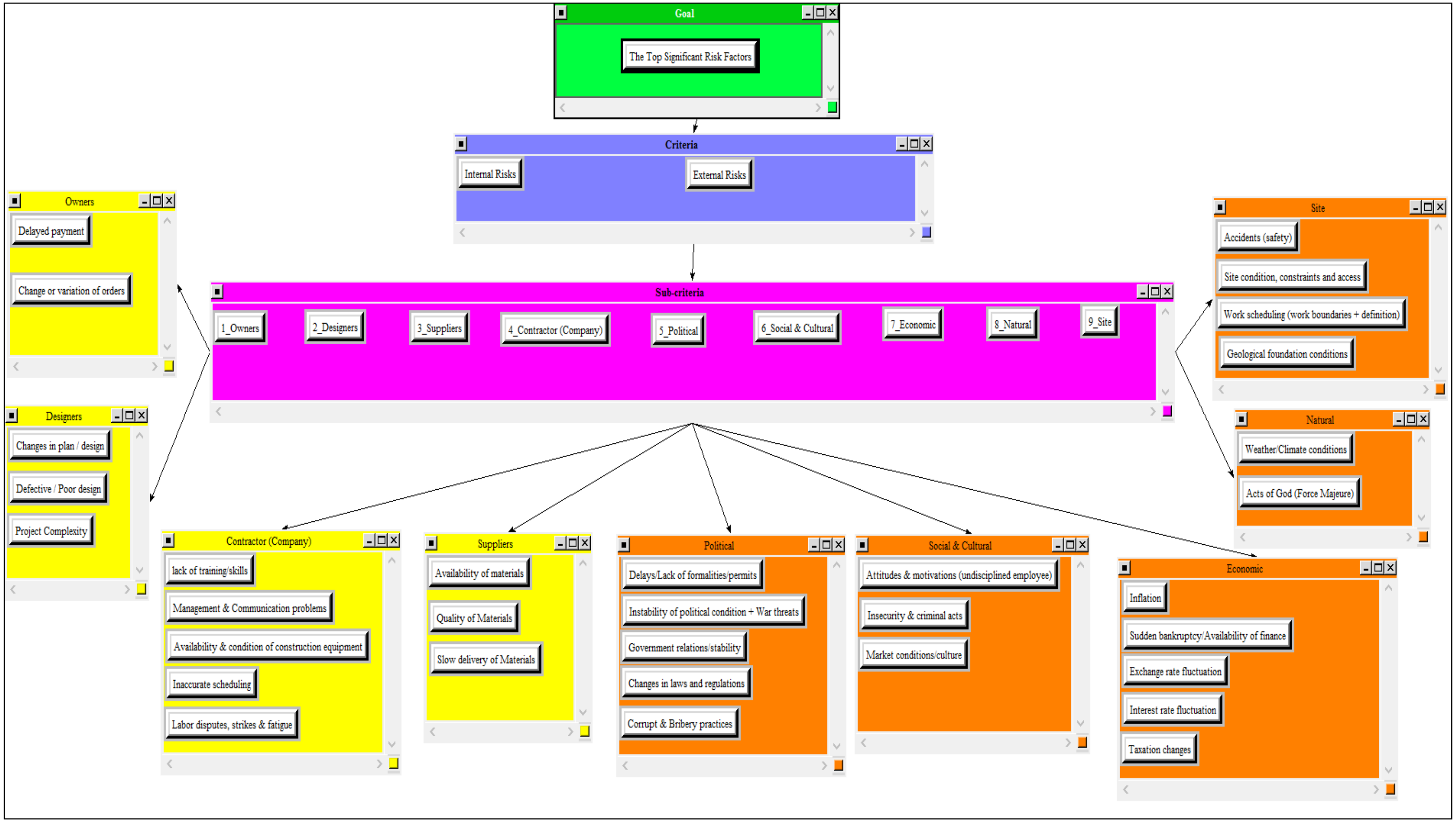

Figure 4.1. AHP Model for Risk Assessment (Retrieved from SUPERDECISION Software).

5. RESULTS AND FINDINGS

The data from 20 professionals are collected from a questionnaire prepared in English and Turkish for the Tanzania and Turkish focus expert groups. The prefabricated construction related data is collected from Turkish experts while the traditional construction related data is collected from Tanzania's experts. A total of 32 risk factors are gathered. They are classified into 9 sub-categories:

- Owner risks
- Designer risks
- Contractor/Company risks
- Supplier risks
- Political risks
- Social and Cultural risks
- Economic risks
- Natural risks
- Site risks

The results are separated into TMC and PFC, with further isolation for internal and external risks done separately. These results are all based on experts' opinion. Internal risks included the risk factors in the owner, designer, contractor/company and supplier sub-categories. External risks included the risk factors in the political, social and cultural, economic, natural and site sub-categories. The overall and mean overall normalized weights for the internal PFC risk factors can be seen in (Table 5.1). The risk factors with the highest mean overall normalized weight in the internal PFC are delayed payment (0.1187) and change or variation of orders (0.0749). These risk factors are from the owner sub-group.

The overall and mean overall normalized weights for the external PFC risk factors can be seen in (Table 5.2) and (Table 5.3). The risk factors with the highest mean overall normalized weight in the external PFC are sudden bankruptcy/ availability of finance (0.0796) and instability of political condition and war threat (0.0759). These risk factors are from economic and political sub-categories. Further analysis is made for standard deviation, coefficient of variation and variation degree. This is shown in (Table 5.4) and (Table 5.5). The overall and mean overall normalized weights for the internal TMC risk factors can be seen in (Table 5.6). The risk factors with the highest mean overall normalized weight in the internal PFC is change or variation of orders (0.0840) from the owner category. The overall and mean overall normalized weights for the external TMC risk factors can be seen in (Table 5.7) and (Table 5.8). The risk factors with the highest mean overall normalized weight in the external PFC are acts of God (0.0555) and weather/climate condition (0.0517). These risk factors are from natural sub-categories. Further analysis is conducted for the standard deviation, coefficient of variation and variation degree of the TMC risk factors according to the experts' opinion. This is shown in (Table 5.9) and (Table 5.10).

The risk factors are further analyzed with the coefficient of variations (CV) of the internal and external risks separately. The coefficient of variation is defined as the standard deviation of a variable divided by its mean (Sørensen, 2002). Coefficient of variation is the ratio of the standard deviation to the mean of the original values (Reed *et al.*, 2002). This analysis was based on finding the variation of the experts' opinion to the rating of the risk factors. A variation degree of less than 1 illustrate less variance whereas a ratio of higher than 1 illustrate a high variance. The data was categorized in internal TMC risk factors, internal PFC factors, external TMC risk factors and external PFC risk factors.

The internal TMC risk factors resulted to 6 higher variances (Figure 5.1): delayed payment (1.1893), changes in plan/design (1.0593), project complexity (1.0952), inaccurate scheduling (1.0924), labor dispute and fatigue (1.2877) and availability of materials (1.2793). The internal PFC risk factors resulted to 4 higher variances (Figure 5.2): change or variation of orders (1.2366), changes in plan/design (1.1040), lack of training (1.2969), availability and condition of construction equipment (1.4157). The external TMC risk factors resulted to 5 higher variances (Figure 5.3): sudden bankruptcy/availability of finance (1.0379), interest rate fluctuation (1.1665), taxation changes (1.1081), site condition, constraints and access (1.3170) and geological conditions (1.0657). The external PFC risk factors resulted to 8 higher variances (Figure 5.4): insecurity & criminal acts (1.1332), inflation (1.2529), interest rate fluctuation (1.1573), weather conditions (1.1102), acts of God (1.0224), accidents (1.3319), work scheduling (1.0002), geological conditions (1.1648).

Table 5.1. Overall and Mean Overall Normalized Weights for the Internal PFC Risk Factors.

INTERNAL RISK FACTORS	**PFC1**	**PFC2**	**PFC3**	**PFC3**	**PFC4**	**PFC5**	**PFC6**	**PFC8**	**PFC9**	**PFC10**	**Mean Overall Normalized weights**
Delayed payment	0.0126	0.1008	0.0330	0.0933	0.1499	0.2700	0.0300	0.2421	0.2241	0.0311	0.1187
Change or variation of orders	0.0884	0.0112	0.0110	0.0187	0.0301	0.0300	0.2700	0.0269	0.0449	0.2179	0.0749
Changes in plan/design	0.0015	0.0082	0.0061	0.0032	0.0023	0.0040	0.0027	0.0088	0.0271	0.0041	0.0068
Defective/poor design	0.0161	0.0208	0.0143	0.0286	0.0225	0.0308	0.0225	0.0793	0.0630	0.0161	0.0314
Project complexity	0.0064	0.0020	0.0016	0.0123	0.0051	0.0112	0.0207	0.0088	0.0070	0.0018	0.0077
Lack of training / skills	0.0765	0.0248	0.0883	0.0010	0.0068	0.0151	0.0033	0.0097	0.0059	0.0114	0.0243
Management & communication problems	0.0084	0.0047	0.0540	0.0035	0.0011	0.0186	0.0531	0.0173	0.0151	0.0245	0.0200
Availability & condition of construction equipment	0.0279	0.0059	0.0080	0.0017	0.0035	0.0563	0.0088	0.0011	0.0033	0.0057	0.0122
Inaccurate scheduling	0.0078	0.0156	0.0302	0.0050	0.0127	0.0050	0.0256	0.0024	0.0015	0.0369	0.0143
Labor disputes, strikes & fatigue	0.0073	0.0020	0.0144	0.0139	0.0010	0.0040	0.0082	0.0046	0.0092	0.0154	0.0080
Availability of materials	0.0436	0.0058	0.0046	0.0526	0.0220	0.0538	0.0535	0.0390	0.0123	0.0276	0.0315
Quality of materials	0.0103	0.0521	0.0491	0.0050	0.0057	0.0212	0.0194	0.0390	0.0302	0.0682	0.0300
Slow delivery of materials	0.0041	0.0520	0.0193	0.0125	0.0513	0.0050	0.0070	0.0391	0.0745	0.0112	0.0276

Table 5.2. Overall and Mean Overall Normalized Weights for the External PFC Risk Factors.

EXTERNAL RISK FACTORS	**PFC1**	**PFC2**	**PFC3**	**PFC3**	**PFC4**	**PFC5**	**PFC6**	**PFC8**	**PFC9**	**PFC10**	**Mean Overall Normalized weights**
Delays/lack of formalities/permits	0.0111	0.0107	0.0163	0.0169	0.0406	0.0465	0.0066	0.0260	0.0015	0.0062	0.0182
Instability of political condition + war threat	0.1131	0.1526	0.0076	0.1739	0.1473	0.0247	0.0686	0.0054	0.0112	0.0549	0.0759
Government relations / stability	0.0254	0.0652	0.0977	0.0886	0.0686	0.0811	0.0216	0.0022	0.0030	0.0454	0.0499
Changes in laws and regulations	0.0577	0.0168	0.0530	0.0438	0.0118	0.0110	0.0061	0.0022	0.0032	0.0237	0.0229
Corrupt & bribery practices	0.0098	0.0297	0.0154	0.0138	0.0118	0.0057	0.0661	0.0022	0.0191	0.0248	0.0198
Attitudes and motivations	0.0082	0.0281	0.0154	0.0032	0.0095	0.0033	0.0055	0.0117	0.0124	0.0110	0.0108
Insecurity & criminal acts	0.0033	0.0038	0.0599	0.0135	0.0023	0.0080	0.0022	0.0496	0.0482	0.0110	0.0202
Market conditions / culture	0.0345	0.0231	0.0066	0.0013	0.0242	0.0197	0.0233	0.0047	0.0053	0.0110	0.0154
Inflation	0.1576	0.0265	0.0109	0.0260	0.0273	0.0565	0.0057	0.0061	0.0415	0.0067	0.0365

Table 5.3. Overall and Mean Overall Normalized Weights for the External PFC Risk Factors (Cont.).

EXTERNAL RISK FACTORS	**PFC1**	**PFC2**	**PFC3**	**PFC3**	**PFC4**	**PFC5**	**PFC6**	**PFC8**	**PFC9**	**PFC10**	**Mean Overall Normalized weights**
Sudden bankruptcy/ availability of finance	0.0107	0.1384	0.0182	0.1190	0.1782	0.0989	0.0957	0.0468	0.0155	0.0748	0.0796
Exchange rate fluctuation	0.0595	0.0823	0.0897	0.0491	0.0431	0.0257	0.0328	0.0202	0.0190	0.0454	0.0467
Interest rate fluctuation	0.0818	0.0549	0.1718	0.0183	0.0345	0.0090	0.0124	0.0133	0.0179	0.0225	0.0436
Taxation changes	0.0244	0.0169	0.0404	0.0077	0.0140	0.0139	0.0573	0.0156	0.0082	0.0225	0.0221
Weather / climate conditions	0.0065	0.0218	0.0027	0.0256	0.0030	0.0039	0.0052	0.0594	0.0110	0.0563	0.0195
Acts of God	0.0325	0.0073	0.0243	0.1274	0.0210	0.0271	0.0258	0.0066	0.0550	0.0188	0.0346
Accidents (safety)	0.0026	0.0106	0.0225	0.0119	0.0025	0.0231	0.0112	0.1336	0.1025	0.0207	0.0341
Site condition, constraints and access	0.0054	0.0016	0.0084	0.0056	0.0087	0.0094	0.0020	0.0204	0.0248	0.0267	0.0113
Work scheduling	0.0129	0.0030	0.0028	0.0027	0.0283	0.0046	0.0223	0.0116	0.0580	0.0366	0.0183
Geological / foundation conditions	0.0322	0.0008	0.0024	0.0008	0.0096	0.0029	0.0045	0.0445	0.0248	0.0089	0.0131

Table 5.4. Mean Overall Normalized Weights, Ranks, Standard Deviation, Coefficient of Variation and Variation Degree for the Internal PFC Risk Factors.

INTERNAL RISK FACTORS	Mean Overall Normalized weights	RANK (Category)	Standard Deviation	Coefficient of Variation (CV)	Variation Degree
Delayed payment	0.1187	1 (VS)	0.0974	0.8202	LOW
Change or variation of orders	0.0749	4 (VS)	0.0926	1.2366	HIGH
Changes in plan/design	0.0068	32 (LS)	0.0075	1.1040	HIGH
Defective/poor design	0.0314	12 (MS)	0.0219	0.6987	LOW
Project complexity	0.0077	31 (LS)	0.0060	0.7748	LOW
Lack of training / skills	0.0243	15 (SS)	0.0315	1.2969	HIGH
Management & communication problems	0.0200	19 (SS)	0.0192	0.9568	LOW
Availability and condition of construction equipment	0.0122	27 (SS)	0.0173	1.4157	HIGH
Inaccurate scheduling	0.0143	25 (SS)	0.0126	0.8808	LOW
Labor disputes, strikes & fatigue	0.0080	30 (LS)	0.0052	0.6546	LOW
Availability of materials	0.0315	11 (MS)	0.0197	0.6250	LOW
Quality of materials	0.0300	13 (MS)	0.0216	0.7184	LOW
Slow delivery of materials	0.0276	14 (SS)	0.0248	0.8984	LOW

Table 5.5. Mean Overall Normalized Weights, Ranks, Standard Deviation, Coefficient of Variation and Variation Degree for the External PFC Risk Factors.

EXTERNAL RISK FACTORS	Mean Overall Normalized weights	RANK (Category)	Standard Deviation	Coefficient of Variation (CV)	Variation Degree
Delays/lack of formalities/permits	0.0182	23 (SS)	0.0150	0.8242	LOW
Instability of political condition + war threat	0.0759	3 (VS)	0.0657	0.8658	LOW
Government relations / stability	0.0499	5 (MS)	0.0353	0.7084	LOW
Changes in laws and regulations	0.0229	16 (SS)	0.0210	0.9150	LOW
Corrupt & bribery practices	0.0198	20 (SS)	0.0182	0.9194	LOW
Attitudes and motivations (undisciplined employee)	0.0108	29 (SS)	0.0073	0.6705	LOW
Insecurity & criminal acts	0.0202	18 (SS)	0.0229	1.1332	HIGH
Market conditions / culture	0.0154	24 (SS)	0.0110	0.7174	LOW
Inflation	0.0365	8 (MS)	0.0457	1.2529	HIGH
Sudden bankruptcy/ availability of finance	0.0796	2 (VS)	0.0569	0.7140	LOW
Exchange rate fluctuation	0.0467	6 (MS)	0.0245	0.5250	LOW
Interest rate fluctuation	0.0436	7 (MS)	0.0505	1.1573	HIGH
Taxation changes	0.0221	17 (SS)	0.0156	0.7056	LOW
Weather / climate conditions	0.0195	21 (SS)	0.0217	1.1102	HIGH
Acts of God (force majeure)	0.0346	9 (MS)	0.0354	1.0224	HIGH
Accidents (safety)	0.0341	10 (MS)	0.0454	1.3319	HIGH
Site condition, constraints and access	0.0113	28 (SS)	0.0092	0.8196	LOW
Work scheduling (work boundaries)	0.0183	22 (SS)	0.0183	1.0002	HIGH
Geological / foundation conditions	0.0131	26 (SS)	0.0153	1.1648	HIGH

Table 5.6. Overall and Mean Overall Normalized Weights for the Internal TMC Risk Factors.

INTERNAL RISK FACTORS	**TMC1**	**TMC2**	**TMC3**	**TMC4**	**TMC5**	**TMC6**	**TMC7**	**TMC8**	**TMC9**	**TMC10**	**Mean Overall Normalized weights**
Delayed payment	0.0139	0.0185	0.0555	0.0288	0.0110	0.0630	0.1950	0.0025	0.0284	0.0535	0.0470
Change or variation of orders	0.0971	0.0925	0.0555	0.0032	0.0110	0.1890	0.0650	0.0175	0.2556	0.0535	0.0840
Changes in plan/design	0.0286	0.0887	0.0222	0.0018	0.0106	0.0087	0.0575	0.0258	0.0071	0.0077	0.0259
Defective/poor design	0.0117	0.0117	0.0222	0.0162	0.0247	0.0927	0.0234	0.1001	0.0751	0.0694	0.0447
Project complexity	0.0707	0.0107	0.0666	0.0070	0.0027	0.0366	0.1421	0.0111	0.0178	0.0299	0.0395
Lack of training / skills	0.0359	0.0321	0.0210	0.0013	0.0306	0.0129	0.0575	0.0786	0.0627	0.0192	0.0352
Management & communication problems	0.0440	0.0044	0.0330	0.0020	0.0904	0.0238	0.0127	0.0786	0.0090	0.0192	0.0317
Availability and condition of construction equipment	0.0154	0.0146	0.0251	0.0108	0.0065	0.0229	0.0313	0.0786	0.0071	0.0461	0.0258
Inaccurate scheduling	0.0120	0.0571	0.0110	0.0090	0.0132	0.0035	0.0200	0.0786	0.0149	0.0072	0.0227
Labor disputes, strikes & fatigue	0.0038	0.0038	0.0210	0.0048	0.0132	0.0069	0.0575	0.0786	0.0063	0.0072	0.0203
Availability of materials	0.0198	0.0080	0.0070	0.0048	0.0127	0.0101	0.0207	0.0879	0.0133	0.0087	0.0193
Quality of materials	0.0834	0.0310	0.0294	0.0053	0.0127	0.0025	0.0804	0.0879	0.0133	0.0782	0.0424
Slow delivery of materials	0.0079	0.0720	0.0746	0.0400	0.0127	0.0134	0.0089	0.0882	0.0664	0.0201	0.0404

Table 5.7. Overall and Mean Overall Normalized Weights of for the External TMC Risk Factors.

EXTERNAL RISK FACTORS	**TMC1**	**TMC2**	**TMC3**	**TMC4**	**TMC5**	**TMC6**	**TMC7**	**TMC8**	**TMC9**	**TMC10**	**Mean Overall Normalized weights**
Delays/lack of formalities/permits	0.0175	0.0356	0.0249	0.0105	0.0212	0.0029	0.0037	0.0010	0.0049	0.0041	0.0126
Instability of political condition + war threat	0.0067	0.0038	0.0579	0.0071	0.0594	0.0022	0.0076	0.0191	0.0302	0.0370	0.0231
Government relations / stability (policies/bureaucracy)	0.0545	0.0107	0.0147	0.0223	0.0123	0.0236	0.0147	0.0054	0.0123	0.0144	0.0185
Changes in laws and regulations	0.0098	0.0093	0.0088	0.0281	0.0129	0.0019	0.0233	0.0044	0.0105	0.0144	0.0124
Corrupt & bribery practices	0.0225	0.0516	0.0057	0.0740	0.0042	0.0124	0.0417	0.0080	0.0180	0.0370	0.0275
Attitudes and motivations (undisciplined)	0.0310	0.0286	0.0707	0.0386	0.0086	0.0209	0.0116	0.0123	0.0360	0.0153	0.0274
Insecurity & criminal acts	0.0720	0.0117	0.0286	0.0073	0.0086	0.0034	0.0047	0.0123	0.0360	0.0459	0.0231
Market conditions / culture	0.0080	0.0707	0.0117	0.0291	0.0017	0.0187	0.0287	0.0124	0.0040	0.0458	0.0231
Inflation	0.0085	0.0172	0.0302	0.0176	0.0152	0.0137	0.0056	0.0028	0.0043	0.0196	0.0135

Table 5.8. Overall and Mean Overall Normalized Weights for the External TMC Risk Factors (Cont.).

EXTERNAL RISK FACTORS	TMC1	TMC2	TMC3	TMC4	TMC5	TMC6	TMC7	TMC8	TMC9	TMC10	Mean Overall Normalized weights
Sudden bankruptcy/ availability of finance	0.0049	0.0060	0.0270	0.0123	0.0056	0.0589	0.0036	0.0256	0.0513	0.0926	0.0288
Exchange rate fluctuation	0.0296	0.0566	0.0389	0.0796	0.0240	0.0087	0.0020	0.0028	0.0057	0.0135	0.0261
Interest rate fluctuation	0.0141	0.0163	0.0043	0.0796	0.0121	0.0253	0.0105	0.0028	0.0057	0.0214	0.0192
Taxation changes	0.0549	0.0149	0.0107	0.0728	0.0320	0.1114	0.0113	0.0028	0.0090	0.0060	0.0326
Weather / climate conditions	0.0185	0.0833	0.0925	0.1115	0.0470	0.0440	0.0155	0.0185	0.0380	0.0480	0.0517
Acts of God (force majeure)	0.0925	0.0278	0.0185	0.1115	0.1410	0.0440	0.0155	0.0185	0.0380	0.0480	0.0555
Accidents (safety)	0.0061	0.0291	0.0581	0.0275	0.0954	0.0711	0.0074	0.0093	0.0098	0.0282	0.0342
Site condition, constraints and access	0.0627	0.0129	0.0291	0.0155	0.1796	0.0345	0.0142	0.0093	0.0134	0.0219	0.0393
Work scheduling (work boundaries)	0.0291	0.0581	0.0110	0.0200	0.0195	0.0082	0.0042	0.0093	0.0076	0.0282	0.0195
Geological / foundation conditions	0.0131	0.0110	0.0129	0.0999	0.0475	0.0082	0.0021	0.0093	0.0882	0.0387	0.0331

Table 5.9. Mean Overall Normalized Weights, Ranks, Standard Deviation, Coefficient of Variation (CV) and Variation Degree for the Internal TMC Risk Factors.

INTERNAL RISK FACTORS	Mean Overall Normalized weights	RANK (Category)	Standard Deviation	Coefficient of Variation (CV)	Variation Degree
Delayed payment	0.0470	4 (MS)	0.0559	1.1893	HIGH
Change or variation of orders	0.0840	1 (VS)	0.0810	0.9648	LOW
Changes in plan/design	0.0259	19 (SS)	0.0274	1.0593	HIGH
Defective/poor design	0.0447	5 (MS)	0.0354	0.7914	LOW
Project complexity	0.0395	8 (MS)	0.0433	1.0952	HIGH
Lack of training / skills	0.0352	10 (MS)	0.0242	0.6877	LOW
Management & communication problems	0.0317	14 (MS)	0.0308	0.9703	LOW
Availability and condition of construction equipment	0.0258	20 (SS)	0.0222	0.8581	LOW
Inaccurate scheduling	0.0227	24 (SS)	0.0248	1.0924	HIGH
Labor disputes, strikes & fatigue	0.0203	25 (SS)	0.0262	1.2877	HIGH
Availability of materials	0.0193	27 (SS)	0.0247	1.2793	HIGH
Quality of materials	0.0424	6 (MS)	0.0357	0.8422	LOW
Slow delivery of materials	0.0404	7 (MS)	0.0318	0.7862	LOW

Table 5.10. Mean Overall Normalized Weights, Ranks, Standard Deviation, Coefficient of Variation (CV) and Variation Degree for the External TMC Risk Factors.

EXTERNAL RISK FACTORS	Mean Overall Normalized weights	RANK (Category)	Standard Deviation	Coefficient of Variation (CV)	Variation Degree
Delays/lack of formalities/permits	0.0126	31 (SS)	0.0117	0.9214	LOW
Instability of political condition + war threat	0.0231	21 (SS)	0.0220	0.9542	LOW
Government relations / stability	0.0185	29 (SS)	0.0137	0.7410	LOW
Changes in laws and regulations	0.0124	32 (SS)	0.0080	0.6473	LOW
Corrupt & bribery practices	0.0275	16 (SS)	0.0230	0.8372	LOW
Attitudes and motivations	0.0274	17 (SS)	0.0186	0.6787	LOW
Insecurity & criminal acts	0.0231	23 (SS)	0.0225	0.9748	LOW
Market conditions / culture	0.0231	22 (SS)	0.0215	0.9327	LOW
Inflation	0.0135	30 (SS)	0.0084	0.6224	LOW
Sudden bankruptcy/ availability of finance	0.0288	15 (SS)	0.0299	1.0379	HIGH
Exchange rate fluctuation	0.0261	18 (SS)	0.0258	0.9853	LOW
Interest rate fluctuation	0.0192	28 (SS)	0.0224	1.1665	HIGH
Taxation changes	0.0326	13 (MS)	0.0361	1.1081	HIGH
Weather / climate conditions	0.0517	3 (VS)	0.0334	0.6460	LOW
Acts of God (force majeure)	0.0555	2 (VS)	0.0440	0.7922	LOW
Accidents (safety)	0.0342	11 (MS)	0.0308	0.8992	LOW
Site condition, constraints and access	0.0393	9 (MS)	0.0518	1.3170	HIGH
Work scheduling (work boundaries)	0.0195	26 (SS)	0.0161	0.8253	LOW
Geological / foundation conditions	0.0331	12 (MS)	0.0353	1.0657	HIGH

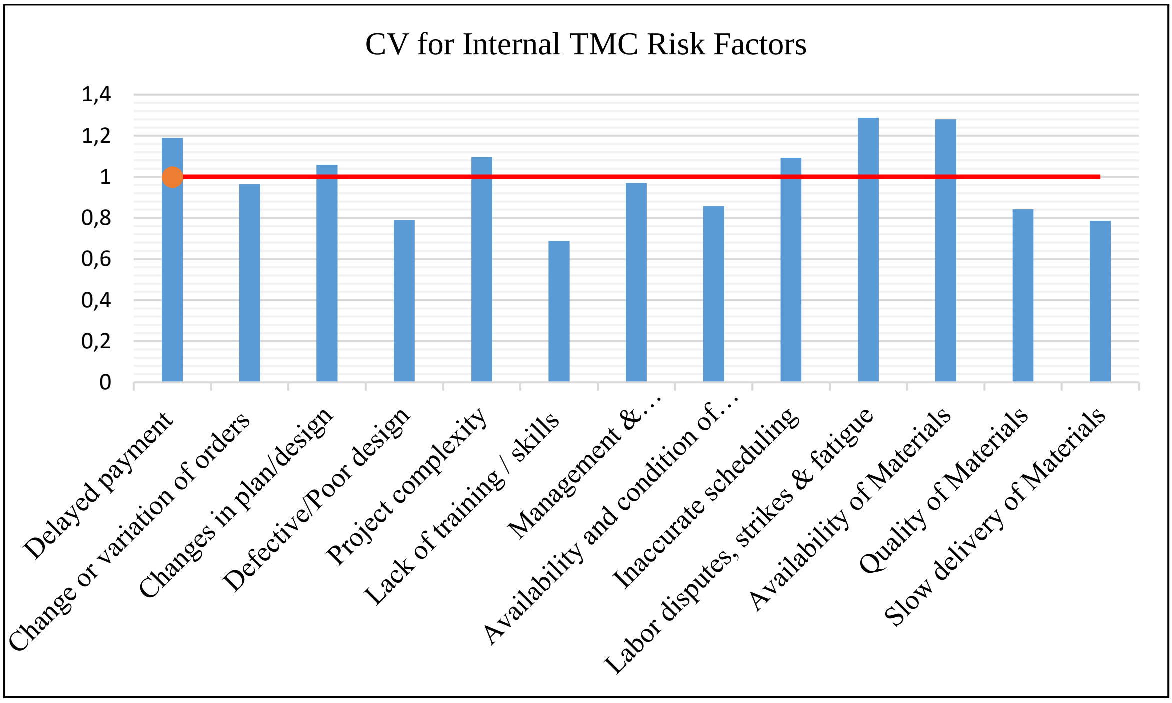

Figure 5.1. CV for Internal TMC Risk Factors.

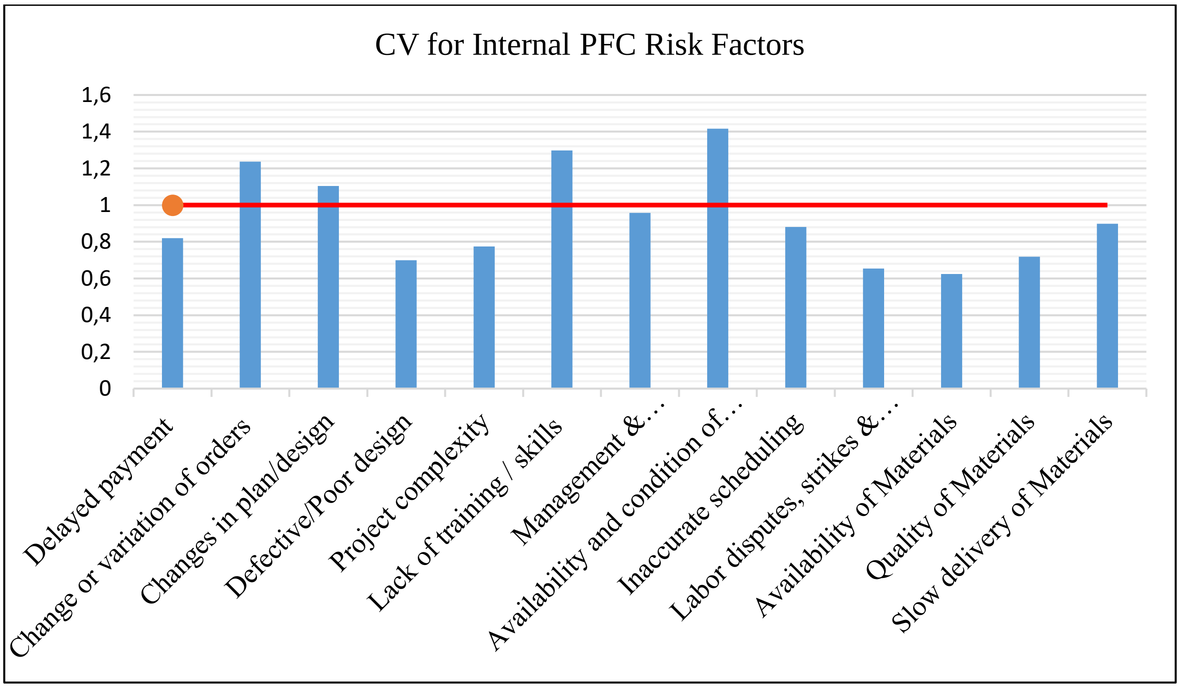

Figure 5.2. CV for Internal PFC Risk Factors.

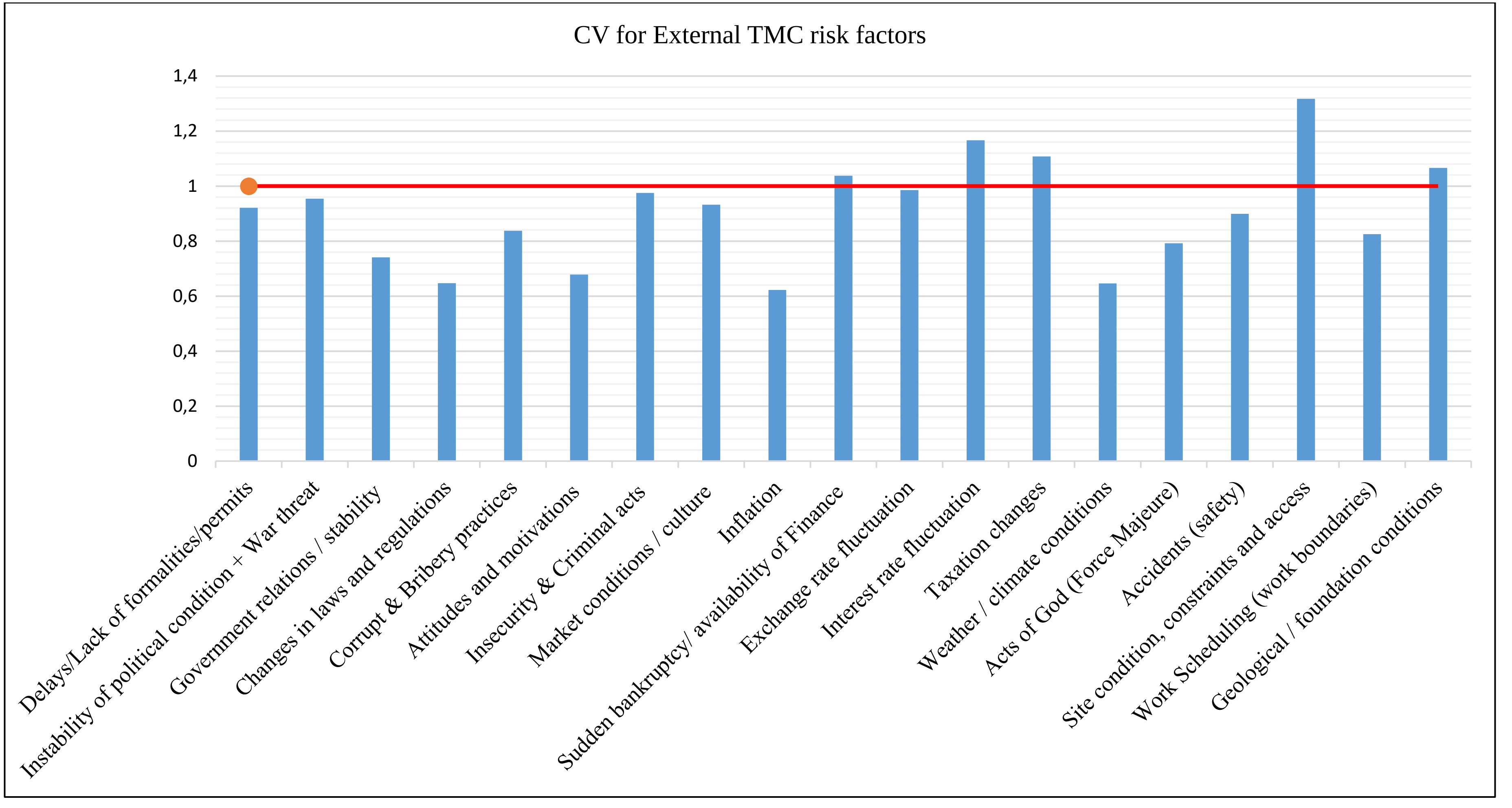

Figure 5.3. CV for External TMC Risk Factors.

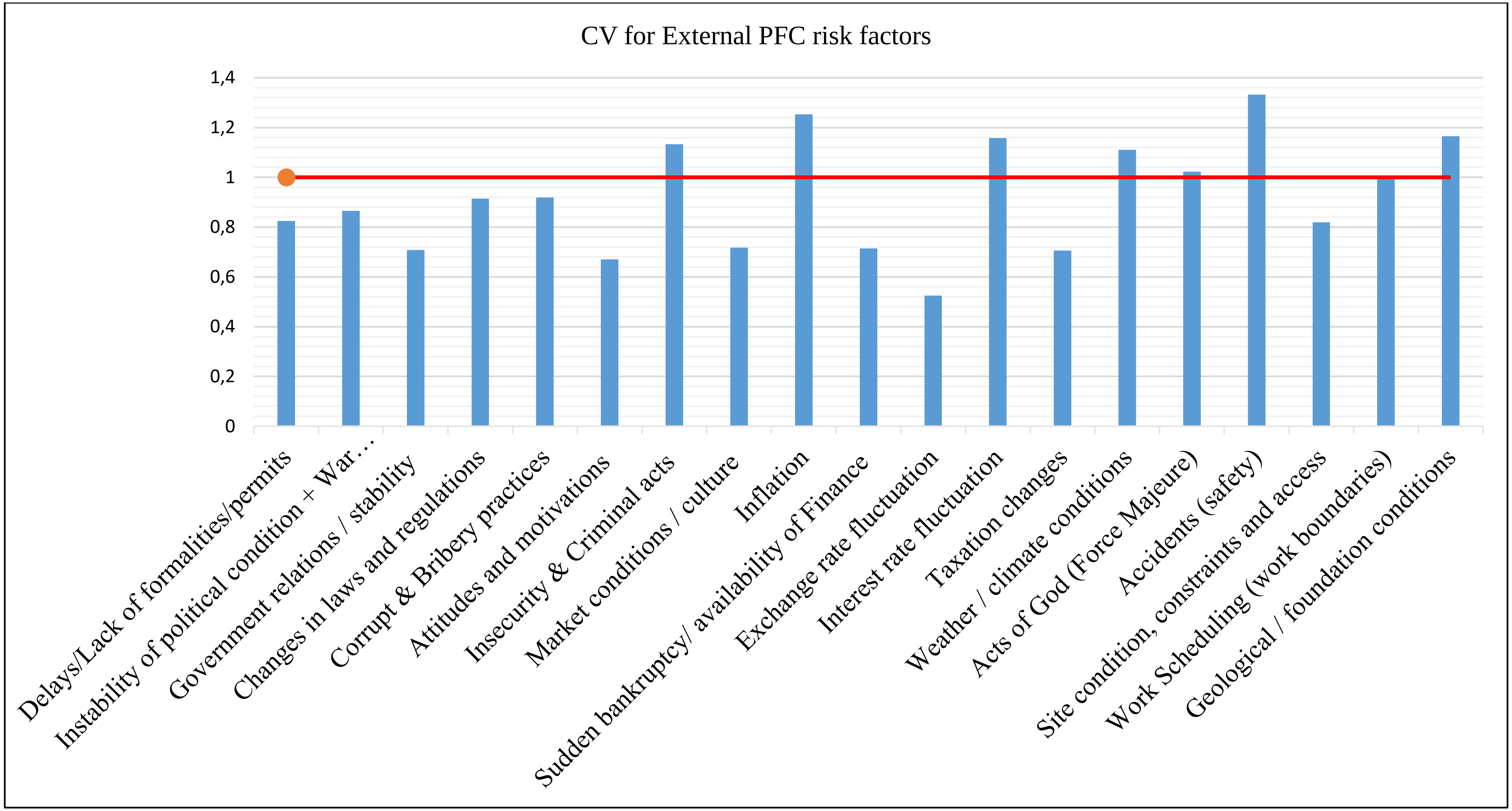

Figure 5.4. CV for External PFC Risk Factors.

In addition to the individual tables of TMC and PFC, comparison tables illustrating the mean overall normalized weights and ranking for both, the TMC and PFC are created. These tables have been categorized into 2 sections: internal risk factors and external risk factors for both methods of construction. They will be further discussed in the discussion section.

Table 5.11. Comparison Table of the Mean Overall Normalized Weights, Ranks, for the Internal TMC and PFC Risk Factors.

INTERNAL RISK FACTORS	For TMC		For PFC	
	Mean Overall Normalized weights	**RANK (Category)**	**Mean Overall Normalized weights**	**RANK (Category)**
Delayed payment	0.0470	4 (MS)	0.1187	1 (VS)
Change or variation of orders	0.0840	1 (VS)	0.0749	4 (VS)
Changes in plan/design	0.0259	19 (SS)	0.0068	32 (LS)
Defective/poor design	0.0447	5 (MS)	0.0314	12 (MS)
Project complexity	0.0395	8 (MS)	0.0077	31 (LS)
Lack of training / skills	0.0352	10 (MS)	0.0243	15 (SS)
Management & communication problems	0.0317	14 (MS)	0.0200	19 (SS)
Availability and condition of construction equipment	0.0258	20 (SS)	0.0122	27 (SS)
Inaccurate scheduling	0.0227	24 (SS)	0.0143	25 (SS)
Labor disputes, strikes & fatigue	0.0203	25 (SS)	0.0080	30 (LS)
Availability of materials	0.0193	27 (SS)	0.0315	11 (MS)
Quality of materials	0.0424	6 (MS)	0.0300	13 (MS)
Slow delivery of materials	0.0404	7 (MS)	0.0276	14 (SS)

Table 5.12. Comparison Table of the Mean Overall Normalized Weights, Ranks, for the External TMC and PFC Risk Factors.

EXTERNAL RISK FACTORS	**For TMC**		**For PFC**	
	Mean Overall Normalized weights	**RANK (Category)**	**Mean Overall Normalized weights**	**RANK (Category)**
Delays/lack of formalities/permits	0.0126	31 (SS)	0.0182	23 (SS)
Instability of political condition + war threat	0.0231	21 (SS)	0.0759	3 (VS)
Government relations / stability	0.0185	29 (SS)	0.0499	5 (MS)
Changes in laws and regulations	0.0124	32 (SS)	0.0229	16 (SS)
Corrupt & bribery practices	0.0275	16 (SS)	0.0198	20 (SS)
Attitudes and motivations	0.0274	17 (SS)	0.0108	29 (SS)
Insecurity & criminal acts	0.0231	23 (SS)	0.0202	18 (SS)
Market conditions / culture	0.0231	22 (SS)	0.0154	24 (SS)
Inflation	0.0135	30 (SS)	0.0365	8 (MS)
Sudden bankruptcy/ availability of finance	0.0288	15 (SS)	0.0796	2 (VS)
Exchange rate fluctuation	0.0261	18 (SS)	0.0467	6 (MS)
Interest rate fluctuation	0.0192	28 (SS)	0.0436	7 (MS)
Taxation changes	0.0326	13 (MS)	0.0221	17 (SS)
Weather / climate conditions	0.0517	3 (VS)	0.0195	21 (SS)
Acts of God (force majeure)	0.0555	2 (VS)	0.0346	9 (MS)
Accidents (safety)	0.0342	11 (MS)	0.0341	10 (MS)
Site condition, constraints and access	0.0393	9 (MS)	0.0113	28 (SS)
Work scheduling (work boundaries)	0.0195	26 (SS)	0.0183	22 (SS)
Geological / foundation conditions	0.0331	12 (MS)	0.0131	26 (SS)

6. DISCUSSION AND CONCLUSION

6.1. Discussion

Residential housing is a major need in Tanzania. Even though the residential housing sector involves both TMC and PFC methods of construction, only TMC is preferred in Tanzania. This study focuses on the risks of both methods of construction in Tanzania's construction era. The construction industry in Tanzania is young creating a challenge on the overall execution and application of project management operations (Chileshe and Kikwasi, 2014). Utilizing prefabrication is necessary to address urgent housing need in Tanzania and it is expected that prefabrication would affect most of the construction industry. This is due to connection between building design, construction, better supervision on improving quality and shorten construction time (Tam *et al.*, 2007) having a significant effect on the construction industry.

Identification of the risk factors for TMC and PFC is done by literature review, where the risk factors in both TMC and PFC were analyzed. The most common risk factors were selected by having a frequency of presence in at least four papers. The risk factors below this threshold were combined and new risk factors were obtained with a frequency of four or greater. This critical risk factors identification was followed by prioritization of the selected risk factors conducted by experts. The experts for the TMC data collection are from Tanzania focused in the residential construction whereas the experts for the PFC data collection are from Turkey with experience doing projects in Africa including Tanzania. The use of PFC experts from Turkey is due to lack of PFC method in Tanzania, since it's a modern method of construction and the public is less aware of it. The TMC focus group involved 10 different construction companies and the PFC focus group involved 4 different prefabrication companies. This provides diversity to the data collected. The data collected for the PFC is mostly from managers and directors with an average of 13 years of experience. The TMC data is mostly collected from civil engineers and architects with an average of 19 years of experience in the construction industry.

In the construction industry around the world, time overruns are regarded as one of the critical project delivery problems (Kazaz *et al.*, 2012). Since the study focuses on risk factors determination for both the TMC and PFC in the Tanzania's construction industry, the results are presented separately for 4 different categories. The very significant risk factors (VS), the moderately significant risk factors (MS), the slightly significant (SS) and the least significant (LS) risk factors. These level of risk factors are grouped according to the mean overall normalized weights. The mean overall normalized weight for the significant levels are VS $\geq$ 0.05, 0.03 $\leq$ MS $<$ 0.05, 0.01 $\leq$ SS $<$ 0.03 and LS $<$ 0.01.

The very significant risk factors for the internal TMC risk factors is change or variation of orders (0.0840). A study conducted in the United Arab Emirates resulted to a similar significant risk factor (Zaneldin, 2006). The moderately significant risk factors for the internal TMC risk factors are delayed payment (0.0470), defective/poor design (0.0447), quality of materials (0.0424), slow delivery of materials (0.0404), project complexity (0.0395), lack of training/skills (0.0352) and management & communication problems (0.0317). The findings of this study are similar to a study conducted on causes of delays in Tanzania in 2013 (Kikwasi, 2013). The similar significant risk factors include: delayed payment and management & communication problems. The other risk factors found were different due to the four years gap of these two studies. This is also due to inclusion of only civil engineers and architects in this study whereas (Kikwasi, 2013) included clients, contractors, consulting firms and regulatory bodies.

A study conducted in Uganda resulted to similar significant risk including lack of training/skills, defective/poor design (Muhwezi *et al.*, 2014). Similar study investigating factors causing construction project delays in Kenya was conducted resulting to identical significant risks such as delayed payment, defective/poor design and management problems (Talukhaba, 1999). Another study conducted in United Arab Emirates found out delayed payment being a crucial risk factor (Zaneldin, 2006). A risk management study for the oil and gas construction projects in Vietnam. Defective/poor design resulted to be a common risk factor. This further shows how different construction sectors can exhibit similar priority patterns in terms of risk affecting the construction sector (Van Thuyet *et al.*, 2007). These similarities with the other studies shows on how different geographical locations exhibit similar internal risk in the construction industry. The slightly significant internal risk factors for the TMC are changes in plan/design (0.0259), availability and condition of construction equipment (0.0258), inaccurate scheduling (0.0227), labor disputes, strikes & fatigue (0.0203) and availability of Materials (0.0193).

The very significant external risk factors for the TMC are weather/climate conditions (0.0517) and acts of God (0.0555). A research conducted in India resulted to weather / climate conditions as a significant risk factor (Iyer and Jha, 2005). The interesting finding is that a study of causes of delays in construction project in Tanzania resulted to acts of God as the least significant (Kikwasi, 2013). This difference in priorities is due to less disasters occurred in the past creating a less priority consideration by the experts. The moderately significant risk factors for the external TMC risk factors are taxation changes (0.0326), site conditions, constraints and access (0.0393), accidents (0.0342) and geological/foundation conditions (0.0331).

The other risk factors are slightly significant. These include: delays/lack of formalities/permits (0.0126), instability of political condition together with war threat (0.0231), government relations / stability (0.0185), changes in laws and regulations (0.0124), corrupt & bribery practices (0.0275), attitudes and motivations (0.0274), insecurity & criminal acts (0.0231), market conditions / culture (0.0231), inflation (0.0135), sudden bankruptcy/ availability of finance (0.0288), exchange rate fluctuation (0.0261), interest rate fluctuation (0.0192) and work scheduling (0.0195). From these slightly significant external TMC risk factors, delays/lack of formalities/permits (0.0126) and changes in laws and regulations (0.0124) have the lowest normalized mean overall normalized weights. These slightly significant risk factors are both from political risk group. Similarly political risks are also found to be less significant in the UAE construction industry (El-Sayegh, 2008). This shows a similarity between the Tanzania and the Middle East construction industries.

Despite the significant level of the risk factors in the TMC, the significant levels of risk factors also exist in the PFC. The very significant risk factors for the Internal PFC risk factors are delayed payment (0.1187) and change or variation of orders (0.0749). These risk factors are from owner. This is expected since the investment of the PFC is currently evaluated from foreign investors' perspective creating a sense of doubt on the owners of the new market. The moderately significant risk factors for the PFC internal risk factors include defective/poor design (0.0314), availability of materials (0.0315) and quality of materials (0.0300). These include the designer and supplier related risks. Since the PFC is a manufacturing industry as much as it is a construction industry, this result is expected. The slightly significant risk factors for the PFC internal risk factors are lack of training / skills (0.0243), management and communication problems (0.0200), availability and condition of construction equipment (0.0122), inaccurate scheduling (0.0143) and slow delivery of materials (0.0276).

The very significant risk factor for the external PFC are the sudden bankruptcy / availability of finance (0.0796) and instability of political together with war threat (0.0759). Availability of finance was also established as a major risk factor in terms of its significance in a study conducted in Indonesia (Widiasih *et al.*, 2015). The instability is caused by the lack of knowledge of the political condition in the new market. The moderately significant external risk factors are government relations / stability (0.0499), exchange rate fluctuation (0.0467), interest rate fluctuation (0.0436), inflation (0.0365), acts of God (0.0346) and accidents (0.0341). Similarly, a study conducted in China also resulted to government Relations / Stability as being one of the significant risk factors (Zhi, 1995). There exists less similarity of the significant risk factors in the literature. This can be due to the fact that these studies are conducted in different geographical locations. Indonesia and China located in Asia, whereas Tanzania is located in Africa.

The slightly significant external risk factors for the PFC include delays/lack of formalities/permits (0.0182), changes in laws and regulations (0.0229), corrupt & bribery practices (0.0198), attitudes and motivations (0.0108), insecurity & criminal acts (0.0202), market conditions / culture (0.0154), taxation changes (0.0221), weather / climate conditions (0.0195), site condition, constraints and access (0.0113), work Scheduling (0.0183) and geological / foundation conditions (0.0131). The least significant risk factors for both internal and external PFC risk factors are changes in plan (0.0068), project complexity (0.0077) and labor disputes, strikes & fatigue (0.0080). These are mostly designer and company related risk factors. This insignificance is due to the easiness to disassemble and alter the design as desired by the client.

The data collected related with PFC is intended to assist providing knowledge to foreign and local investors in Tanzania on the PFC's manageability of its risk factors. In the consideration of the top risk factors that are considered by the PFC companies included instability of political condition together with war threat and government relations/stability. These can be solved by the government creating a secure market for the investors to allow the investment in the PFC. This would also provide knowledge transfer to the local construction companies. Sudden bankruptcy/availability of finance can be considered as an important obstacle for investing in the PFC considering the initial investment for establishment of the company to manufacture the prefabricated parts. This can also be accomplished with the government playing a significant role in motivating the industrialization of construction sector to PFC, including some tax exemptions and reductions.

Thereupon, the TMC have risk factors that are not easily evitable. These include change or variation of orders, acts of God, weather/climate conditions, delayed payment and defective/poor design. In the other case of adaptation of PFC some of the risky factors can be resolved. The study can be broadened by conducting feasibility analysis of the TMC and the PFC. The PFC can be further analyzed considering the initial investments and the rate on investment. These can also be used to countercheck the overall impact of the two methods to a real project. This analysis can also be done by considering some interrelationship between the groups, for instance owner and supplier, political and economic.

The experts used in this study for the TMC included 3 experts with low level of years of experience. Professional number 8, 9 and 10 had 6, 4 and 3 years of experience, respectively. This taken into consideration comparing to the other experts having more than 20 years, reevaluating the risk factors' significance levels is administered. The Table 6.1 and Table 6.2 illustrate the internal and external risk factors of the TMC with and without the less experienced experts in the construction field.

The findings are appealing how this reduction of the less experienced risk factors had slight changes on the risk factors' level of risks. The very significant internal risk factors for the original TMC is change or variation of order whereas the very significant internal risk factors for the TMC after the removal of less experienced experts are change or variation, delayed payment and quality of materials. The moderately significant risk factors for the internal risk factors of the TMC before and after the removal of less experience experts have similar risk factors. These include are defective/poor design, project complexity, lack of training/skills, and slow delivery of materials (Table 6.1). In addition the slightly significant internal risk factors of the TMC before and after the removal of less experience experts have similar risk factors. These are changes in plan/design, inaccurate scheduling, labor dispute, strikes & fatigue and availability of materials.

The very significant external risk factors for the original TMC are weather/climate condition and acts of God (Table 6.2). The moderately significant risk factor for the external risk factors of TMC before and after the removal of the less experts is the geological/foundation conditions. Furthermore, there exists many slightly significant risk factors common in both before and after the removal of less experience experts for the external TMC risk factors. These include instability of political condition together with war threat, government relations / stability (policies/bureaucracy), changes in laws and regulations, corrupt & bribery practices, insecurity & criminal acts, market conditions / culture, inflation, exchange rate fluctuation, interest rate fluctuation and work scheduling (work boundaries + definition). The least significant risk factors for the original TMC are delays/lack of formalities/permits and change in laws and regulations whereas the least significant internal risk factor after the removal of less experienced experts is delays/lack of formalities/permits. These finding illustrates that the less experienced experts (<10 years) used in the data collection for the TMC impose less difference when eradicated.

Furthermore, the experts used in this study for the PFC included 3 experts from the sales division. Professional number 8, 9 and 10 are senior corporate sales manager, corporate sales manager and sales manager respectively. This taken into consideration comparing to the other experts having positions like managers and directors created an interesting finding. Table 6.3 and Table 6.4 illustrate the internal and external risk factors of the PFC with and without the sales division experts in the construction sector.

The findings are fascinating how the reduction of the sales managers in the risk analysis, an insignificant change is experienced. The very significant internal risk factors for the original PFC and the PFC after the removal of sales division experts are the same. Delayed payments, and change or variation of order are the very significant internal risk factors for both (Table 6.3). There are common moderately significant risk factors for the internal risk factors of the PFC before and after the removal of sales managers. These are defective/poor design and availability of materials. There are also a number of similar slightly significant internal risk factors for the original PFC and PFC after the removal of sales division experts. These are lack of training / skills, management & communication problems, availability and condition of construction equipment, inaccurate scheduling and slow delivery of materials.

The very significant external risk factors for the original PFC and the PFC after the removal of sales division experts are the same. Sudden bankruptcy/availability of finance and instability of political condition together with war threat are the very significant risk factor (Table 6.4). The are similar moderately significant risk factors for the external risk factors of the PFC before and after the removal of the sales managers. These include government relations/stability, inflation, exchange rate fluctuation, acts of God and accidents. There is a minor difference in the moderately significant external risk factors of the original PFC and after the removal of sales managers in the analysis.

This shows how sales managers participate in the most of the construction process in the PFC hence their opinion is highly valuable. Most of the slightly significant external risk factors for the original PFC and after the removal of sales managers are similar. These include are delays/Lack of formalities/permits, changes in laws and regulations, corrupt & bribery practices, insecurity & criminal acts, market conditions / culture, taxation changes, weather / climate conditions, site condition, constraints and access, work Scheduling (work boundaries + definition) and geological (ground) / foundation conditions. The least significant risk factors for the original and after removal of sales managers have similarities. This include changes in plan/design and labor dispute, strikes & fatigue. The small difference illustrates the qualification of the sales managers in the PFC data collection for the risk analysis.

Table 6.1. Original Rankings and the Rankings After Removal of Less Experienced Experts for the Internal TMC Risk Factors.

INTERNAL RISK FACTORS	**Original TMC**		**After Removal of Less Experienced Experts**	
	Mean Overall Normalized weights	**RANK (Category)**	**Mean Overall Normalized weights**	**RANK (Category)**
Delayed payment	0.0470	4 (MS)	0.0539	3 (VS)
Change or variation of orders	0.0840	1 (VS)	0.0782	1 (VS)
Changes in plan/design	0.0259	19 (SS)	0.0215	24 (SS)
Defective/poor design	0.0447	5 (MS)	0.0455	7 (MS)
Project complexity	0.0395	8 (MS)	0.0493	4 (MS)
Lack of training / skills	0.0352	10 (MS)	0.0394	9 (MS)
Management & communication problems	0.0317	14 (MS)	0.0284	16 (SS)
Availability and condition of construction equipment	0.0258	20 (SS)	0.0306	13 (MS)
Inaccurate scheduling	0.0227	24 (SS)	0.0218	23 (SS)
Labor disputes, strikes & fatigue	0.0203	25 (SS)	0.0256	17 (SS)
Availability of materials	0.0193	27 (SS)	0.0232	22 (SS)
Quality of materials	0.0424	6 (MS)	0.0540	2 (VS)
Slow delivery of materials	0.0404	7 (MS)	0.0437	8 (MS)

Table 6.2. Original Rankings and the Rankings After Removal of Less Experienced Experts for the External TMC Risk Factors.

EXTERNAL RISK FACTORS	**Original TMC**		**After Removal of Less Experienced Experts**	
	Mean Overall Normalized weights	**RANK (Category)**	**Mean Overall Normalized weights**	**RANK (Category)**
Delays/lack of formalities/permits	0.0126	31 (SS)	0.0095	32 (LS)
Instability of political condition + war threat	0.0231	21 (SS)	0.0237	21 (SS)
Government relations / stability (policies/bureaucracy)	0.0185	29 (SS)	0.0198	28 (SS)
Changes in laws and regulations	0.0124	32 (SS)	0.0142	30 (SS)
Corrupt & bribery practices	0.0275	16 (SS)	0.0296	15 (SS)
Attitudes and motivations (undisciplined employee)	0.0274	17 (SS)	0.0308	12 (MS)
Insecurity & criminal acts	0.0231	23 (SS)	0.0296	14 (SS)
Market conditions / culture	0.0231	22 (SS)	0.0199	26 (SS)
Inflation	0.0135	30 (SS)	0.0127	31 (SS)
Sudden bankruptcy/ availability of finance	0.0288	15 (SS)	0.0310	11 (MS)
Exchange rate fluctuation	0.0261	18 (SS)	0.0246	18 (SS)
Interest rate fluctuation	0.0192	28 (SS)	0.0198	27 (SS)
Taxation changes	0.0326	13 (MS)	0.0239	19 (SS)
Weather / climate conditions	0.0517	3 (VS)	0.0489	5 (MS)
Acts of God (force majeure)	0.0555	2 (VS)	0.0489	5 (MS)
Accidents (safety)	0.0342	11 (MS)	0.0209	25 (SS)
Site condition, constraints and access	0.0393	9 (MS)	0.0237	20 (SS)
Work scheduling (work boundaries + definition)	0.0195	26 (SS)	0.0156	29 (SS)
Geological (ground) / foundation conditions	0.0331	12 (MS)	0.0377	10 (MS)

Table 6.3. Original Rankings and the Rankings After Removal of Experts from Sales Division for the Internal PFC Risk Factors.

INTERNAL RISK FACTORS	Original PFC		After Removal of Sales Managers	
	Mean Overall Normalized weights	**RANK (Category)**	**Mean Overall Normalized weights**	**RANK (Category)**
Delayed payment	0.1187	1 (VS)	0.1290	1 (VS)
Change or variation of orders	0.0749	4 (VS)	0.0995	2 (VS)
Changes in plan/design	0.0068	32 (LS)	0.0074	32 (LS)
Defective/poor design	0.0314	12 (MS)	0.0366	10 (MS)
Project complexity	0.0077	31 (LS)	0.0097	29 (LS)
Lack of training / skills	0.0243	15 (SS)	0.0176	22 (SS)
Management & communication problems	0.0200	19 (SS)	0.0201	20 (SS)
Availability and condition of construction equipment	0.0122	27 (SS)	0.0150	25 (SS)
Inaccurate scheduling	0.0143	25 (SS)	0.0120	28 (SS)
Labor disputes, strikes & fatigue	0.0080	30 (LS)	0.0089	30 (LS)
Availability of materials	0.0315	11 (MS)	0.0403	8 (MS)
Quality of materials	0.0300	13 (MS)	0.0276	12 (SS)
Slow delivery of materials	0.0276	14 (SS)	0.0219	15 (SS)

Table 6.4. Original Rankings and the Rankings After Removal of Experts from Sales Division for the External PFC Risk Factors.

EXTERNAL RISK FACTORS	**Original PFC**		**After Removal of Sales Managers**	
	Mean Overall Normalized weights	**RANK (Category)**	**Mean Overall Normalized weights**	**RANK (Category)**
Delays/lack of formalities/permits	0.0182	23 (SS)	0.0164	24 (SS)
Instability of political condition + war threat	0.0759	3 (VS)	0.0645	4 (VS)
Government relations / stability (policies/bureaucracy)	0.0499	5 (MS)	0.0382	9 (MS)
Changes in laws and regulations	0.0229	16 (SS)	0.0211	18 (SS)
Corrupt & bribery practices	0.0198	20 (SS)	0.0202	19 (SS)
Attitudes and motivations (undisciplined employee)	0.0108	29 (SS)	0.0079	31 (LS)
Insecurity & criminal acts	0.0202	18 (SS)	0.0194	21 (SS)
Market conditions / culture	0.0154	24 (SS)	0.0143	26 (SS)
Inflation	0.0365	8 (MS)	0.0429	6 (MS)
Sudden bankruptcy/ availability of finance	0.0796	2 (VS)	0.0659	3 (VS)
Exchange rate fluctuation	0.0467	6 (MS)	0.0359	11 (MS)
Interest rate fluctuation	0.0436	7 (MS)	0.0250	13 (SS)
Taxation changes	0.0221	17 (SS)	0.0214	16 (SS)
Weather / climate conditions	0.0195	21 (SS)	0.0240	14 (SS)
Acts of God (force majeure)	0.0346	9 (MS)	0.0419	7 (MS)
Accidents (safety)	0.0341	10 (MS)	0.0436	5 (MS)
Site condition, constraints and access	0.0113	28 (SS)	0.0135	27 (SS)
Work scheduling (work boundaries + definition)	0.0183	22 (SS)	0.0212	17 (SS)
Geological (ground) / foundation conditions	0.0131	26 (SS)	0.0169	23 (SS)

6.2. Conclusion

PFC is well known for its time-saving, good quality and controllable working conditions properties. This research seeks to confirm the following objectives: (1) to evaluate the risk factors impacting the TMC and PFC, (2) to rank and analyze the top risk factors for TMC and PFC, (3) make recommendations on how the construction industry in Tanzania can be improved to rise and compete with other developing countries. Through this research, an innovative approach of implementing the Analytic Hierarchy Process (AHP) technique to analyze and rank the risk related to the TMC and PFC in the residential construction in Tanzania. This is conducted by the use of SUPERDECISION software. This use of AHP model was structured with assuming no interrelationships between groups. In the 32 risk factors analyzed it is assumed all the risk factors exhibit no interrelationship with other risk factors of other groups. Another essential fact about this thesis is that the risk assessment model developed was performed separately for two construction methods, TMC and PFC. These two method's data were collected from Tanzania (for the TMC) and Turkey (for the PFC). Turkish prefabricated construction companies are involved in this study since PFC is a modern method and quite new to the construction industry in Tanzania. The Turkish prefabricated construction companies involved in the study have experience with projects in Africa including Tanzania.

A thorough literature review was conducted followed by questionnaires prepared for the twenty experts involved in this study. These questionnaires were structured in pairwise comparisons best for AHP. The findings of the questionnaire, as were performed in the SUPERDECISION tool as an AHP model, revealed that the very significant risk factors for the TMC are change or variation of orders, acts of God and weather/climate conditions. Change or variation of order can be discussed by the owner before execution of the project, making sure that's the exact project needed. The natural risks cannot be controlled thus insurance is needed to provide compensation to any damage. The other risk factors like delays/lack of formalities/permits and changes in laws and regulations were considered as insignificant risks in the TMC. The very significant risk factors for the PFC are delayed payment, sudden bankruptcy, instability of political condition together with war threat and change or variation or orders. Since PFC is a manufacturing industry, without enough capital to produce the components for installation. These significant risk factors can be solved by government intervention to the PFC and providing assistance to the investors in the sector.

The purpose for this thesis is to provide knowledge to the construction sectors and the public in Tanzania on the major risk factors of the PFC and TMC, along with stating the manageability of these major risk factors. The findings suggest that government's role in the PFC would administer a significant advantage to the adoption of the PFC in the Tanzania's construction industry. These findings illustrate on how a very large difference is present in terms of the mean overall normalized weights between the different significant risk factors of the PFC. This is different when referring to the TMC, the difference in the mean overall normalized weights is small showing how close their importance are compared to the large difference in the PFC. The data collected for TMC included 3 experts with 6, 4 and 3 years of experience. Analyzing the data without the information provided by these less experienced experts resulted to minor changes in the significant risk factors. Additionally, the PFC had experts from sales division who participated in the risk assessment. Analyzing the data without the information provided by these sales division experts resulted to an insignificant change in terms of the different levels of significant risk factors. These expert groups have proven to be reliable in the data collection.

This study focus on revealing whether the significant risk factors of the PFC are more manageable compared to the significant risk factors of the TMC. Considering that most of the significant risk factors are government related, this makes it more manageable by a close participation between the government with the investing companies on the PFC. The TMC had various similar risks similar to the other East African countries like Kenya and Uganda. For instance the study conducted in Uganda resulted to similar significant risks including lack of training/skills and defective/poor design (Muhwezi *et al.*, 2014). Similarly investigating factors causing construction project delays in Kenya was conducted resulting to identical significant risks such as delayed payment, defective design and management problems (Talukhaba, 1999). The East African countries are developing countries and highly in need of investors to steepen the growth slope. Considering the high population growth in (East African Community Facts and Figures – 2016 Report) Burundi (3%), Tanzania (2.7%), Uganda (3%) Kenya (1.3%) and Rwanda (2.4%), these population growths require a modern solution to enhance the construction quality, sustainability and time saving.

This study can be used to provide an insight to the East African countries since the countries share the same cultures and are all developing countries. This study also can be used for managing the risks and investments of the PFC to the East African countries since similar risks are witnessed in terms of TMC. The modernization of the construction sectors in the East African countries can be highly accomplished by the collaborative cooperation between the governments and the investors in the PFC. This study also helps to provide insight to other investors who are searching for international investments in East Africa. This study further helps the contractors bidding for projects in Tanzania and East Africa, providing them with information as to what the local contractors and engineering companies put more emphasize in terms of risk assessment before accepting a project.

The method used in this study have some limitations as well. The AHP technique utilized in this study disregards the interrelationship between the risk factors of different groups. The possibility of having an interrelationship between some risk factors can be considered. Moreover, a very limited number of studies have been conducted in the causes of delays in the Tanzania's construction industry. However, since the construction method used in Tanzania is the TMC, all the major risk factor analysis are based on the TMC. This thesis provides an insight on a modern method of the construction, the PFC. The contribution to the literature is providing the significant risk factors of PFC and also comparing it with the significant risk factors of the TMC in Tanzania's construction industry. This study further extends the literature showing the manageability of the major risk factors in the PFC. Since the PFC is a combination of manufacturing industry together with construction industry, a manufacturing facility is required. Thus, the PFC can be further analyzed considering its initial investments and the rate on Investment. These can also be used to countercheck the overall impact of the two methods to a real project.

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