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DEVELOPMENT OF SUPPLY CHAIN RISK MANAGEMENT APPROACHES FOR CONSTRUCTION.

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Abstract

Due to the different parties involved in any construction projects which can face a lot problems during their whole lifecycle of a project. Accordingly, an effective management of risks throughout the project's supply chain is critical to avoid time and cost overruns, that if not controlled properly, will ultimately result in project failure. Despite the great significance of this issue, there is a gap between the literature and practice of project risk management, where managers mostly prefer to rely on their own experiences rather than using available analytical tools. On the other hand, the application of best practices (such as supply chain management and supply chain risk management) from the manufacturing industry in the service industry is highly neglected. To this end, we try to bridge these two gaps by proposing a comprehensive supply chain risk management approach for construction projects that uses, grounded theory, fuzzy cognitive mapping, and grey relational analysis. Moreover, a real world case study is presented to show the applicability and effectiveness of the proposed approach. Accordingly, various risk mitigation scenarios are developed and evaluated by the proposed approach. Subsequently, scenarios are ranked and the best risk mitigation scenarios are identified. By comparing the proposed approach with similar researches in the literature, it is shown that the proposed approach is capable of capturing and representing expert's perceptions of risks in an effective and time efficient manner. Moreover, decision-makers are enabled to simulate the long term effects of different risk mitigation strategies on the risks and make more informed decisions. In this study, along with the novel approach proposed, our major contribution is setting the stage for a discussion between project management field's scholars and practitioners with those in the manufacturing industry, which we strongly believe that is an opportunity for mutual growth.

Keywords –*Project risk management, supply chain risk management, grounded theory, grey relational analysis.*

1. INTRODUCTION

It is emphasized by both practitioners and scholars, that construction projects are exposed to more risks compared to other industries due to their complexities. These risks can cause performance reductions, increased costs, scheduling delays, and ultimately project failures [1]. Accordingly, poor supply chain management (SCM) may be viewed as a potential source of some of the cost overruns and delays related to the construction industry. Although, the concept of SCM is rooted in the manufacturing industry, firms in the construction industry can also benefit from applying such best practices to some of their processes [2]. However, SCM is still not a mature subject within the construction industry [3]. Moreover, despite its great potentials, application of supply chain risk management (SCRM) concepts (as a sub-field of SCM) to the construction industry is not yet explored.

Over previous decades, there have been numerous natural and man-made disasters (e.g. earthquakes, economic crises, war, terrorist attacks and sanctions), disrupting supply chain operations. The Further study was found out extensive evidences representing that the frequency of man-made disasters creating disruptions, is growing exponentially since the 20th century. These disruptions have been observed increasing, both in potential of occurrence and their magnitude [4]. Supply chain disruptions are inevitable, that makes all supply chains inherently risky [5]. Therefore, effective management of risks in construction supply chains plays a pivotal role in the successful delivery of construction projects. During the past decades, a vast body of knowledge formed around the subject of SCRM. These studies cover three general tasks of SCRM including, risk identification [6]. These tasks have been investigated with both quantitative and qualitative methods, however, in order to mitigate supply chain risks effectively, it is crucial to understand how risks are generated, how they propagate through their interdependencies, and how they influence firms'

operations. It is argued that the majority of SCRM studies are only focused on certain tasks of SCRM and there is still a lack of comprehensive SCRM approach in the present literature that is capable of integrating these three different tasks [7].

On the other hand, in the process of SCRM, risk identification task plays a pivotal role for the success of risk management efforts [8] contend that there are myriad of factors (e.g. cognitive biases) affecting managers' perception of supply chain risks which in turn might lead to suboptimal decisions. Therefore, in order to develop a more realistic and effective risk management model, it is critical to capture managers' perception of risks, and incorporate them in the decision process [9].

1.1.Supply chain risk management

As a result of increasing attraction of SCRM in the previous decades, many researchers focused on developing a robust foundation of knowledge for this topic by contributing to the areas of defining, operationalizing and mitigating risks [10]. Despite all these efforts, a gap of definition still exists in the literature [11]. Academics defined supply chain risk management from numerous perspectives [12], defined it as "The identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole". This definition emphasized the risk identification and management process. However, defined it by focusing on its generic process as, "The management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity". The latter definition is used in the present study.

1.2.Construction project risk management

In the literature of project management, risk management is increasingly seen as an aid to improve the possibility of success in complicated engineering projects [13] Although, studies show that risk management practices are insufficiently employed by project managers [14].

More specifically, compared to other industries, construction industry has been facing a great deal of risks due to factors such as, strategic nature of their products, the complexities of construction techniques, changing building environment, involvement of various

stakeholders, and long production time [15]. Therefore, the necessity of having an effective risk management system to avoid project performance reductions, time delays, and unwanted costs, compelled project management scholars to propose a variety of risk management approaches (for comprehensive overview of available approaches see, [16]. Further, we use simulations and a ranking technique that enable managers to use analytical tools along with their valuable experiences to select the best risk mitigation strategy. On the other hand, analytical hierarchy process (AHP) is the analytical method used predominantly in the literature [17]. However, AHP method is not able to address the interdependencies amongst various risk elements, which creates the possibility of producing unrealistic results. However, by using FCMs we were able to capture and present these interdependencies in the form of causal relationships more effectively.

2. METHODOLOGY

This paper aims to propose a comprehensive SCRM model for construction projects. To this end, three methods including GT, FCM and GRA are used as demonstrated in Fig. 1. First, experts with appropriate work experience are selected and interviewed. Afterwards, by using GT, essential abstract concepts of the SCRM system are extracted from the data gathered by interviews, and grouped under six main categories (i.e. causal conditions, intervening conditions, contextual conditions, strategies, consequences and main phenomenon). Each of these concepts are assigned specific codes which will be used to represent each concept in the FCMs. Next, six risk mitigation scenarios developed by the experts are simulated using the inference process of FCMs. In the last step of the proposed approach, results of the inference process are used to rank risk mitigation scenarios by applying GRA method. For this purpose, relative importance of each risks (weights) are calculated using Shannon's entropy. In the following sub-sections each of the methods used in this paper will be elaborated in details individually.

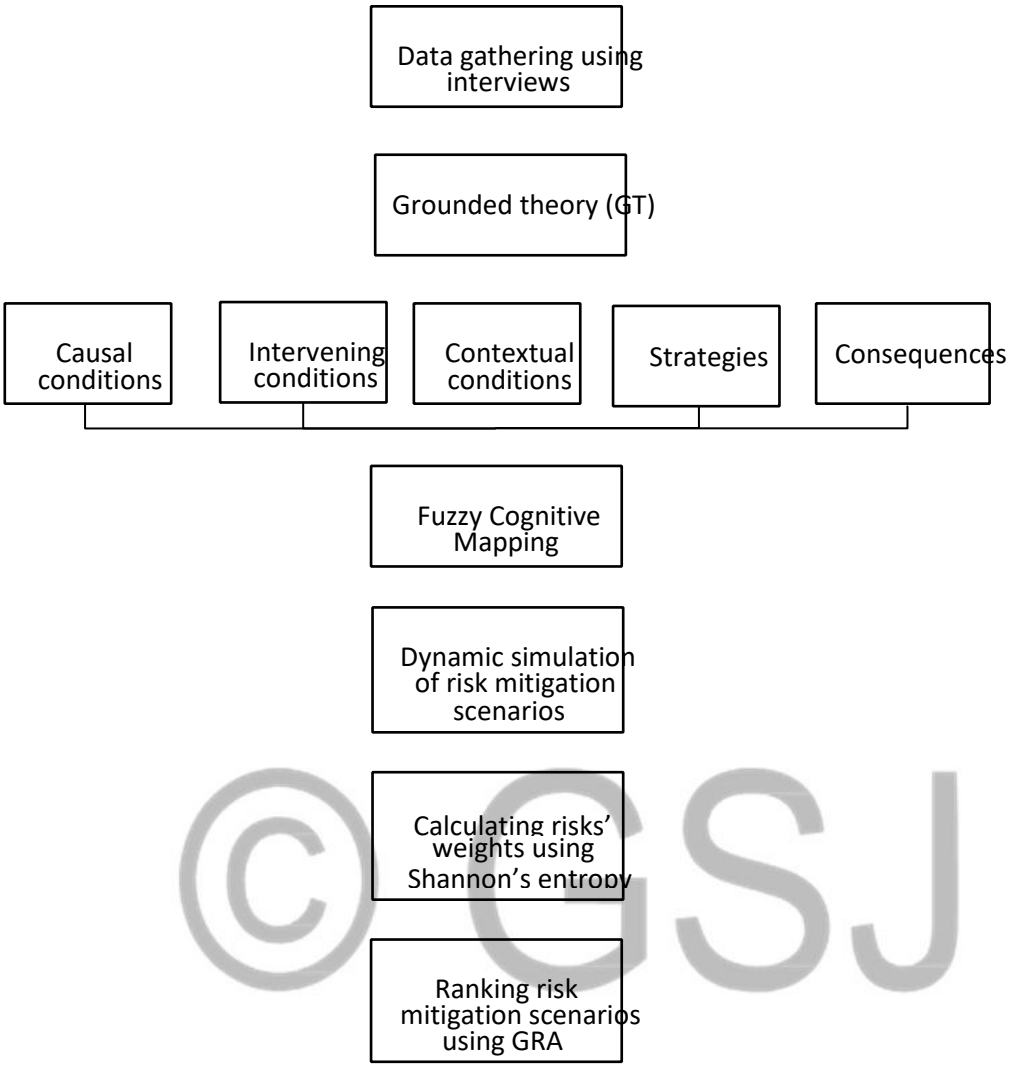

Fig 1. Flowchart of the proposed method.

3. LITERATURE REVIEW

Grounded Theory (GT) is a systematic qualitative research method introduced by Glaser and Strauss in 1967 [18]. As they meticulously defined, "It is a way of arriving at theory suited to its supposed uses". GT is generated through the abstraction of concepts and their interdependencies that are obtained from analyzing qualitative data (e.g. interview transcripts). There are three approaches in adopting GT, which are listed as follows:

a. Straussian approach
b. Glaserian approach
c. Constructive approach

[19] contend that researchers should choose their methodology of GT, congruent to their cognitive style. Also it has been emphasized, not to mix different approaches of GT together [20]. Therefore, in this research we adopted Straussian approach since its more prescriptive and provides more guidelines compared to others [21] maintain that systematic research design of GT highlights the use of data analyzing stages through open coding, axial coding and selective coding.

A CM is a graphical representation of experts' documents and their perception of a phenomenon's causality. Fuzzy cognitive maps (FCMs) introduced by develop the idea of cognitive maps by enabling the use of fuzzy causal relationships rather than precise ones. FCM is a signed fuzzy weighted digraph. Nodes represent concepts, and edges indicate strength, sign, and direction of causal relationships [21]. By synthesizing ideas from artificial neural networks and fuzzy sets, FCM is a well-established artificial intelligence technique [22]. FCMs are utilized to analyze the effects of different strategies with respect to achieving certain goals [23]. FCMs have been applied in various disciplines including, business, control, medicine, robotics, environment and information technology (for a detailed review see: In the field of business, FCMs have been used with different purposes namely, planning, management, decision making, modeling, prediction, and decision support systems (DSSs) [24].

Generally, there are two main approaches to develop and construct FCMs including, expert based approaches (deductive modeling) and the computational methods (inductive

modeling) [25]. The expert-based approach relies solely on human expertise and domain knowledge. However, the computational method employs available data and a learning algorithm to construct or support development of a FCM model for a given system. The approach used in this research is the expert-based one.

The expert-based approach uses the following three steps to construct FCMs [26]

1. Identification of important concepts (nodes)
2. Identification of causal relationship between these concepts
3. Estimation of the strength of the causal relationship.

A panel of experts is used to accomplish the abovementioned three steps. Each expert determines the degree of influence (causal relationship) between nodes using linguistic variables, such as strong influence, medium influence, weak influence, etc. In this study, experts are asked to express their perception of the degree of intensities between concepts using linguistic variables. These values are then defuzzified using center of gravity (COG) method.

4. RESULT AND CONCLUSION:

The Conclusion of this Research paper can be summarized as

- Compared to other industries, construction industry has been facing numerous risks that if they are not managed properly, project failure is an inevitable result. Despite the great importance of this issue, project managers mostly prefer to rely on their own experience to manage projects' risks rather than using the analytical tools available in the literature.
- On the other hand, in the manufacturing sector, an immense body of knowledge and experience has been formed around best practices such as supply chain management and supply chain risk management. Given this situation, there exist a unique opportunity for both the scholars and practitioners in the field of project management to begin exploiting this rich source of knowledge to address their own problems.

- Given many differences between industries in the service sector and those in the manufacturing sector, this task requires major modifications and customizations, so the tools that work well in the manufacturing companies also work well in construction companies. Therefore, in this study we propose a novel supply chain risk management model for construction projects using GT, FCMs and GRA method.
- Since each construction project has specific complexities and uniqueness, it is necessary to take these factors into account while proposing a new decision-making tool for project managers. Further, as there is a gap between the literature and practice in the field of project risk management, considering the managers experience along with using analytical tools in decisionmaking activities, plays a pivotal role in the success of bridging this gap. Therefore, we used both GT and FCMs to reserve and exploit valuable experience of project managers, while capturing a clear image of their perception of this system (projects' supply chain risk management) and its dynamics. Moreover, we also used GRA method to identify the best risk mitigation scenario.

5. RECOMMENDATION:

Based on the outcomes of the study it is strongly recommended to\

- Our major goal in this study is to set the stage for linking two well-developed literatures (i.e. project risk management and supply chain risk management), which we strongly believe that will result in the proliferation of each of them individually.
- The present study puts forward a possibility of discussion between project management scholars and practitioners with those active in the field of supply chain management, by proposing a novel supply chain risk management approach for construction projects. This discussion has a great potential to bring upon a wide horizon of possibilities to expand project managers' problem-solving toolbox, while developing more neglected concepts such as make-to-order and construction supply

chains. Having this goal in mind, our proposed approach contributes to the literature and practice of both SCM and project management in three major ways.

- First, by using GT along with FCMs we shed light on the building blocks of a complicated system in which project's supply chain risks are generated, propagated, and mitigated through time. Additionally, intricate causal relationships between these blocks are identified and presented. Second, construction industry has been dealing with a great deal of uncertainties during each project's lifecycle. On the other hand, extreme penalties for projects' delivery delay limits the ability of project managers to use the trial and error approach to manage risks. Accordingly, our proposed approach enables managers to simulate and examine their risk mitigation scenarios with the minimum cost, and be prepared for any unintended consequence of their scenarios.
- Finally, as it is stated above, our proposed approach captures a clear image of the experts' perception of the risk management system. This characteristic, enables managers to see how might their cognition of the system be flawed and requires major modification, or even how they can improve it.

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