A Decision-Support System for Identifying the Best Contractual Delivery Methods of Mega Infrastructure Developments

Moza T. Al Nahyan[1], Yaser E. Hawas[2], Mohammad S. Mohammad[3] and Basil Basheerudeen[3]
[1]*Department of Managment, Abu Dhabi University, Abu Dhabi, U.A.E.*
[2]*Department of Civil and Environmental Engineering, UAE University, Al Ain, U.A.E.*
[3]*Roadway, Transportation, and Traffic Safety Research Center, UAE University, Al Ain, U.A.E.*

Keywords: Decision Support System, Megaprojects, Delivery Methods, Fuzzy Logic Model.

Abstract: This article describes the Decision Support System (DSS) software for identifying the best contractual delivery methods for megaprojects, based on the elements of risks, opportunities of investments and project constraints. A fuzzy-based multi-criterion decision-making technique is used to develop the DSS, to assist the client in the selection of the appropriate contractual delivery method. The system accounts for the relative importance of the various stakeholders in the different project stages. The system enables the client to depict his/her best choices (regarding project delivery methods and stakeholder entities) that would likely provide the best environs for the project to succeed. With such complicated system, the client can also investigate the specifics of the various project stages and study the effects of enhancements or deficiencies of the stakeholder entities capabilities. The system was developed and calibrated based on the results obtained from extensive surveys among key stakeholders in the UAE.

1 INTRODUCTION

During the past years, there is an unprecedented growth in the infrastructure development in the Middle East, rendered by the looming mega capital events such as Dubai Expo and Qatar FIFA World Cup in 2020 and 2022 respectively. The fast pace infrastructure expansion and lessen period for project planning puts pressure on the client to make appropriate decisions, specifically with the choice of selection of the project delivery. It is well understood that the proper selection of contractual delivery method is a crucial factor in the project success (Qiang et al., 2015) and is reliant on the owner's objectives, project requirements and project performance objectives (Touran et al., 2009). In the context of UAE construction industry, the inadequate early planning and the slowness in client's decision-making process were identified amongst the significant factors contributing to the construction delays and affecting the project success (Faridi and El-Sayegh, 2006). Based on the available project information, the clients have inconclusive knowledge of the influential factors, risks and constraints in the early project planning and the decisions on the choice of project delivery are built on the little understanding of the possible project outcome. Each delivery method is a specific systematic approach attempted by the client with other stakeholder entities to design the construction procedure comprehensively. This includes the project scope definition, sequencing of construction activities and engaging the public/private entities for the successful completion of the construction project (Khalil, 2002; Touran et al., 2009; Chen et al., 2011; Al Nahyan, 2013). As per the Construction Country Institute (CII), there are three fundamental project delivery methods, which includes the Design Bid Build (DBB), Design-Build (DB) and Construction management at risk (CMR). Later, Miller et al., (2000) established the additional classes of delivery methods based on the source of finance (Direct or Indirect) and the integration of delivery (combined or segmented).

Although many practitioners adopt the most common traditional delivery method – Design Bid Build, no universally acknowledged project delivery method suits for every construction project requirement. Apart from the fundamental delivery methods, the alternate methods are often overlooked by the past researchers due to lack of familiarity and

Al Nahyan, M., Hawas, Y., Mohammad, M. and Basheerudeen, B.
A Decision-Support System for Identifying the Best Contractual Delivery Methods of Mega Infrastructure Developments.
DOI: 10.5220/0006694704070414
In *Proceedings of the 20th International Conference on Enterprise Information Systems (ICEIS 2018)*, pages 407-414
ISBN: 978-989-758-298-1

their applicability in different sectors of the construction industry. Some little research efforts were devoted to the development of client's advisory or management systems for the large-scale infrastructure projects. The primary aim of this research is to bridge this research gap and deficiency of tools to assist the client in making vital decisions on how to execute the project. A front-end expert system is developed to assist the client/owner in the choice of selection of Contractual Delivery Method (CDM) based on the evaluation of the multiple criteria influencing the project delivery selection.

2 REVIEW OF EXISTING CDM SELECTION MECHANISM

The appropriate selection of contractual delivery method is fundamental to improving the performance of infrastructure projects. Many researchers addressed the effectiveness of the different delivery methods, while some identified the suitable selection criterion for specific project requirements and owner priorities, whereas others attempted different decision-making mechanism for the contractual delivery selection. Gordon (1994) utilized flowcharts to choose the best contracting method, which allows the client to prioritize amongst the list of significant factors provided without weights.

Konchar and Sanvido (1998) proposed specific criteria (both quantitative and qualitative) to investigate the effectiveness of DB, DBB, and CMR. The effectiveness of conventional contractual methods was investigated across the different project objectives and owner preferences, (El Sayegh, 2008), though it only highlighted the criterion set for the client to rank their preferences. Skitmore (2001) estimated the utility factors to set priority ranking (multi-attribute technique) for different project delivery alternatives, but fail to reflect the subjective judgment of public/private entities involved. Analytical Hierarchy Process (AHP) is a multi-criterion decision-making mechanism applied to the suitable selection of delivery method by many practitioners (Mahdi and Alreshaid, 2005; Touran et al., 2009). AHP requires massive dataset of indicators, and inaccuracy arises with the imprecise perception of the experts/professionals in the industry. AHP is sensitive and can lead to varying decisions on situations with a higher degree of uncertainty (Kordi and Brandt, 2012). A summary of the literature listing the selection mechanism of contractual delivery methods is provided in Table 1.

3 RESEARCH APPROACH

The selection of contractual method is a complicated decision-making process and substantially varies with the project characteristics and the owner objectives. Moreover, the uncertain nature and the inherent complexities associated with the increasing size of the infrastructure projects makes it even more difficult for the owner in the decision-making process. However, it is arduous for the client to obtain information (quantitative or qualitative) on the alternate delivery methods confining to the diverse project requirements and owner needs. Moreover, the project delivery selection is governed by multiple factors constituting the project characteristics, owner needs, preferences and risk factors. It is appealing to adopt the Multi-Criteria Decision Making (MCDM) approach to model the multi-dimensional and complex interface of the factors governing the

Table 1: Literature listing of factors governing the project.

	Author and Year		Contractual Delivery Selection Mechanism
(i)	Khalil (2002) ,Mahdi & Alreshaid (2005)	:	Analytical Hierarchy Process & Pairwise Comparison
(ii)	Mafakheri (2007)	:	Interval Analytical Hierarchy Process & Rough Set Theory
(iii)	Alhamzi & McCaffer (2000) ,Touran et al. (2009)	:	Analytical Hierarchy Process (AHP) and Weighted Matrix
(iv)	Ribeiro (2001), Yoon et al. (2016)	:	Case-based Reasoning (CBR) and Decision Tree
(v)	Chen et.al (2011)	:	ANN and Data Envelopment Analysis Bound Variable
(vi)	Kumaraswamy and Dissanayaka (2001)	:	Expert-based Advisory System
(vii)	Ratnasabapathy and Rameezdeen (2007)	:	Multi-Attribute Utility Technique using Delphi Method
(viii)	Oyetunji and Anderson (2006)	:	Multi-Attribute Rating Technique with Swing Weights
(ix)	Chan (2007), Mostafavi and Karamouz (2010)	:	Fuzzy Set Theory- Relationship & Evaluation model Fuzzy Multi-Attribute Decision Making: TOPSIS

selection of project delivery alternatives. Based on the predefined criterion of multiple factors, a fuzzy-based MCDM is used in the assessment of the contractual delivery alternatives for the large-scale infrastructure projects. The relative weights of the multiple criteria are estimated for the project delivery alternatives using the linguistic values represented by the fuzzy numbers. An aggregate measure of weights is evaluated for the suitability of delivery alternatives depending on the client preference and project goals. Also, to reflect the influence of managerial and coordinated action of project stakeholders on the decision process, the system requires a qualitative judgment of weights of the project stakeholders amongst the different project stages (Al Nahyan, 2013; Hawas and Al Nahyan, 2017). It is feasible to adopt a human intuitive judgment process to capture the vagueness in the selection procedure and hence a fuzzy-based approach is adopted to characterize the factors influencing the contractual delivery in mega infrastructure projects. The fuzzy based modeling is more appealing in the decision making of large scale projects, characterized with complex interfaces and higher uncertainties.

Based on the thorough review of the literature, the critical factors influencing the selection process are grouped into three categories; Risk, Constraints, and Opportunities. The indicators of the listed categories are assessed qualitatively using a questionnaire survey amid the industry professionals and used to validate the developed model structure and weight factors. Based on the qualitative inputs of the system users, the indicators of the risk elements, opportunities and constraints are used collectively to estimate a qualitative measure (L, M, H) for each element separately. Such qualitative measures are then compared with decision matrix, to rank the alternative project delivery methods, where highest index score refers to the best suitable method of project delivery. The paper addresses the model structure devised to aid the client/owner in the selection of the most appropriate project delivery methods.

4 MODEL STRUCTURE

The model software was developed in C#.net using an Integrated Development Environment (IDE), specifically the Microsoft Visual Studio®.NET. The system uses a MySQL database to store the input, output values, and the processed information. It is compatible with Microsoft Windows Operating System and needs installation of Microsoft.Net framework 4.5 or higher to run the program. Besides, it uses FuzzyTech® generated runtime files to implement fuzzy logic.

As shown in Figure 1, the system evaluates elements of risks, opportunities of investments and constraints on delivery. Each category has elements defined by a set of indicators. For example, in the risk category, the Technical Risk is evaluated by the indicators of technical competence of employees, established technical feasibility study, work breakdown structure, design quality and design completion.

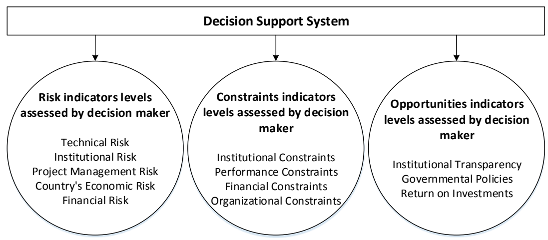


Figure 1: Elements and indicators of MCDM based DSS.

The developed Decision Support System (DSS) ensures a toolkit to assist the client or owners in evaluating the multiple factors based on predetermined or flexible criteria to select the best suitable contractual delivery method. The DSS has three components: the input interface, the fuzzy rule-based processing (granular) core, and the output interface. The input and output components are designed to provide the user with an interactive Graphical User Interface (GUI). Hence, it allows the users to interact easily through graphical icons and visual indicators. The input space offers flexibility to the end-users to define or prioritize the mega-project attributes, essential in identifying the best delivery methods.

The granular fuzzy core is designed using FuzzyTech® software which is a runtime file used in the fuzzy calculations. The linguistic values of the indicators (as input by the user) are very low, low, medium, high, and very high. Some indicators are binary as Yes or No. Figure 2 shows a schematic representation of the working process for the Technical Risk element, where the user selects the fuzzy input term from a combo box. Before passing the values on to the granular core, the fuzzy user-input terms are 'defuzzified' into numeric values by the system. The system collects the defuzzified inputs and processes them further through subsequent fuzzification process, before firing the rule base blocks. The system intermediately reports a numeric value and corresponding fuzzy term for each element (e.g., Technical Risk). In the calculations, the processing core relies on the built-in correlation values and signs (positive or negative) defined for every composition in the fuzzy rule-base. The developed DSS model structure has three stages; configuration, computation, and output and reports. These stages are described in detail hereafter.

4.1 Stage 1 – Configuration

The configuration stage is the one where the user inputs the essential information to the system. Once the configuration is completed through a GUI interface, the data entries are saved to a database where they can be retrieved, or re-edited whenever necessary for further calculations. Figure 3 shows the schematic representation of the user interaction with the system at the configuration stage. As discussed earlier and as shown in Figure 2, the indicators' values are processed through the fuzzy system and outputs are stored in the database. The various input modules for the end user are outlined hereafter.

4.1.1 Project Stages and Stakeholders

Each project has a clear set of stages with a distinct set of activities (in each stage) that take the project from the concept idea to its implementation. The project activities in each stage are significant enough to contribute to the overall success of the project. The process of directing and controlling a typical mega-project development from start to finish is divided into 6 stages: Planning, Scoping, Design, Scheduling, Tendering, & Construction. Besides, a stakeholder can be an individual or entire organizations who can affect or get affected by the project implementation or outcome of a project. It does not matter whether the project affects them negatively or positively. They can be internal or external to the organization. Based on previous reviews, the default stakeholders considered in the system development are 1) Clients / Sponsors, 2) Government Agencies, 3) Project Managers, 4) Consultants, 5) Contractors. The system allows the user to modify the various stakeholder groups, edit, add or remove.

The stakeholder engagement varies amongst the different stages of the project, and it is captured in the decision mechanism by estimating their importance levels as shown in Figure 4. Each stakeholder can have different levels of importance in different project phases. The system scales the importance value from 0 to 9, where 0 and 9 represent no importance and profoundly influential, respectively. The default values of the relative significance of specific stakeholders in the different stages of project cycle are determined using surveys of expertise in large-scale projects. The user, however, can edit and adjust these importance levels.

4.1.2 Contractual Delivery Methods

The contractual delivery is a sequence or a process by which a construction project is comprehensively designed and constructed. It includes the project initiation, scope definition, organization of designers, constructors and various consultants, sequencing of design and construction operations, execution of design and construction, and closeout (Project Delivery Systems for Construction, 2004). The model covers all possible contractual delivery alternatives to rank them based on the criteria provided by the user. The user has the option to add more delivery methods (if needed). The system accounts for Design-Bid-Build (DBB), Design-Build (DB), Performance-Based Maintenance Contracts (PBMC), Construction Management at Risk (CMR), Design-Build with Warranty (DBW), Design-Build-Operate-Maintain (DBOM), Design-Build-Finance-Operate (DBFO), Build-Own-Operate-Transfer (BOOT), Design-Build-Finance-Operate-Maintain (DBFOM), Alliance Contracting (AC), and Build-Own-Operate (BOO) (Miller et al., 2000).

4.1.3 Decision Matrix

The default values of the Decision Matrix are constructed based on thorough literature review and data surveys. Each row in Figure 5 represents a specific delivery method. The Low, Medium and High column represent its corresponding values for each delivery method based on the chosen element from the combo box list. For instance, Figure 5 represents the mapping values of Technical Risk as the chosen element. Further, Low, Medium, and High show the suitability scores for specific delivery methods. The entry of 1 indicates the suitability of the delivery method (raw entity), and 0 indicates the non-suitability. As shown in Figure 5, the conventional Design-Bid-Build (DBB) method may be suitable for projects where the technical risk is either low or medium, but not suitable when technical risk is high.

4.1.4 Priority Weights and Indicators

The user can set a priority weight for each element and group/category of elements (risks, opportunities, and constraints) based on his knowledge and understanding. Easy to use GUI interface facilitates the user to set the ratio for the priority. For example,

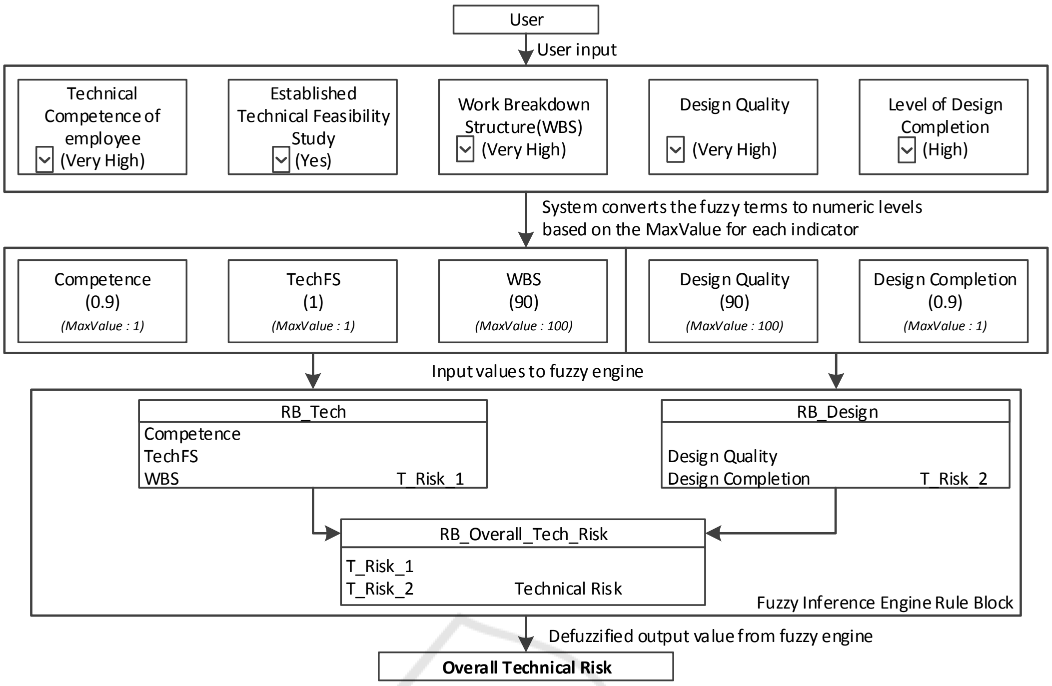


Figure 2: Estimation of technical risk from user input using fuzzy inference engine rule block.

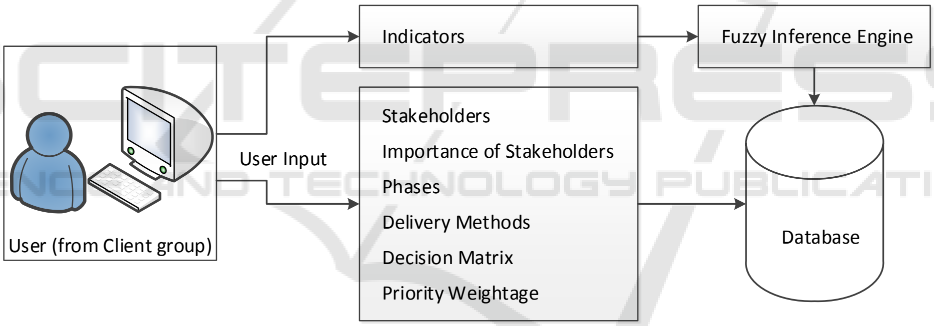


Figure 3: Configuration stage – user input and fuzzy calculation.

as shown in Figure 6, the priority weight ratio for categories of Risks, Constraints, and Opportunities are assigned as 2:1:1, where Risk takes 50% priority, and Constraints and Opportunities take 25% each. Similarly, the user preferences can be input to all the categories and the corresponding elements identified in the mulita criterion decision making.

The inputs for indicators require the domain knowledge of the expert or decision maker. Each element of risk has its indicators to identify its overall risk value, which in turn becomes a part of the overall project's risk. The indicator values then passed onto the fuzzy engine. The fuzzy rule-based inference units are used to estimate the corresponding element risks based on the input values of its indicators. The fuzzy inference block is validated using the qualitative judgment of experienced practitioners.

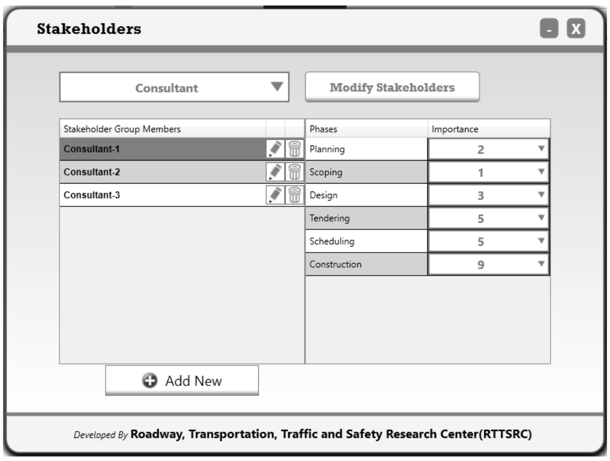
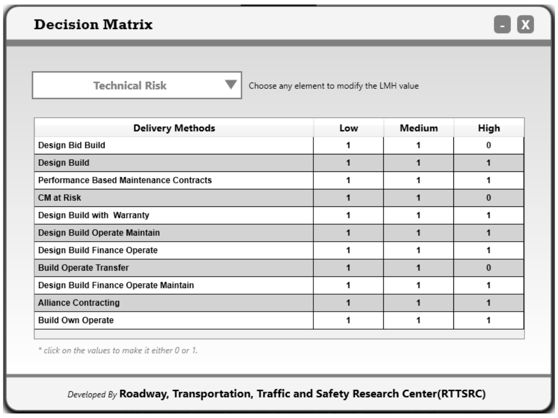


Figure 4: Configuration of the importance levels of stakeholders involved in megaprojects.



Delivery Methods	Low	Medium	High
Design Bid Build	1	1	0
Design Build	1	1	1
Performance Based Maintenance Contracts	1	1	1
CM at Risk	1	1	0
Design Build with Warranty	1	1	1
Design Build Operate Maintain	1	1	1
Design Build Finance Operate	1	1	1
Build Operate Transfer	1	1	0
Design Build Finance Operate Maintain	1	1	1
Alliance Contracting	1	1	1
Build Own Operate	1	1	1

Figure 5: Configuration of decision matrix of every contractual delivery alternative for technical risk element.

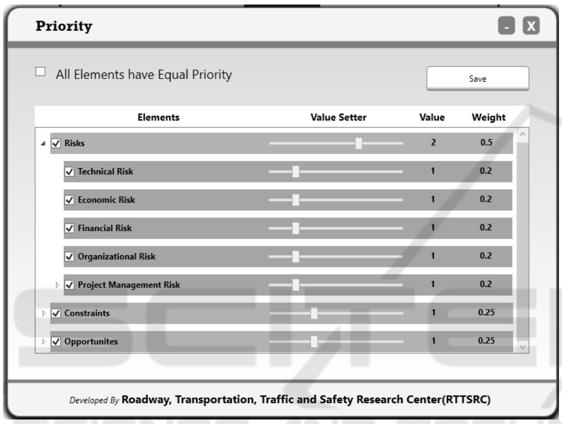


Figure 6: User-defined priority preferences for the categories and elements.

For example, the Return On Investment (ROI) element identified amongst the Opportunity category determines the likeliness of private companies to invest in public infrastructure projects. The ROI is affected by two indicators; the capital asset and level of profit. The ROI improves with the decrease in capital assets and increases by level of profit and vice versa. The users set their preferences using linguistic terms provided in a drop-down menu.

4.2 Stage 2 – Computation

The system user/client provides inputs of importance rating of stakeholders in different project stages, priority weights of different categories such as Risk, Constraints and Opportunities and their respective elements and lastly, the qualitative judgement of the identified indicators. A rule-based fuzzy multi-criterion decision-making (MCDM) model is recognized to derive the consolidated effects of the multiple factors. The fuzzy rules are established with the aid of expert knowledge and understanding of distinct factors influencing the CDM selection. Further, the fuzzy model estimates are integrated with the decision matrix to derive an absolute index for every delivery method (Al Nahyan et al., 2018). The DSS normalize the absolute index (to a value between 0-1) and compares the values of different CDM, where the CDM corresponding to highest index defines the best suitable delivery method for the user inputs. Figure 7 shows the schematic representation of the computation process of the user-defined input data. In addition, the client/user have the flexibility to run the program considering all the delivery methods and stakeholders or evaluate by choosing a specific delivery method and stakeholder group/entities for the specific project requirements. Based on the user

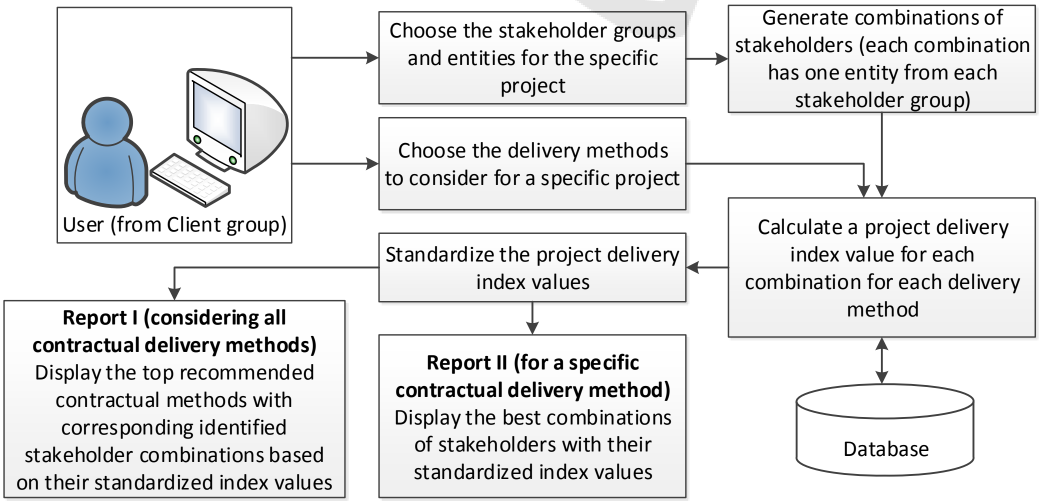


Figure 7: Working process at computation stage.

selection of potential stakeholder groups/entities, different stakeholder entities combination are generated.

4.3 Stage 3 – Output and Reports

At the end stage, the best suitable delivery methods are documented in output report based on the estimated index standardized values. The developed system displays two reports as indicated in Figure 7. It enables the decision maker more options for making decisions by switching among the reports. As shown in Figure 8, report type I enables the user to identify the top recommended project delivery methods and stakeholder entities that are likely to achieve best project performance and success (ranked by their standardized indices). Besides, Report type II enables the user to optimize the selection of the best stakeholder entities for a specific delivery method as seen in Figure 9. For instance, for the DBB, who are best stakeholder entities that are likely to achieve the highest project success and suitability.

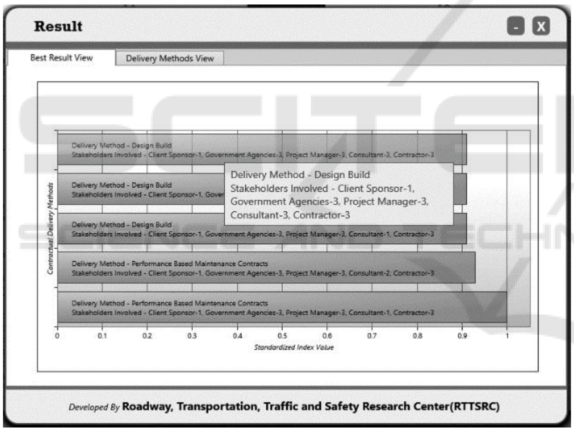


Figure 8: Report Type I Sample.

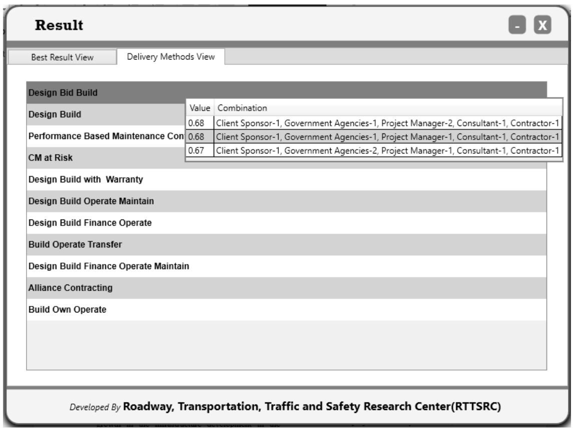


Figure 9: Report Type II Sample.

5 SUMMARY

A fuzzy-based multi-criterion decision-making technique is used to develop the DSS, to assist the client in the selection of the appropriate project delivery method. The software helps to identify the best and rank the project delivery alternatives based on project requirements, stakeholders involved, and potential elements of risks, investment opportunities, and constraints. This application can be adapted easily to preferences/priority requirements of the user owing to the dynamic computational structure, and it can be modified easily by the user using GUI interface. The model structure reflects the intuitive judgment of experienced construction industry professionals, as the model is validated using the qualitative information collected from different stakeholder expertise. The input interfaces are easily managed and necessarily does not require substantial data inputs in the selection process.

All the elements of risks, opportunities and constraints were identified throughout the literature review. Also, extensive surveys with various stakeholders (more than 150 surveys) of mega-projects have assisted in identifying the system elements as well as the indicators. Such surveys were also used to calibrate the fuzzy relations (strength and sign) between the indicators and their corresponding element assessment.

The existing AHP models requires extensive data inputs and fails to account the megaproject expertise perspectives and the managerial influence of stakeholders resulting in imprecise estimates Notably, less efforts are witnessed in development of client advisory system, particularly in the large scale civil infrastructure construction. Currently, the DSS model serves as a standalone application and further enhancements can be recognized to operate the system remotely The DSS offers the flexibility to account for the user's preferences of adding/removing project delivery methods, elements of risks, opportunities, and constraints, indicators, weights, stakeholder groups, and entities. Nonetheless, not to overload, the user with new inputs each time he/she uses the system, default values are stored for ease of retrieval and editing. Finally, the system enables the client to depict his best choices (regarding project delivery methods and stakeholder entities) that would likely provide the best environs for the project to succeed. With such complicated system, the client can also investigate the specifics of the various project stages and study the effects of enhancements or deficiencies of the stakeholder entities capabilities (as reflected by indicators).

ACKNOWLEDGEMENTS

The authors would like to acknowledge the research project funds (Grants # 31R064 and 21R018) by the UAE University and the UAE Ministry of Higher Education and Scientific Research.

REFERENCES

Alhazmi, T. and McCaffer, R., 2000. Project procurement system selection model. *Journal of Construction Engineering and management*, 126(3), pp.176-184.

Al Nahyan (2013) "Management of transportation infrastructure projects in the United Arab Emirates". Ph.D. Dissertation, Monash University, Australia.

Al Nahyan, Hawas, Y.E., Raza, M., Al Jassmi, H., Maraqa, M., Thonnamthodi, B., Mohammad, M.S**.,** (2018) "A Fuzzy-based Decision Support System for Ranking the Delivery Methods of Mega Projects," *International Journal of Managing Projects in Business*, Vol.11**,** Issue 1 *(In press)***.**

Chan, C.T., 2007. Fuzzy procurement selection model for construction projects. *Construction Management and Economics*, 25(6), pp.611-618.

Chen, Y. Q. et al., 2011. 'Project delivery system selection of construction projects in China', *Expert Systems with Applications. Elsevier Ltd*, 38(5), pp. 5456–5462.

El-Sayegh, S.M., 2008. Evaluating the effectiveness of project delivery methods. *Journal of Construction Management and Economics*, 23(5), pp.457-465.

Faridi, A. S. and El-Sayegh, S. M., 2006. 'Significant factors causing delay in the UAE construction industry', *Construction Management and Economics*, 24(11), pp. 1167–1176.

Gordon, C.M., 1994. Choosing appropriate construction contracting method. *Journal of construction engineering and management*, 120(1), pp.196-210.

Hawas Y.E., Al-Nahyan M.T. (2017) A Fuzzy-Based Approach to Estimate Management Processes Risks. In: Meier A., Portmann E., Stoffel K., Terán L. (eds) The Application of Fuzzy Logic for Managerial Decision Making Processes. Fuzzy Management Methods. Springer, Cham.

Jato-Espino, D., Castillo-Lopez, E., Rodriguez-Hernandez, J. and Canteras-Jordana, J.C., 2014. A review of application of multi-criteria decision making methods in construction. Automation in Construction.

Khalil, M. I. Al, 2002. 'Selecting the appropriate project delivery method using AHP', *International Journal of Project Management*, 20(6), p. 464.

Konchar, B. M., Sanvido, V. and Members, A., 1998 'Comparison of U. S. Project Delivery Systems', 124(December), pp. 435–444.

Kordi, M., & Brandt, S. A., 2012. Effects of increasing fuzziness on analytic hierarchy process for spatial multicriteria decision analysis. *Computers, Environment and Urban Systems*. 36(1), 43–53.

Kumaraswamy, M.M. and Dissanayaka, S.M., 2001. Developing a decision support system for building project procurement. *Building and Environment*, 36(3), pp.337-349.

Loforte Ribeiro, F., 2001. Project delivery system selection: a case-based reasoning framework. *Logistics Information Management*, 14(5/6), pp.367-376.

Mafakheri, F., Dai, L., Slezak, D. and Nasiri, F., 2007. Project delivery system selection under uncertainty: Multicriteria multilevel decision aid model. *Journal of Management in Engineering*, 23(4), pp.200-206.

Mahdi, I. M. and Alreshaid, K., 2005. 'Decision support system for selecting the proper project delivery method using analytical hierarchy process (AHP)', *International Journal of Project Management*, 23(7), pp. 564–572.

Miller, J.B., Garvin, M.J., Ibbs, C.W. and Mahoney, S.E., 2000. Toward a new paradigm: Simultaneous use of multiple project delivery methods. *Journal of Management in Engineering*, *16*(3), pp.58-67.

Mostafavi, A. and Karamouz, M., 2010. Selecting appropriate project delivery system: Fuzzy approach with risk analysis. *Journal of Construction Engineering and Management*, 136(8), pp.923-930.

Oyetunji, A.A. and Anderson, S.D., 2006. Relative effectiveness of project delivery and contract strategies. *Journal of Construction Engineering and Management*, 132(1), pp.3-13.

Project Delivery Systems for Construction. Associated General Contractors of America, Arlington, Va., 2004.

Qiang, M. et al., 2015. 'Factors governing construction project delivery selection: A content analysis', *International Journal of Project Management. Elsevier Ltd and Association for Project Management and the International Project Management Association*, 33(8), pp. 1780–1794.

Ratnasabapathy, S. and Rameezdeen, R., 2010. A decision support system for the selection of best procurement system in construction. *Built-Environment Sri Lanka*, 7(2).

Touran, A. et al., 2009. 'Decision Support System for Selection of Project Delivery Method in Transit', *Transportation Research Record: Journal of the Transportation Research Board*, 2111(1), pp. 148–157.

Yoon, Y., Jung, J. and Hyun, C., 2016. Decision-making Support Systems Using Case-based Reasoning for Construction Project Delivery Method Selection: Focused on the Road Construction Projects in Korea. *The Open Civil Engineering Journal*, 10(1).