Ranking project success criteria in power engineering companies using fuzzy decision-making method

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ABSTRACT

In the global market economy, most power consulting enterprises in Vietnam have many engineering investment projects. The successful implementation of investment projects is a vital part of their business. For projects to succeed, CEO and leaders in those firms must make the right criteria for evaluating projects. In real practice, it is not an easy task because there are many factors that influence the success of a project such as time, cost, quality, and the satisfaction of stakeholders, etc. Assessing the importance of these project success criteria is a complex multi-criterion decision problem. On the other hand, traditional assessment methods are often based on t customarily based on subjective opinions of the decision maker, resulting in the wrong decision. Therefore, this paper presents a new fuzzy decision-making method for weighting project success criteria in power consulting companies in Vietnam. This new method is expected to provide an objective measure in project success appraisal process.

1. Introduction

Project success is a problematic synopsis because of its complexity (Joslin and Müller, 2015; Todorović et al., 2015). Until now, there is no accepted universal definition of project success. It depends on human perceptions, and it has been discussed for a long time by many authors (Abdullah et al., 2015; Shaari et al., 2015). It may vary depending on many factors and stakeholders point of views (Chan et al., 2004). For example, a construction project engineer may consider success regarding quality and cost aspect, but an architect may refer to project aesthetic appearance (Nguyen et al., 2015; 2017a).

Evaluating the success of the engineering project is essential. In the construction industry, for example, project success definition varies among different projects depending on participants, project size, scope and time constraint to implement a project (Iram et al., 2017; Oke and Aigbavboa, 2017; Nguyen and Nguyen, 2017). Therefore, the list of critical criteria for evaluating project success should be explored before making the assessment decision

(Nguyen et al., 2016a). Moreover, most of the currently evaluated project criteria models are usually based on qualitative and subjective opinions of evaluators, resulting in inappropriate decisions (Nguyen et al., 2017b). Also, these models ignore the risk factors and the importance of assessors (Quyen et al., 2017a; 2017b). To overcome these limitations, our paper uses a multi-attribute decision analysis method for based on Analytical Hierarchy Process (fuzzy-AHP) in project success criteria evaluation.

2. Research background

According to Oxford Advanced Learner's Dictionary, criterion means "a standard or principle by which something is judged, or with the help of which a decision is made." However, the definition of a factor is "one or several things that cause or influence something." So, the concept of "project success criteria" and "project success factor" are generally different even though some researchers consider them are the same. In general, a set of criteria project success establishes the groundwork for project success judgment (Azhar et al., 2015). It includes principles which are used to judge the project. On the other hand, project success factors are the set of several things that cause or influence outcomes, which contribute to the project success or failure (Al-Tmeemy et al., 2011).

Measuring project success is a complex task. Its activity depends on the different stakeholders' points of view. A project can be perceived as a success for one party but a failure for another (Altahtooh and Emsley, 2017). DeWit (1988) believed the concept that one can objectively measure the success of a project is an illusion. Nevertheless, he pointed out that it is possible and valuable to evaluate the project at the post-completion stage. He also provided evidence, the Project Management Institute conference held in Montreal in 1986, to demonstrate the possibility of success measurement. The purpose of this conference was to examine the importance of good measurement indicators of project success. It received the earlier version of papers related to "measuring success" implying a message that project success is possible to determine. Result measure, process measure, and relationship measure are three types of measures of the partnering (Crane et al., 1999). All of them are important and strong in their proper place. Among them, result measure is the most difficult to evaluate, but it is the most useful for future strategy adjustments. According to the proposed objective of this research, from this point forward, project success is considered at the completed stage.

Project objectives are the most appropriate criteria for project success. The success or failure of a project is determined based on the degree to which these objectives are being met. From DeWit (1988), the criteria for project success are restricted to time, cost, and quality. He also discussed the results of project success from a pilot study at the University of Texas. According to the results, project success was frequently measured by six criteria including budget performance, schedule performance, and project stakeholders' satisfaction.

A list of six criteria for success was developed by Songer et al. (1996). They are 'On budget,' 'On schedule,' 'Meets specifications,' 'High quality of workmanship,' 'Conforms to user's expectations,' and 'Minimizes aggravation.' 'On a budget' refers to the completion of the project within the contracted cost. 'On schedule' means this completion is achieved before or on the date as shown in the contract. 'Meets specifications' suggests the ability to meet or exceed the entire owner has provided specifications of technical performance. 'Conforms to user's expectations' is the ability to meet or exceed the envisioned functional goals of the user (fitness for purpose). Finally, an ability to meet or exceed the standards required for workmanship in all areas is called 'High quality of workmanship,' and using a process that does not cause overwhelming workload to the owner's project management staff is 'Minimizes aggravation.' The results from 137 qualified responses in the U.S. and U.K. showed that project success is judged based on such criteria as a budget variation, schedule variation, and conformity to expectations. These criteria are consistent with the construction industry in general.

Liu and Walker (1998) suggested that a project should be evaluated at two levels. The first level is project goals, which include time, budget, functionality, quality, technical specification, safety, and environmental sustainability. The second level is the satisfaction of the claimant. Crane et al. (1999) introduced partnering measures which are result measure, process measure, and relationship measure. Among them, result measure is the most important but also difficult to perform. So, they provided an example framework to evaluate results which included cost, schedule, safety, quality, and litigation. Lim and Mohamed (1999) discussed a framework for evaluating project success similar to the framework suggested by Crane et al. (1999). Besides time, cost, quality, and safety, Lim and Mohamed (1999) added performance and satisfaction to their model. After nearly ten years, environmental impact has become an important index in evaluating project success (Ahadzie et al., 2008). Recently, the concept of project success has broadened. The importance of the roles of project schedule, budget, quality, safety, and satisfaction in project success measurement is in no doubt. Al-Tmeemy et al. (2011) added four indexes to this framework which are a functional requirement, technical specification, revenue and profit and market share. We proposed seven critical criteria for project success criteria problem in Vietnam using literature review and in-depth interview in Table 1 (Nguyen and Nguyen, 2017).

Table 1: Key project success evaluation criteria

No	Project success criteria
1	Quality
2	Time
3	Cost
4	Health and safety
5	Environmental sustainability
6	Satisfaction
7	Legal

3. Research methodology

One of the most commonly used decision-making methods is the Analytical Hierarchy Process (AHP), introduced by Saaty (2005). AHP was known as an of a set of multi-attribute decision analysis methods (Hamid-Mosaku et al., 2016; Khalila et al., 2015; Umara et al., 2015; Nguyen et al., 2016b; Zaini et al., 2015). However, decision-makers regularly found that it is more convenient and more confident to use interval judgments than only a fixed value opinion (Kabir and Sumi, 2014; Paksoy et al., 2012). It reflects the fuzzy nature of the project evaluation process (Heo et al., 2010).

The following section demonstrates the computational procedure of the weights of project success criteria (Chou et al., 2012).

1. According to the committee with three experts about the relative importance of project success criteria, then the pairwise comparison matrices of them was obtained. We apply the fuzzy numbers defined in Table 2 (Chang et al., 2016).

Table 2: Linguistic scales for relative importance (Nazari et al., 2017; Plebankiewicz and Kubek, 2015)

Fuzzy number	Linguistic	The scale of fuzzy number
1	Equal	(1,1,1)
2	Weak Advantage	(1,2,3)
3	Not bad	(2,3,4)
4	Preferable	(3,4,5)
5	Good	(4,5,6)
6	Fairly good	(5,6,7)
7	Very good	(6,7,8)
8	Absolute	(7,8,9)
9	Perfect	(8,9,10)

2. We calculated the elements of synthetic pairwise comparison matrix by using the geometric mean method suggested by Buckley (1985):

$$\tilde{a}_{ij} = \left(\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \tilde{a}_{ij}^3 \otimes \dots \otimes \tilde{a}_{ij}^n \right)^{1/n}$$

It can be obtained the other matrix elements by the same computational process. Then, the synthetic pairwise comparison matrices of the evaluators could be constructed as follows matrix:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \dots & \tilde{a}_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \dots & 1 \end{bmatrix}$$

where

$$\tilde{a}_{ij} = \begin{cases} \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}, \\ \text{if criterion } i \text{ is relative importance to criterion } j, \\ 1, \text{ if } i = j, \\ \tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1} \\ \text{if criterion } i \text{ is relative less importance to criterion } j. \end{cases}$$

3. To calculate the fuzzy weights of project success criteria, we need to calculate:

$$\tilde{r}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \tilde{a}_{i3} \otimes \dots \otimes \tilde{a}_{in} \right)^{1/n}$$

For the weight of each criterion, they can be done as follows:

$$\widetilde{w}_i = \tilde{r}_i \otimes \left(\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \dots \oplus \tilde{r}_n \right)^{-1}$$

4. Results and discussion

We applied FAHP technique for a group of decision making consisting of three managers at the Power Engineering Consulting Company in Vietnam for project success criteria assessment. In this case study, seven project success criteria were compared and assessed cautiously. These importance weights of success criteria were defined using fuzzy pairwise comparison matrices based on triangular numbers (TFNs). It is reasonable because of its ability to precisely represent and process fuzzy data (Heo et al., 2010; Routroy and Shankar, 2015).

By applying all formulas in FAHP method above, the results of all main project success criteria are $w_1 = 0.329$, $w_2 = 0.152$, $w_3 = 0.188$, $w_4 = 0.097$, $w_5 = 0.095$, $w_6 = 0.149$, and $w_7 = 0.064$. This means that in the project success evaluation problem, the project quality, time, and cost are the top three most critical criteria. These results were different from business projects, which focused on customer satisfaction criteria. This research result proved that the common triple constraint (cost, time, quality) was the most basic evaluation success criteria in power engineering companies in Vietnam.

5. Conclusion

There are many methods for evaluating project success criteria. However, most of them are qualitative approach and do not reflect the uncertainty in the opinion of the decision maker. Therefore, this paper presents a quantitative decision analysis model using fuzzy way to rank project success criteria weights. It is based on Analytical Hierarchy Process (AHP) methodology. The advantage of the fuzzy-AHP method is that it takes into account the importance of decision-makers and it reflects the uncertainty in their assessment. This helps organization to evaluate project success criteria more accurately and fairly.

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References

Abdullah MN, Asmoni M, Mohammed A, Mei J, and Ting L (2015). Critical success factors of project quality management system for Malaysian construction industry. Jurnal Teknologi, 74(2): 123-131.

Ahadzie DK, Proverbs DG, and Olomolaiye PO (2008). Critical success criteria for mass house building projects in developing countries. International Journal of Project Management, 26(6): 675-687.

Altahtooh UA and Emsley MW (2017). An introduction to project end theory in project management. International Journal of Information Technology Project Management, 8(3): 69-81.

Al-Tmeemy SMHM, Abdul-Rahman H, and Harun Z (2011). Future criteria for success of building projects in Malaysia. International Journal of Project Management, 29(3): 337-348.

Azhar YM, Al-Munawar N, and Tuan YC (2015). Critical success factor on e-Government it projects in Brunei Darussalam. International Journal of Applied Business and Economic Research, 13(9): 6969-6990.

Buckley JJ (1985). Fuzzy hierarchical analysis. Fuzzy Sets and Systems, 17(3): 233-247.

Chan AP, Scott D, and Chan AP (2004). Factors affecting the success of a construction project. Journal of Construction Engineering and Management, 130(1), 153-155.

Chang SC, Lin CF, and Wu WM (2016). The features and marketability of certificates for occupational safety and health management in Taiwan. Safety Science, 85: 77-87.

Chou YC, Sun CC, and Yen HY (2012). Evaluating the criteria for human resource for science and technology (HRST) based on an integrated fuzzy AHP and fuzzy DEMATEL approach. Applied Soft Computing, 12(1): 64-71.

Crane TG, Felder JP, Thompson PJ, Thompson MG, and Sanders SR (1999). Partnering measures. Journal of Management in Engineering, 15(2): 37-42.

Dewit A (1988). Measurement of project success. International Journal of Project Management, 6(3): 164-170.

Hamid-Mosaku IA, Mahmud MR, and Mohd MS (2016). An evaluation of marine geospatial data infrastructure (MGDI) by delphi-Analytic Hierarchy Process (AHP) approach. Jurnal Teknologi, 78(6-12): 57-68.

Heo E, Kim J, and Boo KJ (2010). Analysis of the assessment factors for renewable energy dissemination program evaluation using fuzzy AHP. Renewable and Sustainable Energy Reviews, 14(8): 2214-2220.

Iram N, Khan B, Ahmad MS, and Sahibzada UF (2017). Critical factors influencing the project success: An analysis of projects in manufacturing and construction industries in Punjab, Pakistan. International Journal of Business Studies Review, 1(1): 41-52.

Joslin R and Müller R (2015). Relationships between a project management methodology and project success in different project governance contexts. International Journal of Project Management, 33(6): 1377-1392.

Kabir G and Sumi RS (2014). Power substation location selection using fuzzy analytic hierarchy process and PROMETHEE: A case study from Bangladesh. Energy, 72: 717-730.

Khalila N, Kamaruzzamanb SN, and Rizal M (2015). A survey on the performance-risk rating index for building performance assessment in higher education buildings. Jurnal Teknologi, 75(9): 57–63.

Lim CS and Mohamed MZ (1999). Criteria of project success: an exploratory re-examination. International Journal of Project Management, 17(4): 243-248.

Liu AMM and Walker A (1998). Evaluation of project outcomes. Construction Management and Economics, 16(1): 209-219.

Nazari A, Vandadian S, and Abdirad H (2016). Fuzzy AHP Model for prequalification of engineering consultants in the Iranian public procurement system. Journal of Management in Engineering, 33(2): 04016042.

Nguyen PT and Nguyen QTTHL (2017). Application fuzzy multi-attribute decision analysis method to prioritize project success criteria. AIP Conference Proceedings, 1903(1): 070011.

Nguyen PT, Nguyen PV, and Nguyen QTTHL (2017a). Application of fuzzy analytic network process and TOPSIS method for material supplier selection. Key Engineering Materials, 728: 411-415.

Nguyen PT, Nguyen PV, Nguyen QTTHL, and Huynh VBD (2016a). Project success evaluation using TOPSIS algorithm. Journal of Engineering and Applied Sciences, 11(8): 1876-1879.

Nguyen PT, Nguyen TA, Ha NTH, and Nguyen TN (2017b). Facilities management in high rise buildings using building information modeling. International Journal of Advanced and Applied Sciences, 4(2): 1-9.

Nguyen PV, Nguyen PT, Nguyen QTTHL, and Huynh VBD (2016b). Calculating weights of social capital index using analytic hierarchy process. International Journal of Economics and Financial Issues, 6(3): 1189-1193.

Nguyen TA, Nguyen PT, and Peansupap V (2015). Explaining model for supervisor's behavior on safety action based on their perceptions. ARPN Journal of Engineering and Applied Sciences, 10(20): 9562-9572.

Oke AE and Aigbavboa CO (2017). Measures of project success. In: Oke AE and Aigbavboa CO (Eds.), Sustainable value management for construction projects: 75-86. Springer, Berlin, Germany.

Paksoy T, Pehlivan NY, and Kahraman C (2012). Organizational strategy development in distribution channel management using fuzzy AHP and hierarchical fuzzy TOPSIS. Expert Systems with Applications, 39(3): 2822-2841.

Plebankiewicz E and Kubek D (2015). Multicriteria selection of the building material supplier using AHP and fuzzy AHP. Journal of Construction Engineering and Management, 142(1): 04015057.

Quyen NLHTT, Nguyen PT, and Huynh VBD (2017a). A hybrid multi criteria decision analysis for engineering project manager evaluation. International Journal of Advanced and Applied Sciences, 4(4): 49-52.

Quyen NLHTT, Nguyen PT, and Huynh VDB (2017b). Prioritization of social capital indicators using extent analysis method. International Journal of Advanced and Applied Sciences, 4(10): 54-57.

Routroy S and Shankar A (2015). Performance analysis of agile supply chain. International Journal of Manufacturing Technology and Management, 29(3-4): 180-210.

Saaty TL (2005). Making and validating complex decisions with the AHP/ANP. Journal of Systems Science and Systems Engineering, 14(1): 1-36.

Shaari N, Abdullah MN, Asmoni M, Lokman M, Hamid H, and Mohammed A (2015). Practices for project quality management systems (PMMS) in construction project. Jurnal Teknologi, 77(26): 69-76.

Songer AD, Molenaar KR, and Robinson GD (1996). Selection factors and success criteria for design-build in the US and UK. Journal of Construction Procurement, 2(2): 69-82.

Todorović ML, Petrović DČ, Mihić MM, Obradović VL, and Bushuyev SD (2015). Project success analysis framework: A knowledge-based approach in project management. International Journal of Project Management, 33(4): 772-783.

Umara A, Embia MR, Yatimb YM, Alkalic IA, and Bahru UJ (2015). Experts influence on fire safety criteria ranking for factory buildings in Nigeria. Jurnal Teknologi, 77(14): 95-98.

Zaini NSM, Basri NEA, Zain SM, and Saad NFM (2015). Selecting the best composting technology using analytical hierarchy process (AHP). Jurnal Teknologi, 77(1): 1-8.