Literature Review – Using Multi-Criteria Decision-Making Methods in Information Technology (IT) Investment

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Abstract. The application of Multi-Criteria decision-making (MCDM) method was important in Information Technology (IT) project investment. The results of several studies it showed that use the MCDM method obtained were not accurate. Several MCDM methods were combined to help the more accurate results. Therefore, the study aims to determine the decision-making methods that have higher accuracy obtained from 30 research literature. A literature search was obtained from database providers such as ScienceDirect, IEEE Xplore, Emerald Insight, and ACM. Based on 30 literature obtained from the 2008-2018, MCDM was used in the process of evaluation and selection projects in IT investments. Both processes used three MCDM methods which have highest frequency of use, because they are considered easy to use. The method used was Analytic Network Process (ANP), Priority Order Technique based on Ideal with Ideal Solutions (TOPSIS), Analytic Hierarchy Process (AHP), and Data Envelopment Analysis (DEA). Then from the four methods, found that the AHP method was more accurate and easier to use in IT investment.

Keywords: Evaluation, Selection, Investment, Accurate, AHP, ANP, TOPSIS, DEA

1 Introduction

Decision making occurs when a company will carry out several projects, for example in development, procurement, and projects. Information Technology Decision making processes are complex and can produce positive results or do damage to a company [1]. Analysis needed with certain criteria to assist decision making. In the process, the Company has several criteria called Multi-Criteria Decision Making (MCDM). These criteria will be used as parameters or indicators in making decisions correctly. The process of selecting IT projects can be modeled with multi-criteria decision making (MCDM) that can deal with problems with a variety of different and conflicting criteria to make choices among predetermined decision alternatives [2].

Some studies use the MCDM method for IT project investment have previously been implemented. The current literature review offers several IT investment methods that provide a framework for quantifying risks and benefits [3]. The framework is created using several Multi-Criteria Decision Making methods to produce the right decisions. The methods that are widely used include Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for the Order of Priority by Ideal Solution (TOPSIS), PROMETHEE, Simple

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Multi-Attribute Rating Technique Method (SMART Method), ELECTRE, and Fuzzy method. Based on several studies, each method has different characteristics both from strengths and weaknesses therefore the final results obtained are not accurate. one of the causes of inaccuracies produced because the method used is not appropriate or the method has not been able to provide accurate results. in the end, it must be assisted by other methods that can make the method accurate [4] .

In the IT project investment process, MCDM is used to give weight to defined criteria. [5] Fuzzy AHP is proposed to tolerate obscurity and ambiguity in information. And [3] using fuzzy AHP for the risks associated with each investment strategy are quantified using a group. While in IT project selection MCDM, besides being used to determine criteria, it is also used to rank the priority order of projects that will be implemented. [6] using ANP and PROMETHEE in their research. ANP is used to determine weights all criteria, then the weights obtained are used in the PROMETHEE method for optimal ranking alternative system selection. The research by [7] AHP is used to select the best alternative and TOPSIS is used as a hybrid approach. Based on some literature obtained, the MCDM method has been used. In this study aims to find out what studies related to MCDM in IT investment and what methods are used and know the most frequently used and most accurate methods in IT project investment, especially in project evaluation and selection.

2 Background

2.1 Multi-Criteria Decision-Making

Multi criteria decision making (MCDM) is an operational research branch that deals with find optimal results in complex scenarios including various indicators, objectives and conflicting criteria. This method has become popular in the planning field because of the flexibility provided for decision makers to make decisions while considering all the criteria and objectives simultaneously [8]. MCDM is considered an evaluation technique to solve the environmental, socio-economic, technical, and institutional barriers involved in planning [9].
Besides MCDM can be applied singly for decision making, technological developments over the past few decades have made it possible for more complex decision analysis methods to be developed. This experiment with the combined multi-criteria decision making method provides a new approach to decision analysis. Certain MCDM methods are more suitable for certain situations [10]. Some MCDM methods according to [10] are 1) Multi-attribute Utility Theory (MAUT), 2) Analytic Hierarchy Process (AHP), 3) Fuzzy Set Theory, 4) Case-based Reasoning, 5) Data Envelopment Analysis (DEA), 6) Simple Multi-Attribute Rating Technique (SMART), 7) Goal Programming, 8) ELECTRE, 9)PROMETHEE, 10) Simple Additive Weighting (SAW), and 11) Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

2.2 Information Technology (IT) Investment

IT investment is defined as the amount of money the company uses to buy IT architecture [11]. Investment in technology, combined with IT management skills and knowledge, produces IT capabilities [12] [13]. IT investment is often associated with the company's business strategy, with the aim of increasing its competitive advantage [14]. IT investment is

associated with other factors of production, labor, and capital. In general, the literature shows that companies that invest the most in technology related to information and communication are companies that get the best results in terms of efficiency and productivity [15].With new IT investments, many international companies are focusing their efforts on improving the IT environment by effectively using communication and management capabilities / functions to gain competitive advantage.

3 Research Method

The research method is an approach used in conducting this literature review and consist of several step.

3.1 Database and Keyword Search Selection

Improving the understanding of literature studies on IT investment decision projects, the literature needed to support this research. Literature search can be obtained from several online databases of literature search focus on IT project decisions and project with MCDM. Table 1 shows the online literature search database in this study, while table 2 shows the number of literature searches based on keywords for each database.

Table 1. Database Online

Database	URL
Science Direct	http://www.sciencedirect.com
IEEE	https://ieeexplore.ieee.org
Emerald Insight	https://www.emeraldinsight.com/
ACM	https://dl.acm.org/

Table 2. Literature Searches Based On Keywords

Keyword	Database			
	Science Direct	IEEE	Emerald Insight	ACM
IT Investment Decision	285,135	354	53,787	300,064
IT Project with MCDM	236,083	2,383	70773	311,769

3.2 Literature Search Criteria

Segregation of literature search results is done by filtering the literature search results that have been obtained based on predetermined criteria. The criteria used for sorting consist of two inclusion and exclusion.

3.2.1 Criteria

a. Inclusion
   - Literature search results in English.

- The literature search results have words in the local language that are still related.
- The literature search results consist of journals, conference proceedings, books, and other studies relating to the application of IT project investment decision.
- The literature search in 2008 – 2018
- The literature search results are obtained from an online database based on table 1.

b. Exclusion
- The literature search results are not in English form.
- The literature search results are not related to the IT Project investment.
- The literature less than 2008 and more than 2018
- The literature search results are short articles.

3.2.2 Literature Search Segregation

Based on the criteria of inclusion and exclusion to filter the literature, there were candidates of literature that will be used as reference of this literature review. The literature candidate is derived from title analysis and abstract literature. Next will be analyze literature by reading the overall content. The results of the analysis obtained a number of 30 literatures which will then be used as the main reference in doing literature review on the IT Project investment. Table 3 shows the results of literature sorting based on literature databases.

Table 3. The Results of Literature Sorting

Database	Literature Used	
	Journal	**Conference**
Science Direct	13	4
IEEE		6
Emerald Insight	4	
ACM		3
Total	17	13

3.3 Qualitative Analysis

Based on the 30 literatures obtained and used as the main reference, then the next step is to conduct a qualitative analysis. Qualitative analysis is a more detailed analysis of 30 literatures obtained. Qualitative analysis includes detailed analysis of the theme of literature, the literature quality assessment criteria, and literature extraction.

3.2.1 Theme Analysis

Based on the analysis of 30 literature that serves as the main reference, two themes were found in research related to IT investment. Themes are the main topic of research in the literature. This theme shows about the development of research on the topic of IT investment. Table 4 describes two themes found on the topic of IT investment.

Table 4. Theme Classification

Theme	Description
Information Technology (IT)	Project evaluation is a systematic and

	Project Evaluation	objective assessment of information technology projects that are running or completed. Project evaluation aims to determine the level of achievement of project objectives, effectiveness, and the impact of sustainable development
	Information Technology (IT) Project Selection	The success of the organization is based on the selected information technology project. In choosing a project, facts are needed that can help the selection of projects that can effectively improve organizational performance and reduce the risk of project failure

3.2.2 Literature Quality Assessment Criteria

Literature quality assessment is carried out through identification of journals that have been found by answering 5 question points, while the question points are:

- What is the purpose of the research?
- What methods are used in research?
- What are the results of the study?
- What are the limited of research and what is the further research?

3.2.3 Extrating

Extracting the literature includes more detail on the literature information related to themes, bibliography, and quantitative. Table 5 describes the description of literature extraction.

Table 5. Extrating Literature

Item	Description
Theme	The theme is a major topic in a study. Based on the literature found, there are several themes on IT investment decision making with MCDM
Bibliography	The bibliography contains the author's information, the publication year, and the title of the literature.
Quality Assesment Criteria	Purpose, methods, results, limited and further research

4 Result and Discussion

4.1 Qualitative Result

Qualitative result contains how the distribution of journals used from 2008-2018 and the classification of themes that aim to answer the research questions in this study “what studies related to MCDM in IT investment”. Figure 1 shows the distribution of journals from 2008-2018. While Figure 2 shows that from 30 literature, the research focuses on the evaluation factor of IT projects with 9 literature 21 literature that focuses on the selection of IT projects.

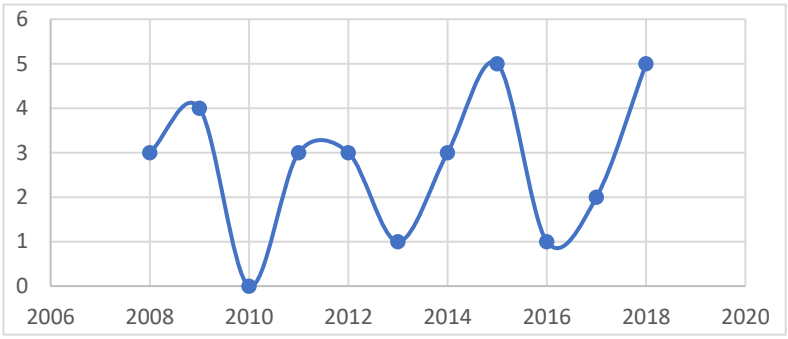

Figure 1. Distribution Journals

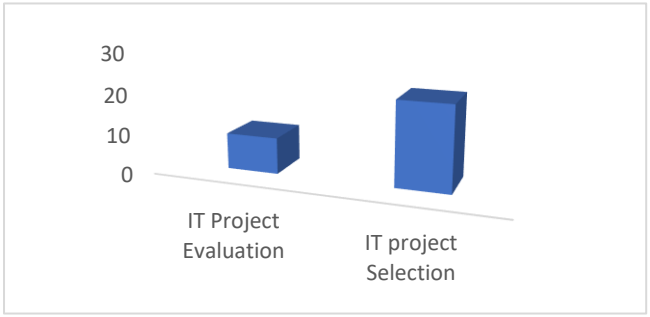

Figure 2. The Number of Literature For Each Theme

While in Figure 3 explains the research questions "which MCDM methods are popular and most accurate in IT investment". Based on the literature obtained, there are 4 MCDM methods whose frequency of use is often Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Priority Order Technique based on Ideal with Ideal Solutions (TOPSIS), and Data Envelopment Analysis (DEA). The literature use AHP is 14, TOPSIS 8, ANP 5, and DEA 5.

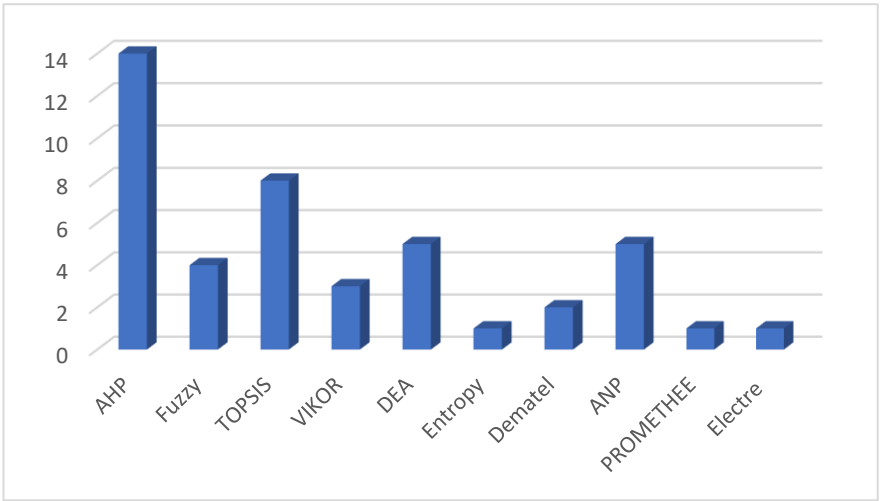

Figure 3. The Number of MCDM in The Literature

AHP can be used for evaluation and selection of information system projects [16]. The proposed AHP methodology adopts a multi-criteria approach for selecting different information systems projects with a single criteria approach. [17] use AHP to choose the best projects among a series of alternatives and show that AHP results are more reliable. AHP can be used to solve MCDM problems. When criteria are determined and weights are calculated using a paired comparison matrix, similar procedures can be applied to calculate alternative weights [18]. AHP has several advantages, including acceptance of inconsistencies in managerial assessment / perception and user friendliness because users can directly enter assessment data without requiring further mathematical knowledge. It also allows users to arrange complex problems in the form of hierarchies or a set of integrated levels. AHP has several advantages, including acceptance of inconsistencies in managerial assessment / perception and user friendliness because users can directly enter assessment data without requiring further mathematical knowledge. Because of its many benefits, AHP is one of the most accurate methods compared to other MCDM methods. Besides that, the use of the AHP method is easy so that it is used more often. In addition, AHP can also be combined with well-known operating research techniques to deal with more difficult problems [19]. AHP can also be combined with well-known operating research techniques to deal with more difficult problems.

4.2 Theme

4.2.1 IT Project Evaluation

Project evaluation is a systematic and objective assessment of projects that are running or completed. The purpose of project evaluation is to determine the relevance and level of achievement of project objectives, effectiveness, and the impact of sustainable development. Evaluate Phase, is a phase where the organization/company compares the actual and expected conditions when the project has been fully implemented. This phase is done by assessing the impact of the project on the organization's performance in achieving its objectives, identifying possible changes or modifications needed, and changing the investment management process from the lessons learned during the project (Office, 2004). The process of evaluation and selection involves simultaneous consideration of several attributes to rank available alternatives and choose the best [20]. Some studies reveal that investment evaluation methods provide a framework for measuring risk and benefits [3]. The results of literature, Multi Criteria Decision Making (MCDM) can use to evaluate IT project investment. The researches use MCDM method shows in table 6.

Table 6. Evaluating Project Use MCDM Method

Authors	Method
[3]	Investment strategies that can be delayed are prioritized according to their value using real option analysis (ROA) and the risks associated with each investment strategy are quantified using a group of fuzzy analytic hierarchical processes (FAHP).
[21]	Determine intangible factors that are an important priority for technology transfer through the method of analytic hierarchy

	process (AHP) and correlation analysis (CA)
[5]	Fuzzy AHP for determine weight of criteria. Fuzzy VIKOR is used to rank the various sectors based on the importance of sustainability criteria. DEA highlights whether the national investment is intune with the sustainability criteria for sustainable development.
[20]	System is selected based on a set of metric results using Integrated Analytic Hierarchy Process (AHP) and TOPSIS
[22]	Real Options (ROs) and analytical hierarchy processes (AHP) are common decision analysis frameworks that provide integrated multi criteria models, called ROAHPs, to evaluate and to prioritize ICT business alternatives
[23]	AHP was formed and tested with real data containing attributes and results (success / failure) from ten technopreneurship projects
[24]	entropy method to calculate the objective weights of evaluation criteria and reduce subjective factors. TOPSIS method is used to evaluate the final rankings of alternative cloud services based on overall performance
[25]	Determine the relative weights assign using AHP method
[19]	An analytic hierarchical process (AHP) based on fuzzy numbers multi-attribute method is proposed for the evaluation project

4.2.2 IT Project Selection

The selection of the appropriate Information Technology (IT) investment has become one of the most significant business challenges in the past decade [3]. The success of the organization is based on the selected project and if the project is not selected correctly, this can cause the organization to get lost from its desired goals [26]. In choosing a project, it requires facts that can help project selection to effectively improve organizational performance and reduce the risk of project failure [27]. The project selection process can be carried out by analysis based on predetermined criteria with the help of the MCDM method. The MCDM method used can be integrated so that it can determine the weight and rank the priority of the project [6].The MCDM use for selecting project IT investment shows in table 7.

Table 7. Selecting Project Use MCDM Method

Authors	Method
[14]	Adopt AHP method to analyze the weight of critical factors and measurement indicators in each level and the bulid a decision support model of IT investment-making
[28]	TOPSIS is proposed for portfolio selection problem that can solve real-world instances of the problem in a reasonable time
[29]	A new MCDM model that combines the Fuzzy Decision Making Trial and Evaluation Laboratory Model (DEMATEL), fuzzy Analytical Network Process (ANP) and fuzzy method

	Višekriterijumska Optimizacija i kompromisno Rešenje (VIKOR)
[18]	The weights of the criteria are determined by AHP method and the alternatives are evaluated by Grey-TOPSIS
[6]	Analytic Network Process (ANP) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), used in combination to solve the best ERP selection problems
[30]	selection of the best alternative uses an analytic hierarchy process (AHP) and techniques for order preferences by similarity to the ideal solution (TOPSIS) as a hybrid approach
[31]	ELECTRE-TRI's various criteria decision-making methods are applied to help Brazilian retail distribution center companies to decide on new technology investments that will be implemented in the company's central data processing system
[32]	Fuzzy VIKOR is used to rank various sectors based on the importance of sustainability criteria. fuzzy AHP DEA shows IT projects on water resources, river & environmental development located in border efficiency areas.
[1]	adoption of a multi-criteria method through AHP – Analytic Hierarchy Process by a large Brazilian multinational company in the oil & gas segment
[22]	Real Options (ROs) and analytical hierarchy processes (AHP) are common decision analysis frameworks that provide integrated multi criteria models, called ROAHPs, to evaluate and to prioritize ICT business alternatives
[33]	AHP is used for pairing comparisons between selection criteria and then comparing available projects with criteria and the overall weight for each project is calculated and used as a coefficient in the Linear Programming (LP) model
[34]	Data Envelopment analysis (DEA) approach to solve project selection problems taking into account intervals or incorrect data.
[35]	Decision-Making Trial and Evaluation Laboratory Model (DEMATEL), Analytical Network Process (ANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) has been used to select the optimal LSS project.
[36]	TOPSIS using four kinds of criteria include qualitative, quantitative, negative and positive criteria
[37]	first developing criteria for network structure according to the ANP method, fuzzy methods are used to evaluate interdependent interests between criteria.
[38]	Data Envelopment Analysis (DEA) for identification the most efficient IS project with emprecise data
[39]	Extend the TOPSIS with grey theory for project selection
[40]	Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), to choose optimal information system
[41]	illustrates an application of analytic network process (ANP)

[42]	Fuzzy Quality Function Development (FQD) and DEA for project portfolio selection methodologies
[43]	integrated Information Technology planning methodology combining Fuzzy Quality Function Deployment, Fuzzy Axiomatic Design and Fuzzy Rule Based Systems

5 Conclusion

This study uses 30 literature review literature from 2008 to 2018 related to Information Technology (IT) investments. The results of the analysis show that there are two themes related to IT investment, namely the evaluation of IT projects and the selection of IT projects. From the study of literature, the evaluation of IT projects totaling 9 and the selection of IT projects as many as 21. This shows that most research addresses the selection of projects. While the MCDM method has the highest frequency of use is AHP, ANP, TOPSIS, and DEA. From the four methods, AHP considered the most accurate because it is easy to use. The study was limited because the number of literature was only 30 and the literature study in this study from 2008 to 2018. To deepen the analysis of subsequent research more literature can be used and use research conducted in the last five years. The literature database used is also limited to four online databases, so there is still a lot of literature available in other online databases. For future research, developing research opportunities from each theme is project evaluation and selection of IT projects.

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