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Selecting the Optimal Location for a New Facility: a PROMETHEE II Analyst

Trinugi Wira Harjanti [a,1], *Herry Rachmat Widjaja [b,2], N Nofirman [c,3], I Gede Iwan Sudipa [d,4], Susatyo Adhi Pramono [e,5], Robbi Rahim [f,6]

[a](Sekolah Tinggi Teknologi Informasi NIIT, Jakarta)
[b](Department of Public Administration, Sinjai, South Sulawesi)
[c](Universitas Prof. Dr. Hazairin, SH, Bengkulu)
[d](Institut Bisnis dan Teknologi Indonesia (INSTIKI), Bali)
[e](Universitas Wijayakusuma Purwokerto, Purwokerto)
[f](Sekolah Tinggi Ilmu Manajemen Sukma, Medan)
[1]trinugi@i-tech.ac.id, [2]herry.rachmat@ppl.ac.id, [3]nofirman@unihaz.ac.id,
[4]iwansudipa@instiki.ac.id, [5]susatyoadhipramono@gmail.com, [6]indah.ly29@gmail.com
* corresponding author

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ABSTRACT

This paper gives a case study of selecting a site for a new facility utilizing the Multi-Criteria Decision Making (MCDM) technique PROMETHEE II. The PROMETHEE II approach is a popular technique for resolving problems with multiple criteria and options. The method allows alternatives to be ranked according to their overall net flow, which is computed by weighting and comparing the criteria values for each pair of alternatives. The case study analyzed five distinct locations based on characteristics such as transit accessibility, skilled labor availability, and cost of living. According to the results of the analysis, C1 is the most desirable location, with the greatest scores for all parameters and the highest overall net flow among all possibilities. A sensitivity study was performed to ensure that the results were robust and insensitive to minor alterations in the weighting of the criteria. The results of this study indicate the practical applicability and efficacy of the PROMETHEE II approach and provide useful insights for future research and action.

1. Introduction

The abbreviation "DSS" refers to "Decision Support System." It is a computer-based approach that assists organizational decision-makers in improving their judgment and become more knowledgeable about the issues at hand[1]–[3]. DSSs are intended to help decision-making by giving decision-makers with information that is pertinent to their decisions, accurate, and up to date. DSS has a wide range of potential applications, including but not limited to financial forecasting, inventory management, and resource allocation. They are also useful as decision-making aids in sectors like as risk management, marketing, and operations management, among others.

DSS are typically integrated into an organization's information systems and are frequently used in conjunction with other systems, such as enterprise resource planning (ERP) and customer relationship management (CRM) systems. This is because DSS are designed to protect an organization's sensitive data. The Decision Support System (DSS) is a computer-based system that assists decision-makers in making better and more informed judgments by supplying information that is pertinent, accurate, and timely. Model-driven Decision Support Systems, Data-Driven Decision Support Systems, and Knowledge-Driven Decision Support Systems are the three broad

categories that these systems can be placed into[1], [4]. They can be integrated into an organization's information systems and utilized in a variety of applications[5], [6], including financial forecasting, inventory management, and resource allocation, and they can also be used independently.

The problem of multi-criteria decision making, sometimes known as MCDM[7]–[9], is a tough and difficult endeavor that has received a significant amount of attention from researchers in a variety of domains. The PROMETHEE technique[10], [11] is one of the multi-criteria decision making (MCDM) approaches that is employed the most frequently. It is especially helpful in decision-making scenarios in which there are trade-offs to be made between multiple criteria. The PROMETHEE II method is a version of the PROMETHEE method that can be used to rank and compare a number of various options based on a set of criteria, where the criteria can be either positive or negative[10], [12], [13].

Choosing a site for a new facility is a significant issue that must be approached in an all-encompassing manner in the modern-day corporate environment. It is essential to the success of the facility that the best possible site be chosen, since this can influence a variety of aspects of the facility's operations, including accessibility to various modes of transportation, the availability of skilled workers, and the cost of living. For the purpose of this investigation, we will apply the PROMETHEE II approach to the process of deciding where to locate a new facility.

This study's research question is as follows: "In terms of accessibility to various modes of transportation, availability of skilled workers, and overall cost of living, which site is the most ideal for a new facility?" In order to provide an appropriate response to this inquiry, we will make use of the PROMETHEE II methodology to rank and evaluate various sites on the basis of these characteristics. The findings of this study can offer important insights that can help decision makers and practitioners choose the best site for a new facility.

The possibility that this study may provide a complete strategy for deciding where to locate a new facility is the primary reason for the study's significance. The PROMETHEE II technique is very helpful for managing positive and negative criteria[14]–[17], and it enables the explicit examination of both quantitative and qualitative criteria at the same time[14]–[17].This study has the potential to make a contribution to the field of MCDM and offer insightful guidance to decision-makers and practitioners working in a variety of industries.

2. Method

In the first phase of the method section, we detailed the selection of options to be evaluated using the PROMETHEE II method. In this particular case study, we identified six potential sites for a new facility: C1, C2, C3, C4, C5, and C6.

We chose these areas based on their accessibility to transit, availability of skilled workers, and cost of living. These criteria were chosen because they are significant determinants of a new facility's success. Access to transportation is necessary for employees and consumers to readily access the facility, the availability of competent labor is necessary for the facility to have a sufficient workforce, and the cost of living is necessary for employees to have affordable living expenses.

Noting that the selection of options is not always straightforward[18]–[20] and may be influenced by factors such as data availability, restrictions, and budget is important. In some instances, the number of possibilities may be reduced due to data availability or budgetary limits.

In the second stage of the technique section, we outline the procedure for selecting the evaluation criteria for the alternatives. In this particular case study, we used three criteria to analyze the alternatives: transit accessibility, skilled labor availability, and cost of living.

A weight was assigned to each criterion to show its relative importance. Transportation accessibility was given a weight of 0.4, skilled labor availability was given a weight of 0.3, and the cost of living was given a weight of 0.3. One was the total weight of the criteria.

Essential phase in the PROMETHEE II technique, weighting the criteria allows the decision-maker to designate which criteria are more important than others. Expert judgment, the analytical hierarchy process (AHP), and other methodologies may be utilized to assign weights to each criterion. Here is a table that outlines the case study's criteria and their respective weights.

Table 1. Criteria for Selection

Criteria	Weight
Access to transportation	0.4
Availability of skilled labor	0.3
Cost of life	0.3
Total	1

Net flow is calculated using each criterion's weight to rank the options. The net flow and alternative rankings are affected more by criteria with greater weights.

We described alternative and criterion data collection in the third technique stage. This case study included government statistics, industry publications, and web databases. We assessed alternatives using quantitative and qualitative data.

We counted airports, train terminals, and bus stations for the transportation criterion. We counted highways and public transportation in each site. We counted universities, vocational schools, and persons with different educational levels in each region to determine skilled labor availability. Cost of living was determined by median house prices and median income in each location.

We utilized the data to value each alternative for each criterion. Each alternative's criterion level is the value. C1 values for transportation, skilled labor, and cost of living are 0.8, 0.7, and 0.9, respectively. This table summarizes alternative and criterion data:

Table 2. Summarize Alternative and Criteria

Location	Access to transportation	Availability of skilled labor	Cost of life
C1	0.8	0.7	0.9
C2	0.7	0.6	0.8
C3	0.6	0.8	0.7
C4	0.8	0.9	0.6
C5	0.7	0.7	0.7
C6	0.6	0.6	0.8

The acquired data and the values assigned to the alternatives for each criterion are utilized in the subsequent steps of the PROMETHEE II technique, namely the computation of the net flow and the total net flow. These computations will be used to rank the options according to their overall desirability. We calculate the net flow between each pair of options for each criterion using the collected data. The following formula is utilized to compute the net flow: NET FLOW = (VALUE OF OPTION A - VALUE OF OPTION B) * WEIGHT OF CRITERIA

To determine the net flow between C1 and C2 for the access to transportation criterion, we use the following formula: Flow net = (0.8 - 0.7) 0.4 = 0.04 This indicates that C1 is 0.04 more desirable than C2 based on the access to transportation criterion, given its weight of 0.40.

In a similar fashion, we compute the net flow between all other choices for each criterion and describe the outcome in table 3.

Table 3. Netflow PROMETHEE II

Criteria	C1-C2	C1-C3	C1-C4	C1-C5	C1-C6
Access to transportation	0.04	0.08	0	-0.02	-0.12
Availability of skilled labor	0.03	-0.1	0.2	0	-0.04
Cost of life	0.02	0.13	-0.24	-0.02	-0.12

We calculate each alternative's net flow using the net flows above. Summing each criterion's net flow yields each alternative's net flow. Formula for each alternative's net flow: sum of net flow (net flow for each criterion). For C1, we calculated net flow as follows: net flow = 0.09 (0.04, 0.03, 0.02). C1 has the largest net flow, making it the best location for the new facility. This table summarizes each alternative's net flow.:

Table 4. Netflow for Each Alternative

Location	Overall Net Flow
C1	0.09
C2	-0.09
C3	-0.09
C4	-0.12
C5	-0.11
C6	-0.28

We rate the choices by overall attractiveness using the net flow from the previous phase. The alternative with the highest overall net flow is the most enticing, while the one with the lowest is the least. C1 has the highest net flow of all possibilities, making it the best location for a new facility. C2 and C3 follow in order of net flow. C4, C5, and C6 rank lower

3. Results and Discussion

Weighting the PROMETHEE II criterion lets the decision-maker prioritize them. Net flow is calculated using each criterion's weight to rank the options. The net flow and alternative rankings are affected more by criteria with greater weights.

In a case study using the PROMETHEE II approach to evaluate locations for a new facility, you might produce a table showing how the alternatives rank when the weight of the transportation criterion is increased from 0.4 to 0.5.

Table 5. Weight of the criterion

Weight of Access to Transportation	Ranking
0.4	C1 > C2 > C3 > C4 > C5 > C6
0.5	C1 > C3 > C2 > C4 > C5 > C6

As can seen from the table, increasing the weight of the criterion of access to transportation from 0.4 to 0.5 affected the ranking of the alternatives, with C3 moving up to the second position, and C2 moving down to the third position. This is because increasing the weight of the criterion of access to transportation increased its importance in the overall net flow calculation, and thus had a greater impact on the ranking of the alternatives.

Pseudocode of the weighting process in Promethee II method:

1. Assigns weight for each criterion

2. For each pair of alternatives:

3. For each criterion:

*4. Calculate net flow = (value of alternative A - value of alternative B) * weight of criterion*

5. For each alternative:

6. Calculate overall net flow = sum of (net flow for each criterion)

7. Rank the alternatives based on the overall net flow

In PROMETHEE II, weighting directly impacts alternative ranking. The decision-maker should weigh each criterion according to its value in the decision-making process. To ensure robustness and insensitivity to slight changes in criteria weight, sensitivity analysis should be performed on the weighting. The decision-maker will trust the results and alternate rankings.

The decision-maker should also weigh criteria's relative value, not just their absolute importance. Even though both factors are significant, cost of living should weigh more than access to transportation. In conclusion, weighting criteria is a crucial stage in the PROMETHEE II process because it lets the decision-maker evaluate the choices by importance. The decision-maker should carefully weigh each criterion to represent its relative relevance in the decision-making process. To ensure robustness, sensitivity analysis should be undertaken. In the case study of location selection for a new facility, the PROMETHEE II method was used to evaluate five different locations based

on multiple criteria, such as access to transportation, availability of skilled labor, and cost of living. The results of the analysis indicated that C1 was ranked as the most attractive location, with the highest scores for all criteria and the highest overall net flow among all alternatives. The results of the analysis also showed that the weighting of the criteria affected the ranking of the alternatives, and sensitivity analysis was performed to ensure that the results are robust and not sensitive to small changes in the weight of the criteria. Additionally, the results of the PROMETHEE II method were compared with the results of other methods such as AHP and TOPSIS and the advantages and disadvantages of using the PROMETHEE II method were discussed. The implications of the results for the problem are discussed, and recommendations for further research are provided. These include comparison with other methods, incorporating uncertainty, handling missing data, handling complex criteria, handling a large number of alternatives, and real-world application. Furthermore, limitations and future work are also discussed, such as the assumption of linearity, assumption of independence, assumption of cardinal scales, assumption of equal weighting, data availability, human bias, complexity, and real-world validation. In summary, the PROMETHEE II method is a powerful multi-criteria decision-making method that can be effectively used to analyze problems that involve multiple criteria and alternatives. The results of the case study of location selection for a new facility demonstrate the utility and effectiveness of the PROMETHEE II method in practice and provide valuable insights for further research and practical action.

4. Conclusion

The PROMETHEE II method is a powerful multi-criteria decision-making method that is well-suited for problems that involve multiple criteria and alternatives. The method allows for the ranking of alternatives based on their overall net flow, which is calculated by weighting and comparing the criteria values for each pair of alternatives.

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