COMPARATIVE ANALYSIS OF SUPPLIER SELECTION MODELS

BY

WARIN NAMKOTR

AN INDEPENDENT STUDY SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING (LOGISTICS AND SUPPLY CHAIN SYSTEMS ENGINEERING)
SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY
THAMMASAT UNIVERSITY
ACADEMIC YEAR 2023

THAMMASAT UNIVERSITY
SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY

INDEPENDENT STUDY

BY

WARIN NAMKOTR

ENTITLED

COMPARATIVE ANALYSIS OF SUPPLIER SELECTION MODELS

was approved as partial fulfillment of the requirements for
the degree of Master of Engineering (Logistics and Supply Chain Systems Engineering)

on June 15, 2024

Member and Advisor

(Associate Professor Jirachai Buddhakulsomsiri, Ph.D.)

Member

(Associate Professor Pisal Yenradee, D.Eng.)

Director

(Professor Pruettha Nanakorn, D.Eng.)

Independent Study Title	COMPARATIVE ANALYSIS OF SUPPLIER SELECTION MODELS
Author	Warin Namkotr
Degree	Master of Engineering (Logistics and Supply Chain Systems Engineering)
Faculty/University	Sirindhorn International Institute of Technology/ Thammasat University
Advisor	Associate Professor Jirachai Buddhakulsomsiri, Ph.D.
Academic Years	2023

ABSTRACT

Selecting the suitable suppliers is significant for ensuring a company's operational efficiency and product quality. This study investigates and compares three methods for supplier selection including DEMATEL (Decision Making Trial and Evaluation Laboratory), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), and AHP (Analytic Hierarchy Process), to identify the most effective approach for dealing with uncertainty and complexity. The study's methodology includes applying each method to a case study to compare and analyze the outcome of each method. Findings indicate that DEMATEL provides a more comprehensive understanding of criteria interrelationships, making it suitable for complex decision-making scenarios, whereas TOPSIS and AHP are more effective in less complex contexts. This research offers valuable insights into the strengths and weaknesses of each method, highlighting the benefits of DEMATEL in complex environments and providing a basis for businesses to improve their supplier selection processes.

Keywords: Supplier selection methods, Supplier selection processes, Uncertainty, DEMATEL, TOPSIS, AHP

ACKNOWLEDGEMENTS

I am thankful to those who have helped and guided me throughout the completion of this independent study.

First and foremost, I would want to express my sincere thanks to Dr. Jirachai Buddhakulsomsiri, my advisor, for his invaluable guidance, insightful feedback, and continuous support. The kindness and commitment that Dr. Jirachai has shown to his students is simply amazing. Even with his numerous responsibilities, he always made time to help and guide me, providing understanding and care that went above and beyond expectations. His encouragement has been significantly impact in shaping this study.

I also wish to express my sincere thanks to Associate Professor Dr. Pisal Yenradee, a member of my committee, for his constructive criticism and invaluable suggestions. His suggestion have significantly enlightened my methodology, ensuring a robust approach to the study.

I wish to thank the faculty and staff of the Sirindhorn International Institute of Technology at Thammasat University for providing the resources and environment necessary for my research. Their commitment to creating a positive learning environment is much valued.

I would like to acknowledge the support from my colleagues during this study process who have provided helpful discussions and suggestions throughout this research process. Their encouragement has been a source of motivation.

Finally, I am deeply thankful to my family for their unwavering support and understanding. Their patience and belief in my capabilities have been my driving force.

This study would not have been possible without the collective support and assistance of all these individuals. Thank you all for your invaluable contributions.

Warin Namkotr

TABLE OF CONTENTS

	Page
ABSTRACT	(1)
ACKNOWLEDGEMENTS	(2)
LIST OF TABLES	(5)
LIST OF FIGURES	(6)
LIST OF SYMBOLS/ABBREVIATIONS	(7)
CHAPTER 1 INTRODUCTION	1
1.1 Importance of the Study	1
1.2 Problem Statement	2
1.3 Objective of Study	2
CHAPTER 2 REVIEW OF LITERATURE	3
2.1 Overview of Supplier Selection Methods	3
2.2 Supplier Selection Beyond AHP and TOPSIS	3
2.3 DEMATEL	4
2.4 Integration of Method	4
2.5 Research Gaps	5
2.5.1 Limited Comparative Analysis of Supplier Selection Methods	5
2.5.2 Criticisms of Traditional Methods	5
2.5.3 Insufficient Focus on Handling Uncertainty	5
2.5.4 Underexplored Practical Applications of DEMATEL	6
2.5.5 Limited Understanding of Decision-Maker Perspectives	6

CHAPTER 3 METHODOLOGIES 8
3.1 Supplier Selection Method 8
3.1.1 DEMATEL 8
3.1.2 Analytic Hierarchy Process (AHP) 11
3.1.3 TOPSIS 16

CHAPTER 4 RESULT AND DISCUSSION 20
4.1 Comparison of DEMATEL with AHP 20
4.2 Comparison of DEMATEL with TOPSIS. 23
4.3 Comprehensive Comparison of DEMATEL, TOPSIS and AHP 26

CHAPTER 5 CONCLUSION 30
5.1 Summary of Findings 30
5.1.1 Criteria Weight Differences 30
5.1.2 Supplier Ranking 30
5.2 Recommendations for Future Research 31
5.2.1 Methods Integration 31
5.2.2 Trend Analysis in Weight Discrepancies 31
5.2.3 Case Studies 31
5.3 Conclusion 32

REFERENCES 33

BIOGRAPHY 36

LIST OF TABLES

Tables Page

2.1 Summary of Literature Review 7

3.1 Comparison scales of DEMATEL Method 8

3.2 Fuzzy Comparison scales of DEMATEL Method 9

3.3 Comparison scales of AHP Method. 12

3.4 Fuzzy Comparison scales of AHP Method 12

3.5 Comparison Scales of TOPSIS Method 17

3.6 Fuzzy Comparison Scales of TOPSIS Method 17

4.1 Criteria Weights Assigned by DEMATEL and AHP Methods for Supplier Selection with Fuzzy Logic (5 Criteria and 3 Suppliers) 20

4.2 Supplier Rankings from Table 4.1 20

4.3 Criteria Weights Assigned by DEMATEL and AHP Methods for Supplier Selection with Fuzzy Logic (4 Criteria and 3 Suppliers) 21

4.4 Supplier Rankings from Table 4.3 21

4.5 Criteria Weights Assigned by DEMATEL and AHP Methods for Supplier Selection with Fuzzy Logic (5 Criteria and 3 Suppliers) 21

4.6 Supplier Rankings from Table 4.5 21

4.7 Criteria Weights Assigned by DEMATEL and TOPSIS Methods for Supplier Selection with Fuzzy Logic (4 Criteria 5 Suppliers) 23

4.8 Supplier Rankings from Table 4.7 23

4.9 Criteria Weights Assigned by DEMATEL and TOPSIS Methods for Supplier Selection with Fuzzy Logic (10 Criteria 5 Suppliers) 23

4.10 Supplier Rankings from Table 4.9 24

4.11 Criteria Weights Assigned by DEMATEL and TOPSIS Methods for Supplier Selection with Fuzzy Logic (5 Criteria 3 Suppliers) 24

4.12 Supplier Rankings from Table 4.11 24

4.13 Criteria Weights Assigned by DEMATEL, TOPSIS, and AHP Methods for Supplier Selection with Fuzzy Logic (10 Criteria 5 Suppliers) 26

4.14 Supplier Rankings Based on DEMATEL, TOPSIS, and AHP Methods 27

LIST OF FIGURES

Figures	Page
3.1 The Hierarchical Structure of AHP Method	11

LIST OF SYMBOLS/ABBREVIATIONS

Symbols/Abbreviations	Terms
AHP	Analytic Hierarchy Process
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
DEMATEL	Decision Making Trial and Evaluation Laboratory

CHAPTER 1
INTRODUCTION

Making the right choice is a crucial task that can determine the difference between the company's success and failure. This choice has a substantial effect on product quality and operational effectiveness across numerous sectors.

1.1 Importance of the Study

This era is characterized by intense competition and rapidly shifting markets, a company's ability to develop strategies with dependable and effective suppliers frequently determines its success or failure. The process of choosing a supplier is crucial in establishing a business's overall competitiveness because it can improve product quality and operational effectiveness. On the other hand, inappropriate supplier selection can result in bad incidents including production delays, degraded product quality, and disruptions in the supply chain. Other than that, it can cause a bad reputation, and financial performance of a business may suffer as a result of these difficulties. As a result, the use of reliable and effective supplier selection techniques is needed.

Due to the complexity of supply chains, the traditional method like AHP (Analytic Hierarchy Process) or TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) was invented to solve those problems. But now that approaches like DEMATEL (Decision Making Trial and Evaluation Laboratory) have been developed, it is necessary to compare and evaluate these methods.

1.2 Problem Statement

Selecting the suitable supplier method poses challenges for various industries due to its potential impact on company operational efficiency and product quantity. To deal with these challenges normally traditional methods like TOPSIS and AHP have been utilized. However, the decision-making process becomes even more difficult and complex due to the subjectivity of expert judgments, which is why a new method is necessary to investigate how these techniques handle ambiguity and take into account subjective insights.

1.3 Objective of Study

This study aims to achieve several key objectives which are:

- To evaluate and compare different supplier selection methods.
- Compare the ability to handle supplier selection between DEMATEL and traditional methods such as TOPSIS.
- Identify the benefits and drawbacks of the DEMATEL method compared to the traditional method.
- Identifying the most effective supplier selection methods that can handle uncertainty.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Overview of Supplier Selection Methods

Supplier selection is a significant component of supply chain management, demanding the application of both qualitative and quantitative techniques. Among the various supplier selection method TOPSIS and AHP are widely-utilized methods. TOPSIS favored for its universality and ease of application however they are often criticized for its inherent subjectivity (Kochkina et al., 2017). Subjectivity from expert or decision maker from different positions and experience can lead to inconsistency since most supplier selection consists of various department which means the expert from different department may make decision based on their position or their experience (Wu et al., 2022). Overlooked expert experience in the decision-making process can lead to a decrease in the result effective (Du & Zhou, 2019). Additionally, another popular method is AHP which is excellent at setting priorities for decision-making criteria and providing precise outcomes. However, it ignores the connections between criteria which makes it not suitable for intricate problem structures (Rahman et al., 2021).

2.2 Supplier Selection Beyond AHP and TOPSIS

This literature review consists of 5 different methods which are TOPSIS, AHP, GRA, VIKOR, and DEMATEL. Since TOPSIS and AHP are widely used methods this research mainly focused on new methods so the majority of the methods in this research are mostly about DEMATEL, GRA, and VIKOR.

Studies that utilized GRA in their methodology can be mentioned as follows: (Haeri and Rezaei, 2019), (Silva, 2023), (Jahangirzadeh et al., 2020), (Javed et al., 2022), (Hashemi et al., 2015).

Studies that utilized DEMATEL in their methodology can be mentioned as follows: (Du & Zhou, 2019), (Leblebicioğlu & Keskin, 2021), (Mehregan et al., 2014), (Kaya & Yet, 2019), (Yazdani et al., 2019), (Chang et al., 2010).

Studies that utilized VIKOR in their methodology can be mention as follows:

(Sanayei et al., 2010).

However, there are many studies that combine different supplier selection in their methodology can be mentioned as (Gökler & Boran, 2023), (Hsu & Lee, 2023), (Zhang et al., 2020), (Wu et al., 2022), (Li et al., 2020), (Rahman et al., 2021), (Leong et al., 2022), (Wu et al., 2021), (Nguyen et al., 2020).

2.3 DEMATEL

The DEMATEL method is a widely recognized multi-criteria decision-making (MCDM) technique that can clarify relationships and point cause and effect sequences among complex criteria, presenting a clear structural model. It has been widely used in group decision-making situations and has been successful in finding important variables that have a significant impact on various systems (Du & Zhou, 2019). It represents the relationship among criteria by diagram which can help decision-makers understand the complex interaction between each criterion more easily. Since the decision makers clearly understand the relationship among criteria, they can modify or adjust affected criteria groups to effect changes in other criteria. Additionally, the approach helps the decision maker to concentrate on important criteria that provide a greater significant impact on the outcome (Leblebicioğlu & Keskin, 2021).

According to Gökler and Boran's (2023) study, DEMATEL is particularly helpful in addressing resilience and sustainability difficulties when it comes to supplier selection. The study presents a method that achieves excellent outcomes even in uncertain circumstances and is less influenced by subjective evaluations. While the method is less dependent on the opinion of the expert, it means that the method is a reliable technique in uncertain decision-making processes which can help to handle uncertainty.

2.4 Integration of Method

This study also contains various studies that applied DEMATEL methods with different supplier selection methods such as DEMATEL with AHP, DEMATEL with VIKOR, and DEMATEL with GRA to overcome some challenges. For instance, Gökler and Boran (2023) addressed sustainability and resilience in supplier selection for a car manufacturing company by integrating AHP and DEMATEL with the D-AHP technique. Other than automobile manufacturing, combining AHP and DEMATEL can also help the supplier selection to make the right decision for the wind power field (Hsu & Lee, 2023). For another example, it is a study that uses both DEMATEL and VIKOR to solve sustainable supplier selection challenges. The supplier index weight has been calculated using the approximate DEMATEL approach, and the sustainable supplier selection is completed using VIKOR. The rough DEMATEL method examines the interaction among variables during the application process (Zhang et al., 2020).

2.5 Research Gaps

While the literature review offers an in-depth overview of several supplier selection techniques, it also shows some clear research gaps appears and offers an opportunity for further study.

2.5.1 Limited Comparative Analysis of Supplier Selection Methods

When it comes to managing uncertainty, there may not be enough detailed comparison assessments of supplier selection techniques in the research. To fill this gap this study aims to contrast the ability to handle uncertainty between DEMATEL and commonly used techniques (such as TOPSIS and AHP).

2.5.2 Criticisms of Traditional Methods

The literature has identified the drawbacks of commonly used methods like TOPSIS and AHP. This study reacts to these issues and offers substitute techniques that provide better solutions for the supplier. By focusing on the DEMATEL approach as a possible enhancement to overcome that gap.

2.5.3 Insufficient Focus on Handling Uncertainty

A lot of the research that has already been done on supplier selection techniques may not fully address the problems that uncertainty creates. To improve, this study highlights how crucial it is to assess methodologies according to how well they can manage uncertainty, which is a crucial component in supplier selection.

2.5.4 Underexplored Practical Applications of DEMATEL

The DEMATEL technique is acknowledged for its theoretical advantages; however, its practical applications particularly in supplier selection may not have received the same focus in the literature as they could. By using DEMATEL on real-world data and comparing its results to those of conventional techniques, this study seeks to close this gap.

2.5.5 Limited Understanding of Decision-Maker Perspectives

The limitations of traditional techniques highlight the subjectivity and probable inconsistency in decision-making, which suggests a potential research need to understand decision-maker opinions. To close this gap, this study compares approaches based on their theoretical advantages as well as their practical usefulness and degree of comprehension for decision-makers across different departments.

Table 2.1 SUMMARY OF LITERATURE REVIEW

Author(s)	Supplier selection method	Criteria																	
		Economic						Environmental							Finan	Social dimension	Resilience	Others	
		Quality	Price	Delivery	Innovativeness	Technology capability	flexibility	Resource consumption	Green Image	Pollution production	Pollution control	Management commitment	EMS	Green product	Financial situation	Health and safety	Flexibility	Lead time	Service
(Haeri & Rezaei, 2019)	GRA	X	X	X	X	X		X	X	X	X	X							
(Silva et al., 2023)	GRA																		
(Gökler & Boran, 2023)	DEMATEL and AHP	X	X	X		X							X				X		
(Du & Zhou, 2019)	DEMATEL																		
(Sanayei et al., 2010)	VIKOR	X	X	X													X		
(Hsu & Lee, 2023)	DEMATEL and AHP	X	X	X		X													
(Leblebicioğlu & Keskin, 2021)	DEMATEL	X	X	X		X									X				X
(Zhang et al., 2020)	DEMATEL and vikor	X	X	X		X			X	X	X		X	X	X	X			X
(Wu et al., 2022)	DEMATEL and vikor	X	X			X		X								X			
(Jahangirzadeh et al., 2020)	GRA																		
(Javed et al., 2022)	GRA	X	X		X			X	X		X					X			
(Chang et al., 2011)	DEMATEL	X	X	X		X									X			X	X
(Li et al., 2020)	DEMATEL	X	X															X	X
(Rahman et al., 2021)	DEMATEL and AHP	X	X																
(Yazdani et al., 2019)	Dematel		X				X			X			X		X		X		
(Leong et al., 2022)	Topsis and GRA	X	X												X		X	X	
(Wu et al., 2021)	GRA and Dematel	X	X	X		X					X		X	X		X			
(Hashemi et al., 2015)	GRA	X	X	X	X	X	X		X	X	X	X	X	X					
(Mehregan et al., 2014)	DEMATEL	X	X	X		X							X			X			X
(Kaya & Yet, 2019)	DEMATEL	X	X	X			X												
(Nguyen et al., 2020)	DEMATEL and GRA																		

CHAPTER 3
METHODOLOGIES

3.1 Supplier Selection Method

This chapter provides an overview of methodologies used to conduct a comparative analysis of various supplier selection method that employed in this study. The methodologies covered in this article including DEMATEL, AHP and TOPSIS.

3.1.1 DEMATEL

The DEMATEL approach, renowned for its efficiency in analyzing complex systems, constructs and evaluates models by considering causal relationships among intricate criteria. Over the last decade, the DEMATEL method has gained considerable traction and has been widely adopted by researchers to solve complex challenges spanning diverse fields. Its robustness and capabilities have made it a preferred choice in addressing intricate issues. In essence, the formulation of the DEMATEL method will be described as the following steps below (Gökler & Boran, 2023).

Step 1: Evaluate and determine the relationship between criteria.

Experts evaluate and determine the relationships between criteria according to the Table 3.1 but if the relationships in fuzzy logic use Table 3.2. Then create the direct relationship matrix $\tilde{X}$ based on expert evaluation.

Table 3.1 Comparison Scales of DEMATEL Method**.**

Levels of influence	Definition
0	No influence
1	Somewhat influence
2	Medium influence
3	High influence
4	Very high influence

Table 3.2 Fuzzy Comparison Scales of DEMATEL Method.

Levels of influence	Definition	Triangle fuzzy number values
EH	No influence	(0,0,0.25)
VH	Somewhat influence	(0,0.25,0.25)
H	Medium influence	(0.25,0.5,0.75)
L	High influence	(0.5,0.75,1)
VL	Very high influence	(0.75,1,1)

$$\tilde{X}= \begin{bmatrix} 0 & \cdots & \tilde{X}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{X}_{n1} & \cdots & \tilde{X}_{nn} \end{bmatrix}$$

Where $\tilde{X}$ is the n x n fuzzy matrix derived from the expert.

n is the number of experts.

$\tilde{X}_{ij}$ is the degree of influence in the pairwise comparison expressed as a triangular fuzzy number.

Step 2: Create matrix C.

The fuzzy normalized direct relation matrix ($\tilde{C}$) is created by using Equation. (3.1) and Equation (3.2).

$$\tilde{C} = \frac{\tilde{X}}{s} \text{ and } \tilde{C} = [c_{ij}]_{\, n\, x\, n} \text{ when } 0 \leq \tilde{c}_{ij} \leq 1 \qquad (3.1)$$

$$s = max\ (max\textstyle\sum_{j=1}^{n} \tilde{X}_{ij},\ max\sum_{i=1}^{n} \tilde{X}_{ij}) \qquad (3.2)$$

Step 3: Create total relation matrix ($\tilde{T}$).

The total relation matrix ($\tilde{T}$) is created by using Equation (3.3).

$$\tilde{T} = \tilde{C}(I - \tilde{C})^{-1} \qquad (3.3)$$

Where I is the identity matrix.

Step 4: Create the de-fuzzified total relation matrix (T).

The total relation matrix (T) is created by using Equation. (3.4) and Equation (3.5).

$$T_{ij} = \frac{l_{ij} + m_{ij} + u_{ij}}{3} \qquad (3.4)$$

$$T = \begin{bmatrix} T_{11} & \cdots & T_{1j} \\ \vdots & \ddots & \vdots \\ T_{i1} & \cdots & T_{ij} \end{bmatrix} \qquad (3.5)$$

Where l is the lower limit.

m is the most probable value.

u is the upper limit.

T is the de-fuzzified total relation matrix.

Step 4: Determining D and R.

Determining the sums of row and column of matrix T which can be calculated by Equation (3.6) and Equation (3.7).

$$D_i = [\sum_{j=1}^{n} t_{ij}]_{n\,x\,1} = [t_i]_{n\,x\,1}\,, i = 1,2,\ldots,n; \quad (3.6)$$

$$R_j = [\sum_{j=1}^{n} t_{ij}]_{1\,x\,n} = [t_j]_{n\,x\,1}\,, j = 1,2,\ldots,n; \quad (3.7)$$

Where D is the summation of rows in matrix (T).

R is the summation of columns in matrix (T).

Step 5: Create table for D, R, (D+R) and (D-R).

Where (D+R) is the central role which indicates how much important criteria are with greater value of D+R means greater important. For $(D - R) \geq 0$ is means that it have greater influence compare to other criteria or it called cause group. On the other hand, if (D-R) is negative it is called effect group which means it get easier influence by other criteria (Rahman et al., 2021).

Step 6: Find weights of criteria.

The weights of criteria (w_i) can be obtain by using Equation (3.8).

$$w_i = \frac{\sqrt{(D_i + R_i)^2 + (D_i - R_i)^2}}{\sum_{n=1}^{n} \sqrt{(D_i + R_i)^2 + (D_i - R_i)^2}} \quad (3.8)$$

Where w_i is the weights of criteria.

3.1.2 Analytic Hierarchy Process (AHP)

AHP help decision-makers in choosing alternatives by assessing different criteria and factors relying on 3 principles which are decomposition, comparative judgment, and synthesizing.

Decomposition involves structuring the problem hierarchically, starting with the goal, followed by criteria, and alternatives. With a common hierarchy structure shown in Figure 1, this hierarchical structure helps decision-makers concentrate on assessing the weights of each criterion and sub-criterion (Rahman et al., 2021).

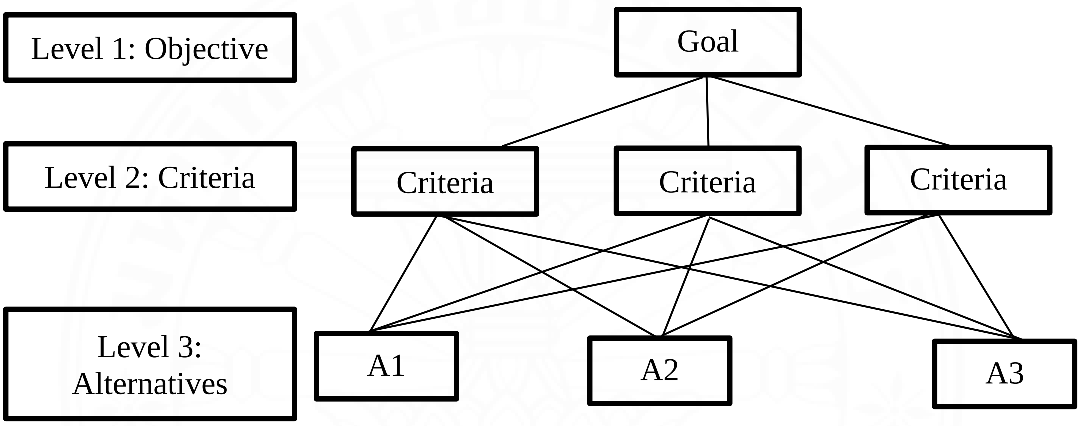

Figure 3.1 The Hierarchical Structure of AHP Method.

In comparative judgment, the human judgement transformed to set of number based on the Table 3.3 and Table 3.4 that are then built into a pairwise comparison matrix. This principle helps the decision maker to evaluate the system's alternative calculate the criteria weight.

Lastly, the synthesizing is a final step which involves combining various parts or pieces to create a single entity. The best alternatives of the system will be determined by synthesizing the criteria (Rahman et al., 2021).

Table 3.3 Comparison Scales of AHP Method.

Scale of importance	**Definition**	**Elaboration**
1	Equally Importance	Two criteria equally important
3	Moderate Importance	One criterion has a moderate importance over another
5	Strong Importance	One criterion has a strong importance over another
7	Very Strong Importance	One criterion has a very strong importance over another
9	Extreme Importance	One criterion has an extremely importance over another
2,4,6,8	Intermediate Values Between the Two Adjoining Judgments	Use when compromise is needed

Table 3.4 Fuzzy Comparison Scales of AHP Method**.**

Initial	**Definition**	**Triangle fuzzy number values**
EI	Equally Important	(1,1,1)
LI	Little More Important	(2,3,4)
MI	Much More Important	(4,5,6)
SI	So Much More Important	(6,7,8)
AI	Absolutely More Important	(9,9,9)
ELI	The intermittent values between two adjacent scales	(1,2,3)
LMI		(3,4,5)
MSI		(5,6,7)
SAI		(7,8,9)

The decision maker can use the AHP method as listed below to calculated the weight standardized rating scores.

Step 1: Create a hierarchical structure.

To analyze the problem, the hierarchical structure is employed. The most widely utilized hierarchical structure is depicted in Figure 3.1.

Step 2: Create pairwise comparison matrix, A and B.

To make the pairwise comparisons, decision makers evaluate the criteria and alternatives in linguistic scales with respect to the Table 3.3 or Table 3.4. The following matrix below is the model of the pairwise comparison matrix:

$$\tilde{A}^k = [\tilde{a}_{j\acute{j}k}] = \begin{bmatrix} EI & \tilde{a}_{12k} & \cdots & \tilde{a}_{1nk} \\ \tilde{a}_{21k} & EI & \cdots & \tilde{a}_{2nk} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1k} & \tilde{a}_{n2k} & \cdots & \tilde{a}_{nnk} \end{bmatrix}$$

$$\tilde{B}^k = [\tilde{a}^{j}_{i\acute{i}k}] = \begin{bmatrix} EI & \tilde{a}_{12k} & \cdots & \tilde{a}_{1nk} \\ \tilde{a}_{21k} & EI & \cdots & \tilde{a}_{2nk} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{m1k} & \tilde{a}_{m2k} & \cdots & \tilde{a}_{mnk} \end{bmatrix}$$

The diagonal is always 1 (EI).

Where i is alternative, i = 1, 2, …, m

j is criterion, j = 1, 2, …, n

m is the number of alternatives

n is the number of criteria

k is the number of decision maker

$\tilde{A}^k$ is a matrix of fuzzy pairwise comparisons that decision makers k evaluated the criteria.

$\tilde{B}^k$ is a matrix of fuzzy pairwise comparisons that decision makers k evaluated the alternatives.

$\tilde{a}_{j\acute{j}k}$ is fuzzy weight of criterion j comparison with the other criterion $\acute{j}$ evaluated by decision maker k

$\tilde{a}_{j\acute{j}}$ is aggregated fuzzy weight of criterion j comparison with the other criterion $\acute{j}$

$\tilde{a}^{j}_{i\acute{i}k}$ is a fuzzy rating score of alternative i in comparison with the other alternative $\acute{i}$ with respect to criterion j evaluated by decision maker k

$\tilde{a}_{i\acute{\imath}}^{j}$ is aggregated fuzzy rating score of alternative i in comparison with the other alternative $\acute{\imath}$ with respect to criterion j.

Step 3: Convert linguistic scales to numerical weights.

Convert linguistic scales to numerical weights based on Table 3.3 or Table 3.4 and the remaining weight can be calculated from the Equation (3.9):

$$\tilde{a}_{j\acute{j}k} = \frac{1}{\tilde{a}_{\acute{j}jk}} \tag{3.9}$$

Step 4: Normalize the weights of criteria and alternatives.

The normalized weights of criterion j can be calculated based on the Equation (3.10):

$$\widetilde{w}_{jk} = \frac{\sum_{j}^{n}\left[\tilde{a}_{ijk}\left(\sum_{j=1}^{n}\tilde{a}_{ijk}\right)^{-1}\right]}{n} \tag{3.10}$$

Where $\widetilde{w}_{jk}$ is normalized weights of criterion j by decision maker k.

Step 5: The fuzzy rating score of each alternative can be calculated based on the Equation (3.11):

$$\tilde{x}_{i} = \frac{\sum_{i}^{m}[\tilde{a}_{i\acute{\imath}k}^{j}(\sum_{i=1}^{m}\tilde{a}_{i\acute{\imath}k}^{j})^{-1}]}{m} \tag{3.11}$$

Where x_{ij} is the normalized rating score of alternative i with respect to criterion j.

Step 6: De-fuzzified weight by Equation (3.12) and normalized the weight by Equation (3.13).

$$Dw_{j} = \frac{w_{jl} + w_{jm} + w_{ju}}{3} \tag{3.12}$$

$$w_{j} = \frac{Dw_{j}}{\sum_{j=1}^{m}[Dw_{j}]} \tag{3.13}$$

Where Dw_j is de-fuzzified weight of criterion j.

w_j is normalized de-fuzzified weight.

Step 7: De-fuzzified normalized rating score by Equation (3.14).

$$x_{ij} = \frac{x_{ijl} + x_{ijm} + x_{ijo}}{3} \tag{3.14}$$

Where x_{ij} is de-fuzzified rating score of alternative i with respect to criterion j.

Step 8: Determine weighted normalized decision matrix (V).

The weighted normalized rating score can be calculated based on the Equation (3.15):

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_1x_{11} & w_2x_{12} & \cdots & w_1x_{1n} \\ w_1x_{21} & w_2x_{22} & \cdots & w_2x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_1x_{m1} & w_2x_{m2} & \cdots & w_mx_{mn} \end{bmatrix} \tag{3.15}$$

Where v_{ij} is the weighted normalized rating score of alternative i with respect to criterion j.

Step 6: Compute the weighted standardized rating scores.

The weighted standardized rating scores of each alternative can be calculated form the Equation (3.16). Rank all of the alternative based on weighted standardized values. The more weight means the better of alternative.

$$s_i = \sum_{j=1}^{n} v_{ij}\, , \forall i = 1,2,\ldots,m \tag{3.16}$$

Where s_i weighted standardized rating scores of each alternative.

3.1.3 TOPSIS

The TOPSIS is the method that chooses the alternative closest to the best solution and farthest from the worst ideal solution (Roszkowska, 2011). The decision maker can use the TOPSIS method as listed below to find the best alternatives:

Step 1: Create the fuzzy decision matrix (matrix D).

Each decision maker evaluated the performance of each alternative and create the decision matrixes (matrix D). Then decision maker gives the important weight with respect to each criterion according to the Table 3.5 or Table 3.6. Then create the weight vector for k-decision maker (matrix W).

$$\widetilde{D} = \begin{bmatrix} \tilde{x}_{11}^{1} & \tilde{x}_{12}^{2} & \cdots & \tilde{x}_{1n}^{k} \\ \tilde{x}_{21}^{1} & \tilde{x}_{22}^{2} & \cdots & \tilde{x}_{2n}^{k} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1}^{1} & \tilde{x}_{m2}^{2} & \cdots & \tilde{x}_{mn}^{k} \end{bmatrix}$$

$$\widetilde{W} = \begin{bmatrix} \widetilde{w}_{11}^{1} & \widetilde{w}_{12}^{2} & \cdots & \widetilde{w}_{1n}^{k} \\ \widetilde{w}_{21}^{1} & \widetilde{w}_{22}^{2} & \cdots & \widetilde{w}_{2n}^{k} \\ \vdots & \vdots & \ddots & \vdots \\ \widetilde{w}_{m1}^{1} & \widetilde{w}_{m2}^{2} & \cdots & \widetilde{w}_{mn}^{k} \end{bmatrix}$$

$$\tilde{x}_{ij} = \frac{1}{K}(\tilde{x}_{ij}^{1} + \ldots + \tilde{x}_{ij}^{k} + \ldots + \tilde{x}_{ij}^{K}) \qquad (3.17)$$

Where $\widetilde{D}$ is fuzzy decision matrix.

$\widetilde{w}_{ij}^{k}$ is fuzzy importance weight of criterion j for k-decision maker.

$\tilde{x}_{ij}^{k}$ is fuzzy rating score of alternative i of decision maker k with respect to criterion j.

$\tilde{x}_{ij}$ is fuzzy rating score of alternative i to criterion j.

$\tilde{x}_{ij}^{k} = (l_{ij}^{k}, m_{ij}^{k}, u_{ij}^{k})$

i is alternative, i = 1, 2, …, m

j is criterion, j = 1, 2, …, n

k is decision maker, k=1,2, …, K

m is number of alternatives.

n is the number of criteria.

K is the number of decision maker.

s is the decision maker (s = 1, 2, …, k)

Table 3.5 Comparison Scales of TOPSIS Method.

Scale	Rating
Poor (P)	1
Medium poor (MP)	3
Fair (F)	5
Medium good (MG)	7
Good (G)	9
Intermediate values between the two adjacent judgments	2,4,6,8

Table 3.6 Fuzzy Comparison Scales of TOPSIS Method.

Scale	Initial	Triangle fuzzy number values
Extremely High	EH	(0.7,0.9,0.9)
Very High	VH	(0.5,0.7,0.9)
High	H	(0.3,0.5,0.7)
Low	L	(0.1,0.3,0.5)
Very Low	VL	(0.1,0.1,0.3)

Step 2: Find the importance weight of each criterion.

Convert linguistic scales in matrix W to numerical weights according to the Table 3.5 or Table 3.6 to determine the alternative rankings. Then importance weight of each criterion can be calculated based on the Equation (3.18):

$$\widetilde{w}_{ij} = \frac{1}{K}[\widetilde{w}_{ij}^{1} + \widetilde{w}_{ij}^{2} + \ldots + \widetilde{w}_{ij}^{K}] \tag{3.18}$$

Where w_{ij} is the weight of i-alternative with respect to j-criterion from K-decision maker

Step 3: Create the normalized fuzzy decision matrix**.**

Determine the normalized decision matrix of each decision maker by using Equation (3.19):

$$\widetilde{N}_{ij}^{k} = \frac{\tilde{x}_{ij}^{k}}{\sqrt{\sum_{i=1}^{n}(\tilde{x}_{ij}^{k})^2}} \tag{3.19}$$

Where N_{ij}^{k} is a normalized fuzzy decision matrix.

Step 4: Create matrix V**.**

The weighted normalized rating score of alternative i with respect to criterion j can be calculated based on the Equation (3.20) and matrix V can be created by Equation (3.21):

$$\tilde{v}_{ij} = \tilde{w}_j * \tilde{N}_{ij}^{k} \quad (3.20)$$

$$\tilde{V} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \cdots & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & \cdots & \tilde{v}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{v}_{m1} & \tilde{v}_{m2} & \cdots & \tilde{v}_{mn} \end{bmatrix} = \begin{bmatrix} \tilde{w}_1 * \tilde{N}_{11}^{k} & \tilde{w}_2 * \tilde{N}_{12}^{k} & \cdots & \tilde{w}_n * \tilde{N}_{1n}^{k} \\ \tilde{w}_1 * \tilde{N}_{21}^{k} & \tilde{w}_2 * \tilde{N}_{22}^{k} & \cdots & \tilde{w}_n * \tilde{N}_{2n}^{k} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{w}_1 * \tilde{N}_{m1}^{k} & \tilde{w}_2 * \tilde{N}_{m2}^{k} & \cdots & \tilde{w}_n * \tilde{N}_{mn}^{k} \end{bmatrix} \quad (3.21)$$

Where $\tilde{V}$ is the fuzzy weighted normalize decision matrix.

$\tilde{v}_{ij}$ is the fuzzy weighted normalized rating score of alternative i with respect to criterion j.

Step 5: Determine positive ideal solutions $(A^{+})$and negative ideal solution (A^{-}).

The positive ideal solution (A^{+}) is the solution that aims to maximize the positive criteria (benefit criteria) and minimize negative criteria (cost criteria). It can be calculated by using Equation (3.22). Conversely, the negative ideal solution (A^{-}) is the solution that aims to minimize the positive criteria (benefit criteria) and maximize negative criteria (cost criteria). It can be calculated by using Equation (3.23).

$$A^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, \ldots, \tilde{v}_n^{+}) = ((\underset{i}{max v_{ij}} \mid j \in B), (\underset{i}{min v_{ij}} \mid j \in C)) \quad (3.22)$$

$$A^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, \ldots, \tilde{v}_n^{-}) = ((\underset{i}{min v_{ij}} \mid j \in B), (\underset{i}{max v_{ij}} \mid j \in C)) \quad (3.23)$$

Where B is the benefit criteria where more is better.

C is the cost criteria where less is better.

Step 6: Determine the distance from alternatives to the positive ideal solution (d_i^{+}) and the negative ideal solution (d_i^{-}).

The distance from alternatives to the positive ideal solution can be calculated based on the Equation (3.24).

$$d_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2}, i = 1,2,\ldots,m \quad (3.24)$$

The distance from alternatives to the negative ideal solution can be calculated based on the Equation (3.25).

$$d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}, i = 1,2,\ldots,m \quad (3.25)$$

Step 7: Determine the closeness coefficient (R_i).

The relative closeness of the i alternative A_j with respect to A^+ can be calculated by using Equation (3.26). If the closeness coefficient large it means that the alternative is better compare to lower closeness coefficient.

$$R_i = \frac{d_i^-}{d_i^- + d_i^+} \quad (3.26)$$

Where R_i is the closeness coefficient, $0 \leq R_i \leq 1$.

Step 8: Rank the alternative.

Find the best alternative according to R_i by ranking the alternatives based on R_i with higher R_i means better ranking.

3.2 Data Collection

Data for this study was collected from classroom workshops and classroom manuals which contain both quantitative and qualitative data. These sources provided practical insights for applying and evaluating each supplier selection method. The workshops involved interactive sessions where different methods were applied to various scenarios, while the manuals provided detailed guidelines and examples for each method.

CHAPTER 4
RESULT AND DISCUSSION

This chapter presents the result and discussion of supplier selection methods: AHP, TOPSIS, and DEMATEL. This analysis aims to clarify the methodological differences among supplier selection methods. The following subtopics present the result from different methodologies including different weights and numbers of suppliers.

4.1 Comparison of DEMATEL with AHP

This section compared the weights and supplier ranking assigned by DEMATEL and AHP. The results showed differences in the weights assigned to criteria and suppliers by these two methods.

Table 4.1 Criteria Weights Assigned by DEMATEL and AHP Methods for Supplier Selection with Fuzzy Logic (5 Criteria and 3 Suppliers)**.**

Criteria	DEMATEL	AHP
Service Quality	0.188	0.304
Technical Capability	0.155	0.269
Performance History	0.205	0.064
Reputation and Position in Industry	0.217	0.141
Warranties and claim policies	0.234	0.222

Table 4.2 Supplier Rankings from Table 4.1.

	DEMATEL		AHP	
Supplier	Score	Rank	Score	Rank
1	0.223	4	0.235	4
2	0.238	3	0.248	3
3	0.252	2	0.251	2
4	0.287	1	0.265	1

Table 4.3 Criteria Weights Assigned by DEMATEL and AHP Methods for Supplier Selection with Fuzzy Logic (4 Criteria and 3 Suppliers).

Criteria	DEMATEL	AHP
Product Quality	0.253	0.364
Reliability	0.298	0.385
Quality of Relationship	0.269	0.176
Manufacturing Capability	0.180	0.075

Table 4.4 Supplier Rankings from Table 4.3.

	DEMATEL		AHP	
Supplier	Score	Rank	Score	Rank
1	0.424	1	0.436	1
2	0.314	2	0.330	2
3	0.262	3	0.234	3

Table 4.5 Criteria Weights Assigned by DEMATEL and AHP Methods for Supplier Selection with Fuzzy Logic (5 Criteria and 3 Suppliers).

Criteria	DEMATEL	AHP
Quality	0.1713	0.3392
Origin	0.2075	0.2623
Cost	0.2706	0.1989
Delivery	0.2165	0.073
After Sales	0.1341	0.1267

Table 4.6 Supplier Rankings from Table 4.5.

	DEMATEL		AHP	
Supplier	Score	Rank	Score	Rank
1	0.438	1	0.484	1
2	0.284	2	0.283	2
3	0.278	3	0.233	3

Analysis and Discussion

The variations in rankings and weights between DEMATEL and AHP demonstrate how different methods affect the results of decision-making. The discussion of the outcomes for each method is presented below:

Weight Assignment

DEMATEL tends to assign weights more equally for each criterion because it focuses on understanding the causal relationships. For instance, in case study 1, weights of every criterion are relatively closer in value compared to those assigned by AHP. In contrast, AHP often results in more weight disparities, demonstrate the relative importance of each criterion through pairwise comparisons. For example, in Table 5.2, the weights for Payment Term, Unitary Price, Percent Defect, and Percent On-Time Delivery using AHP show a structured prioritization, often resulting in more distinct differences between the highest and lowest weights compared to DEMATEL's balanced approach.

Supplier Ranking Outcomes

From the result it showed that even with the variation in weight of each criterion, the ranking in each scenario remains consistent across methods. This consistency indicated that even with different weight of criteria, the outcome can still be the same.

Differential Scoring

While ranking is consistent in each case, the score for each criterion differs which shows how the distance between the suppliers can vary. Therefore, the decision maker can make a decision based on what they need. If the decision maker needed a clearer differentiation based on greater weights for crucial operational criteria, the AHP might be the preferable choice. On the other hand, if the decision maker prefers a balanced perspective that takes interdependencies into account DEMATEL might be more suitable.

4.2 Comparison of DEMATEL with TOPSIS.

This section compares between DEMATEL and TOPSIS methods, focusing on their weight assignments and resulting supplier rankings.

Table 4.7 Criteria Weights Assigned by DEMATEL and TOPSIS Methods for Supplier Selection with Fuzzy Logic (4 Criteria 5 Suppliers).

Criteria	DEMATEL	AHP
Payment Term	0.3068	0.1944
Unitary Price	0.3522	0.4722
Percent Defect	0.2029	0.1389
Percent On-Time Delivery	0.1382	0.1944

Table 4.8 Supplier Rankings from Table 4.7**.**

	DEMATEL		TOPSIS	
Supplier	R_i	Rank	R_i	Rank
1	0.294	5	0.473	5
2	0.426	4	0.584	3
3	0.460	3	0.599	2
4	0.610	2	0.691	1
5	0.693	1	0.511	4

Table 4.9 Criteria Weights Assigned by DEMATEL and TOPSIS Methods for Supplier Selection with Fuzzy Logic (10 Criteria 5 Suppliers).

Criteria	DEMATEL	TOPSIS
Area (sq.m.)	0.152	0.048
Height (m)	0.100	0.080
Distance to Airport (km)	0.077	0.150
Floor Load (mt/sq.m.)	0.117	0.162
Access Road (Lanes)	0.094	0.086
Number of Docks (Docks)	0.107	0.137
Rental Rate for Block Stacking (THB/sq.m month)	0.121	0.118

Material Handling Fee (THB/move/cu.m.)	0.073	0.092
Fulfillment Rate (THB/order)	0.068	0.080
Contract Term (Months)	0.091	0.048

Table 4.10 Supplier Rankings from Table 4.9.

	DEMATEL		TOPSIS	
Supplier	R_i	Rank	R_i	Rank
1	0.398	5	0.319	5
2	0.645	1	0.602	1
3	0.521	3	0.520	3
4	0.519	4	0.451	4
5	0.588	2	0.563	2

Table 4.11 Criteria Weights Assigned by DEMATEL and TOPSIS Methods for Supplier Selection with Fuzzy Logic (5 Criteria 3 Suppliers).

Criteria	DEMATEL	TOPSIS
Cost	0.226	0.295
Delivery Performance	0.265	0.147
Working Day Per Week	0.167	0.113
Compensation Policy	0.172	0.267
Geographical Spread	0.171	0.178

Table 4.12 Supplier Rankings from Table 4.11.

	DEMATEL		TOPSIS	
Supplier	R_i	Rank	R_i	Rank
1	0.533	1	0.523	1
2	0.176	3	0.297	3
3	0.477	2	0.375	2

Analysis and Discussion

The different in rankings and weights between DEMATEL and TOPSIS demonstrate how both methods affect the decision-making outcomes. The discussion of the outcomes for each method is presented below:

Weight Assignment

DEMATEL: Since this method focuses more on casual relationships and more balance in the distribution of the weight it makes all the weight result in more equal values. For instance, in Table 4.5, the weights for Payment Term, Unitary Price, Percent Defect, and Percent On-Time Delivery using DEMATEL are relatively closer in value compared to those assigned by AHP.

TOPSIS: This method emphasizes the relative importance of each criterion by evaluating the distance of each option from the ideal and anti-ideal solutions. This approach results in a clear prioritization of criteria based on their significance in the decision-making process. For example, in case study 1 the weights assigned to Payment Term, Unitary Price, Percent Defect, and Percent On-Time Delivery using TOPSIS show more variation compared to the more balanced distribution of weights seen with DEMATEL.

Supplier Ranking Outcomes

The results from Tables 4.12 and 4.14 indicate that even though the weights given to each criterion are different, the results show a consistency in rankings between scenarios. This consistency shows how reliable the TOPSIS and DEMATEL approaches are for assessing supplier performance. However, the result from Table 4.10 shows a different ranking, possibly due to the different focus of each methodology.

Differential Scoring

The score calculated from DEMATEL and TOPSIS showed that both methods provide different scores assigned to each criterion even if the ranking of each criterion is equal. This variation in score demonstrated the ways that each method assesses the weight of different variables when choosing a supplier. With this knowledge, decision-makers can modify their strategy to meet certain requirements. For instance, the

Analytic Hierarchy Process (AHP) may be more suitable if the goal is to rank key operational criteria and create a more significant differentiation between suppliers because it can provide more weight to important criteria. However, DEMATEL would be a wise option if the criteria are more dependent and effect other criteria. In the end, the decision-maker's goals and requirements of the supplier selection procedure will determine which methodology is the best.

4.3 Comprehensive Comparison of DEMATEL, TOPSIS and AHP

After exploring and comparing DEMATEL with both TOPSIS and AHP individually, this section will focus on a comprehensive comparison of all 4 methods which are AHP, TOPSIS, DEMATEL with AHP and TOPSIS to determine which method is the most suitable choice for different situations.

Table 4.13 Criteria Weights Assigned by DEMATEL, TOPSIS, and AHP Methods for Supplier Selection with Fuzzy Logic (10 Criteria 5 Suppliers).

Criterion	DEMATEL	TOPSIS	AHP
Area (sq.m.)	0.158	0.187	0.187
Height (m)	0.095	0.040	0.040
Distance to Airport (km)	0.079	0.174	0.174
Floor Load (mt/sq.m.)	0.121	0.090	0.090
Access Road (Lanes)	0.096	0.061	0.061
Number of Docks (Docks)	0.110	0.078	0.078
Rental Rate for Block Stacking (THB/sq.m month)	0.126	0.109	0.109
Material Handling Fee (THB/move/cu.m.)	0.069	0.061	0.061
Fulfillment Rate (THB/order)	0.062	0.049	0.049
Contract Term (Months)	0.086	0.151	0.151

Table 4.14 Supplier Rankings Based on DEMATEL, TOPSIS, and AHP Methods.

	DEMATEL with TOPSIS		DEMATEL with AHP		TOPSIS		AHP	
Supplier	CC	Rank	Total	Rank	CC	Rank	Total	Rank
1	0.499	2	0.221	1	0.421	2	0.216	1
2	0.293	5	0.184	5	0.266	5	0.167	5
3	0.382	4	0.211	2	0.397	3	0.210	3
4	0.575	1	0.187	4	0.534	1	0.216	2
5	0.429	3	0.197	3	0.387	4	0.192	4

Analysis and Discussion

After exploring and comparing DEMATEL with both TOPSIS and AHP individually, this section focuses on a comprehensive comparison of all three methods—AHP, TOPSIS, and DEMATEL to assess the consistency of these methods. The discussion of the outcomes for each method is presented below:

Weight Assignment

The results demonstrate that when decision-makers apply weights to criteria based on their perceived importance, AHP and TOPSIS have the same weights since both approaches allocate weights consistently when the same importance levels are given. This method produces a more diverse weight distribution, emphasizing the relative significance of each criterion. DEMATEL, on the other hand, offers a different weight distribution since it emphasizes the connections between the criteria. By emphasizing the ways in which each criterion influences and get influenced by others, DEMATEL produces a more equitable weight distribution that guarantees that criteria with high interdependencies receive the proper attention. These methodological distinctions show that DEMATEL is more appropriate in situations where criteria are interrelated and their combined influence must be taken into account, whereas AHP and TOPSIS are helpful in scenarios requiring a clear hierarchy of criteria relevance.

Supplier Ranking Outcomes

When selecting a supplier, companies need a supplier that delivers the best results. Therefore, in this part, the focus is mostly on identifying the top 1 and top two suppliers. According to Table 4.16, both DEMATEL with TOPSIS and TOPSIS consistently rank suppliers 4 and 1 as the first and second choices. For AHP, suppliers 1 and 4 are very close in ranking, with supplier 4's score almost equal to supplier 1's score. This consistency across different methods highlights that DEMATEL with TOPSIS is a reliable approach for supplier selection.

However, the use of DEMATEL with AHP resulted in an unusual outcome, with supplier 4 receiving a significantly lower rank compared to other methods. This result is unexpected because the criteria weights are the same as those used in DEMATEL with TOPSIS, yet supplier 4's score is significantly different. This divergence suggests that the integration of DEMATEL with AHP might introduce inconsistencies, potentially due to the different ways these methods process and prioritize criteria.

Differential Scoring

According to the result, suppliers 1 and 4 are consistently ranked as the top 2 options for all method except DEMATEL with AHP, although the differential scoring emphasizes the different levels of scoring between suppliers. The top 1 and top 2 ranks for TOPSIS and AHP vary slightly while using the same weights, due to slight variances in their scoring method. Notably, AHP provides extremely similar results for the top 1 and top 2 providers, suggesting that either provider would be a good option. Similarly, DEMATEL with TOPSIS shows slight differences in scoring but maintains the same ranking pattern.

On the other hand, supplier 4 scores much lower than supplier 1 when using DEMATEL with AHP, indicating a considerable disparity in scoring. The significant disparity in supplier rankings may be caused by different method in the processing and prioritization of criteria created by the integration of DEMATEL with AHP.

In summary, although the overall ranking trend stays consistent, the individual scores and the extent of differentiation among suppliers vary. Both TOPSIS and AHP, despite using the same weights, result in slightly different scores and rankings, with AHP presenting closely matched top suppliers. Similarly, DEMATEL combined with TOPSIS produces comparable patterns with minor differences in scores. However, DEMATEL combined with AHP diverges significantly in its scoring outcomes, underscoring the impact of methodological differences on supplier selection.

CHAPTER 5
CONCLUSION

This final section included the findings from the comparative analysis of the supplier selection methods: AHP, TOPSIS, and DEMATEL. The recommendations for decision makers are provided to suggest the most suitable solution for different needs and situations. Future research directions are also provided to fill knowledge gaps and improve the robustness of the methods.

5.1 Summary of Findings

Result obtained from Chapter 4 demonstrate valuable insight knowledge about the use and outcomes of different methods:

5.1.1 Criteria Weight Differences

DEMATEL provided evenly distributed weights because it emphasizes the interrelationships among criteria, reflecting how each criterion influences others. This approach ensures that criteria with significant interdependencies receive balanced attention. On the other hand, AHP and TOPSIS produced similar weight distribution because both methods prioritize criteria based on their perceived importance as given by the decision-makers.

5.1.2 Supplier Ranking

Even with different weight distributions, the top-ranking suppliers from each method remain the same, demonstrating a high level of consistency and reliability. However, DEMATEL with AHP from last case study produced an unexpected outcome by giving supplier 4 a very low score and ranking, differing significantly from other methods. This suggests that further study is needed to understand why DEMATEL with AHP is not as consistent.

5.2 Recommendations for Future Research

Based on the findings and limitations of this study, several recommendations for future research are provided.

5.2.1 Methods Integration

Investigate hybrid models that can combine the advantages of TOPSIS and AHP and DEMATEL to reduce the drawbacks of each method.

5.2.2 Trend Analysis in Weight Discrepancies

The trend of weights from each method should be the same since all methods aim to evaluate the importance of criteria from different perspectives. DEMATEL determines the importance of criteria based on their interdependencies, while AHP and TOPSIS assess the importance of the criteria individually. Therefore, the weights from different methods can be different, but the trend should be similar. However, observations from this study indicate that in many case studies, the weight trends are not consistent. Future research should explore why the trend of DEMATEL results differs from those of other methods.

5.2.3 Case Studies

Apply the model to various industry scenarios to analyze the outcome and validate the effectiveness of each method with different case studies because case studies can enhance methodological robustness and offer useful insights.

5.3 Conclusion

To conclude, this study has focused on evaluating and comparing supplier selection methods: DEMATEL, TOPSIS, AHP to compare and analyze their weight distribution, criteria prioritization, and consistency. The result show that the combination of TOPSIS and DEMATEL provide a consistent result as it matches nicely with the other ranking trends. This indicates that DEMATEL when used with TOPSIS can consistently combine the advantages of both strategies, presenting an excellent choice for supplier selection. However, there were noticeable discrepancies when TOPSIS and AHP were combined, indicating the need for more investigation to determine the underlying causes of this difference.

REFERENCES

Chang, B., Chang, C. W., & Wu, C. H. (2011). Fuzzy DEMATEL method for developing supplier selection criteria. *Expert systems with Applications*, *38*(3), 1850-1858.

Du, Y. W., & Zhou, W. (2019). New improved DEMATEL method based on both subjective experience and objective data. *Engineering Applications of Artificial Intelligence*, *83*, 57-71.

Gökler, S. H., & Boran, S. (2023). A novel resilient and sustainable supplier selection model based on D-AHP and DEMATEL methods. *Journal of Engineering Research*.

Hashemi, S. H., Karimi, A., & Tavana, M. (2015). An integrated green supplier selection approach with analytic network process and improved Grey relational analysis. *International Journal of Production Economics*, *159*, 178-191.

Haeri, S. A. S., & Rezaei, J. (2019). A grey-based green supplier selection model for uncertain environments. *Journal of cleaner production*, *221*, 768-784.

Hsu, M. C., & Lee, H. S. (2023). Applying AHP-IFNs-DEMATEL in Establishing a Supplier Selection Model: A Case Study of Offshore Wind Power Companies in Taiwan. *Energies*, *16*(11), 4481.

Javed, S. A., Gunasekaran, A., & Mahmoudi, A. (2022). DGRA: multi-sourcing and supplier classification through dynamic grey relational analysis method. *Computers & Industrial Engineering*, *173*, 108674.

Jahangirzadeh, A., Mousavi, S. M., & Dorfeshan, Y. (2020). An extended grey relational analysis based on COPRAS method for sustainable supplier selection in project procurement problems. *Journal of Quality Engineering and Production Optimization*, *5*(1), 103-118.

Jindal, A., Sharma, S. K., Sangwan, K. S., & Gupta, G. (2021). Modelling supply chain agility antecedents using fuzzy DEMATEL. *Procedia CIRP*, *98*, 436-441.

Kaya, R., & Yet, B. (2019). Building Bayesian networks based on DEMATEL for multiple criteria decision problems: A supplier selection case study. *Expert Systems with Applications, 134*, 234-248.

Kochkina, M. V., Karamyshev, A. N., Isavnin, A. G., Makhmutov, I. I., & Rozencvajg, A. K. (2017). Modified multi-criteria decision making method development based on "AHP" and "TOPSIS" methods using probabilistic interval estimates. *Turkish Online Journal of Design Art and Communication*, *7*, 1663-1674.

Leblebicioğlu, B., & Keskin, A. (2021). Evaluation of supplier selection criteria with fuzzy DEMATEL method: An application on the pharmacy industry. *Avrupa Bilim ve Teknoloji Dergisi*, (23), 236-242.

Leong, W. Y., Wong, K. Y., & Wong, W. P. (2022). A new integrated multi-criteria decision-making model for resilient supplier selection. *Applied System Innovation, 5*(1), 8.

Li, Y., Diabat, A., & Lu, C. C. (2020). Leagile supplier selection in Chinese textile industries: a DEMATEL approach. *Annals of Operations Research, 287*(1), 303-322.

Mehregan, M. R., Hashemi, S. H., Karimi, A., & Merikhi, B. (2014). Analysis of interactions among sustainability supplier selection criteria using ISM and fuzzy DEMATEL. *International Journal of Applied Decision Sciences, 7*(3), 270-294.

Nguyen, P. H., Tsai, J. F., Nguyen, T. T., Nguyen, T. G., & Vu, D. D. (2020). A grey MCDM based on DEMATEL model for real estate evaluation and selection problems: a numerical example. *The Journal of Asian Finance, Economics and Business, 7*(11), 549-556.

Rahman, N. D. A., Mersing, E. F., Syafieqah, N., Yazid, S. M., & Mahad, N. F. (2021). An Integrated Approach of Analytic Hierarchy Process and Decision-Making Trial and Evaluation Laboratory (AHP-DEMATEL) to Solve the Supplier Selection Problem. *Int. J. Acad. Res. Bus. Soc. Sci.*, *11*, 2279-2299.

Sanayei, A., Mousavi, S. F., & Yazdankhah, A. (2010). Group decision making process for supplier selection with VIKOR under fuzzy environment. *Expert systems with applications, 37*(1), 24-30.

Silva, N. F., dos Santos, M., Gomes, C. F. S., & de Andrade, L. P. (2023). An integrated CRITIC and Grey Relational Analysis approach for investment portfolio selection. *Decision Analytics Journal*, 100285.

Wu, C., Lin, Y., & Barnes, D. (2021). An integrated decision-making approach for sustainable supplier selection in the chemical industry. *Expert Systems with Applications*, *184*, 115553.

Wu, J., Jin, Y., Zhou, M., Cao, M., & Liu, Y. (2022). A group consensus decision making based sustainable supplier selection method by combing DEMATEL and VIKOR. *Journal of Intelligent & Fuzzy Systems*, *42*(3), 2595-2613.

Yazdani, M., Wen, Z., Liao, H., Banaitis, A., & Turskis, Z. (2019). A grey combined compromise solution (CoCoSo-G) method for supplier selection in construction management. *Journal of Civil Engineering and Management*, *25*(8), 858-874.

Zhang, J., Yang, D., Li, Q., Lev, B., & Ma, Y. (2020). Research on sustainable supplier selection based on the rough DEMATEL and FVIKOR methods. Sustainability, *13*(1), 88.

BIOGRAPHY

Name	Warin Namkotr
Education	2022: Bachelor of Engineering (Mechanical Engineering) Sirindhorn International Institute of Technology Thammasat University

Publication

Mahattanavuttakorn, S., Tiputhai, K., Senivong, P., Putsa, N., Namkotr, W., Tancharoensup, C., & Chancharoen, W. (2023). A Comprehensive Review of Thermal Control of Moveable and Non-Moveable Spacecraft in Mars Sample Collecting Mission. *Engineering Journal*, *27*(11), 85-98.