An Integrated Model for Selecting and Evaluating Logistics Outsourcing Decisions using AHP and PROMETHEE II

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ABSTRACT

Given the increasing demand and a number of Logistics Service Providers (LSPs) available in the market, it becomes challenging for the company to select and evaluate the best LSP objectively. Current decision-making is merely based on judgements and historical experience. Therefore, a proper and objective selection tool is essential for decision makers or managers to assess potential LSPs. The present study aims at designing a holistic and user-friendly decision-making framework and tool using a hybrid AHP-PROMETHEE II to assess and select potential LSPs. The present study proposed decision-making tool deploying hybrid AHP and PROMETHEE II as part of multi-criteria decision making (MCDM). The proposed hybrid approach is necessary to improve the weaknesses of AHP by pairing with PROMETHEE II to overcome the problem of rank reversals and the breach of a so-called order preservation criterion (COP). Hence, a hybrid AHP-PROMETHEE II was developed. The model was designed using VBA solver in spreadsheet in XML format which can be used in any different multi-criteria decision-making problem. To demonstrate the applicability and efficacy of the hybrid approach, the hybrid approach was implemented in a hair care manufacturing company GHD UK in order to identify the most suitable LSP company. AHP was used to determine the criteria weight, then PROMETHEE II was used to define the final ranking of each alternative. To balance the numerous measurements in this framework, multiple criteria and multiple stakeholders were evaluated. A comprehensive literature review was conducted in determining the identification and assessment of criteria. AHP model was performed in determining the criteria weight, and expert's opinions from the case company are taken into consideration. The output of the AHP workbook was the criteria weights. Once the criteria weights were calculated, the PROMETHEE method was performed to evaluate and rank all the alternatives. The findings indicate that the holistic developed framework was an effective and robust tool to solve a strategic logistics outsourcing decision making.

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1. Introduction

In the past few years, logistics outsourcing has continued to expand globally. A BCG survey conducted in the last quarter of 2020, showed that of 200 global companies with Logistics Service Providers (LSP) users, with a majority in the US and the UK, these companies will still rely on LSP to undertake some or all of their logistics functions (BCG Global, 2020). Since there is a rising trend for LSP activities, LSP businesses are expanding more rapidly. Consequently, LSP users have been compelled to choose the LSP company that best meets their requirements. Additionally, in recent years, the number of LSPs has increased tremendously, making it challenging to choose the best LSP partner in the logistics sector.

Historically, the decision-making process depended heavily on the decision-makers' personal understanding and subjective emotions, with little theoretical backing or consideration for the criteria involved (Ho *et al.*, 2010). According to (Gürcan *et al.*, 2016), many decision-makers and experts choose service providers based on their experience and intuition. This technique may not provide excellent results. These approaches tend to be subjective. Therefore, the increasing demand and increasing quantity of LSP companies available on the market underline the significance of the assessment and selection process for LSP outsourcing. However, LSP assessment consists conflicting criteria. These conflicting criteria must be optimised (Karrapan, 2017; Singh *et al.*, 2017). LSP selection is always practically related to purchasing department's task alone. However, on top of the purchasing department, there are the other decision-makers involved such as from marketing, finance, and logistics who participate in the selection process because those departments are very likely to be affected and have their own preferences.

In addition, the selection of LSPs involves subjective value judgements. Several of these criteria may be unclear and inconsistent. Due to uncertainty, although some of the criteria may be measured mathematically, others must be communicated verbally. In addition, there may be obstacles involving various criteria and perhaps opposing objectives. In most cases, challenging decisions about selecting suitable logistics providers based on several important aspects are made using professional judgment and personal expertise. The reasons above highlight the importance of having a robust yet practical tool to help managers in the company choose the best LSP suppliers objectively.

This research seeks to answer the question, "*if the decision is to outsource the logistics activities, how will companies evaluate and select the best logistics outsourcing vendor from a user perspective?*". This study attempts to assist firms, in this case, GHD UK company, in selecting the best Logistics Sourcing Providers (LSP) to work with. This research will thus concentrate mainly on the assessment and selection phases. This research follows the outsourcing decision tree adapted by Godsmark & Richards (2019). The present research aims at designing a holistic and user-friendly decision-making tool using a hybrid AHP-PROMETHEE II. The present contributes to investigate and identify the main criteria used in LSPs selection and evaluation, to analyse the impact-relationship of each criterion using a pair-wise matrix in AHP method, to develop model for decision-making, to run the model and evaluate model in assisting decision-makers, to evaluate the outsourcing decision-making objectively, and finally to assess and test the model's consistency and stability using sensitivity analysis.

AHP is one of the MCDM methods that organises complicated criteria hierarchically (Saaty, 1994). Even though AHP is the most prevalent approach for MCDM problems, it seems inadequate and imprecise in capturing the decision-maker's subjective evaluations of qualitative assessment and competing criteria. At the same time, AHP has been heavily criticised for the problem of rank reversals and the breach of a so-called order preservation criterion (COP). To overcome this weakness, a hybrid AHP-PROMETHEE II was developed and used in a real-world case study to identify the most suitable LSP company. Its established use in real-world scenarios and user-friendliness are other compelling features. Furthermore, PROMETHEE II is also a way to outrank a restricted number of alternative actions that must be rated and chosen based on possibly contradictory Criteria. Figure 1 below indicate the strengths and drawbacks of each method and explains how one's strength cover one's weakness.

	AHP	PROMETHEE
Handle real data	NO	YES
Determination of the weight	YES	NO
9 point scale	YES	NO
Provide multi preference	NO	YES
Provide Best Choice	NO	YES
Rank Reversal Problem	NO	NO

Figure 1. The comparison between AHP and PROMETHEE

The article is structured into four sections. The next section reviews relevant literature, which is then followed by the research methodology in Section Three. Section Four presents results, followed by discussion in Section Five. Section Six concludes the overall findings.

2. Literature Review

The literature review comprises assessment and selection techniques from worldwide logistics and supply chain publications published between 2011 and 2021, sourced from credible source databases such as ScienceDirect, IEEE, Emerald, and MDP. For the literature study conducted, the terms "LSP selection", "MCDM for LSP selection", and "logistics outsourcing in manufacturing companies" were used to take out articles unrelated to the LSP selection process. As a result, 45 journals were reviewed to support the analysis and investigation of critical criteria used in LSPs evaluation and selection to assess the current decision making for LSP outsourcing, to review the literature on methods and criteria used for LSP evaluation and selection, to support the theoretical side of the models. Besides, additional supporting works of literature are also analysed to achieve the research's objective. On top of that, 32 journals from publications published between 2015 and 2021 were found, and all of them are specific to LSP evaluation and selection in various manufacturing industries using MCDM methods. Out of 32 journals, most of the examined publications were case study surveys (25 journals), followed by dummy study cases (7 journals). Hence, a total of 77 journals were analysed as the following.

2.1 Current state of logistics service provider (LSP) outsourcing

Over the last two decades, the LSP sector has expanded significantly in income and geographic reach. Langley (2022) provides information on the vast expansion of the LSP sector and its developments from 2021 to 2022, which will be summarised as follows:

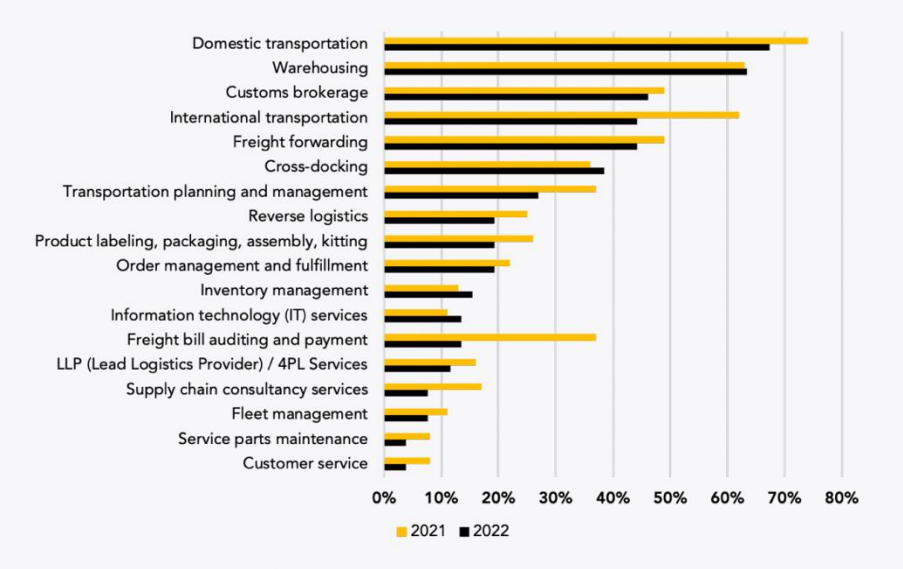

Figure 2. The variety of logistics Services in 2021 and 2022 (Langley, 2022)

In general, the majority of percentages presented in Figure 2 indicates a decreasing tendency relative to the survey conducted in 2021. The proportion of domestic transportation that was outsourced declined from 74% in 2021 to 67% in 2022, while the percentage of foreign transportation that was outsourced decreased from 62% to 44%. According to Langley (2022), this is mainly due to Covid-19 disruptive that have caused disparities, and another reason is due to the different composition of survey. However, overall, the number of different LSP services is increasing over time compared to a decade ago especially in the UK. It can be concluded that the trend of LSP outsourcing is still competitive in the future even though it is reduced from last year. Moreover, there are hundreds of logistics service providers that available on the market and are highly fragmented. Based on Statista (2022) data,

there are 14,784 LSP companies in the UK, showing stable growth since 2018. The increase in the number of LSP users and in the range of LSPs services highlight the need for a robust selection process.

2.2. Existing decision making for LSP outsourcing

Sun and Sun (2022) mentioned that the current methods that are used to select the best suppliers are merely based on expert judgment and cost methods. This observation is consistent with Suratos and Srinon (2021) that the traditional methods for selecting an LSP company are based on the simple evaluation and rule-based reasoning decision support system. However, these methods can not reflect the human complexity in making decisions. Polat *et al*. (2017) contended that managers often select the best supplier only based on their experience. That might result in the selection of unsuitable suppliers will, which in turn, potentially lead to difficulties with performance, as well as loss in budget. As a result, those methods are subjective in the evaluation and contain many uncertainties that will impact the results' accuracy. The selection of the best LSP becomes more critical as many variables (tangible and intangible criteria) are involved and impacted. According to Dutta and Borah (2021), there may be a mismatch between supplier selection methods and supplier evaluation criteria recently. Therefore, a fair supplier selection Decision Support System (DSS) must evaluate crucial real-world aspects and guide decision-makers. Purchasing organisations must develop criteria that are unique to their organisation which may reflect the underlying profit drivers of the business.

Tang and Liao (2021) also conclude that decision-makers in companies are prone to have disputes and conflicts while choosing vendors. Tang and Liao (2021) also assert that experts have their interests, emotions, attitudes, and perceptions while making decisions. In group decision making, the decision-makers often represent their interests based on their department. For example, a manager from the manufacturing department will represent the interest of the manufacturing division, aligned with the KPI of the logistics department, which often contradicts the interest of the finance department who prioritise cost saving instead of delivery. Therefore, there will unavoidably be disagreements among specialists. Based on classification principles, scholars have made contributions to the categorization of group disputes and gained matching accomplishments.

2.3. Methods and criteria for LSP outsourcing decision

Various MCDM tools have been developed to support complex decisions, including supplier selection. Adapted from Majdi (2013), Figure 3 below illustrates the MCDM approach's hierarchy.

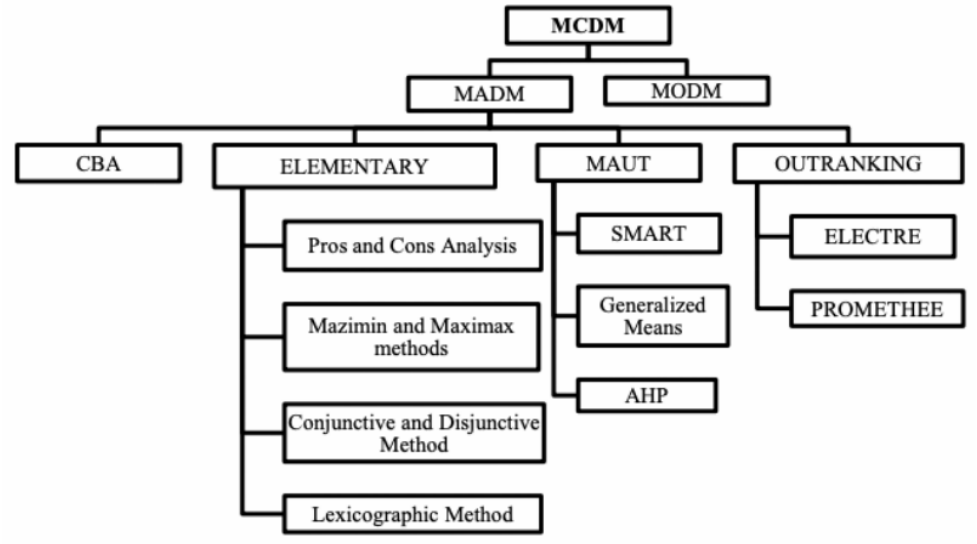

Figure 3. MCDM hierarchy (Majdi, 2013)

Many researchers have proposed different approaches to MCDM to provide optimum solutions to supplier selection, from the simple ones such as the Weighted Sum Model (WSM) to the complex ones such as ANP, AHP, ELETRE, TOPSIS, PROMETHEE, and so on. Those methods are very prevalent due to their benefits in addressing numerous qualitative and quantitative criteria. However, each approach has its advantages and disadvantages. Consequently, integrating one MCDM approach from the same category or other techniques becomes a desirable strategy. These hybrid techniques may represent the many phases of the LSP selection process more effectively, including determining criteria weighting, excluding inappropriate providers, and the final selection. This is further supported by Liu et al. (2020). They claim that LSP selection difficulties have become more complicated, necessitating combining many MCDM methods, commonly called Hybrid Multi-Criteria Decision Making (HMCDM).

From an analysis of 32 research published in 2015-2021, most scholars employed various MCDM methods to tackle LSP selection, with or without a case study. Out of 32 types of research, 19 of them (60%) use hybrid MCDM approaches. From the literature review, 25 used actual companies as a study case, while the other 7 used dummy data to demonstrate their model. In this research, in terms of method structure, it is evident that the pairwise based comparison of the criteria is the way of choice that is most preferred. In terms of methods, AHP or Fuzzy AHP was the most prevalent approach, followed by TOPSIS, ANP, ELECTRE, and DEMATEL. The evidence suggests that researchers mostly combine two methods to overcome deficiencies. Based on the 32 publications from 2015 to 2021, AHP is often paired with FST, DEMATEL, TOPSIS, and DEA.

3. Methodology

The methodology involves four stages as shown in Figure 4. Each stage has different approaches, requires different types of data, and hence different output. This study adopted two kind of methodologies including comprehensive literature review and hybrid MCDM method (AHP and PROMETHEE II).

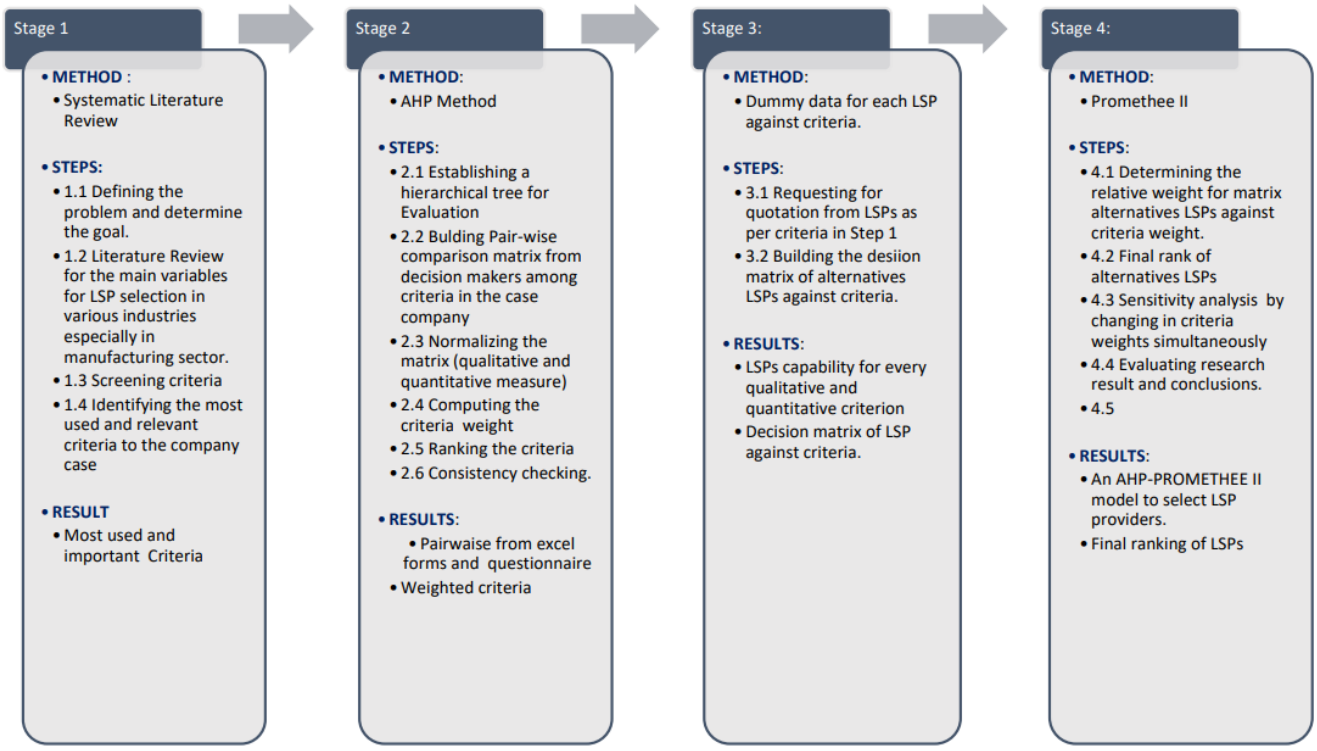

Figure 4. The proposed approach (adapted from Saaty (1994))

After the literature review, model building consisting of three stages was conducted. Each stage in building the model is explained as the following. The first stage is to collect the criteria and sub-criteria used to select LSP

companies relevant to the manufacturing industry. This data will be collected via a systematic literature review. The second stage is collecting the data of pair-wise comparisons to define the relationship and importance of each criterion. This data will be collected through a solver model to all decision-makers in the case company, such as logistics manager, procurement manager, logistics director, supply chain director, and procurement director. The pair-wise comparison is computed by establishing a comparison matrix using a nine-point scale rating (Saaty, 1994). The third stage is to generate dummy data on each criterion for every LSP. The dummy data demonstrated reflects the accurate and real data.

4. Results

4.1 Development of the decision-making model

The decision making model was implemented using Macro programming and VBA Solver in Microsoft Excel. Therefore, the model automatically generated the result by simply clicking the button. However, this template has some limitations. For example, the maximum number of criteria for this model template is 15, and maximum number of alternatives is 10. However, a number of decision-makers can be determined by adding the column on the spreadsheet.

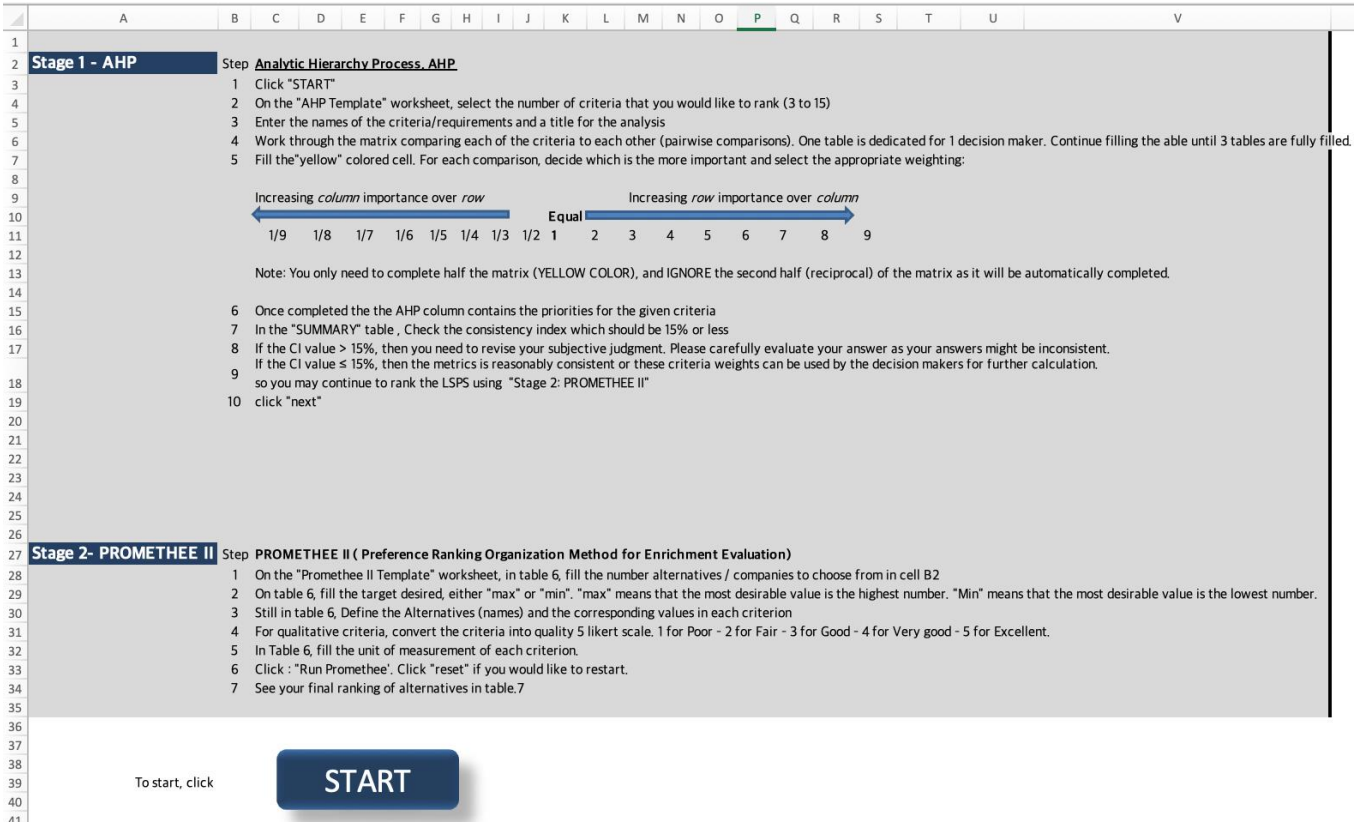

Figure 5. Interface of instruction workbook

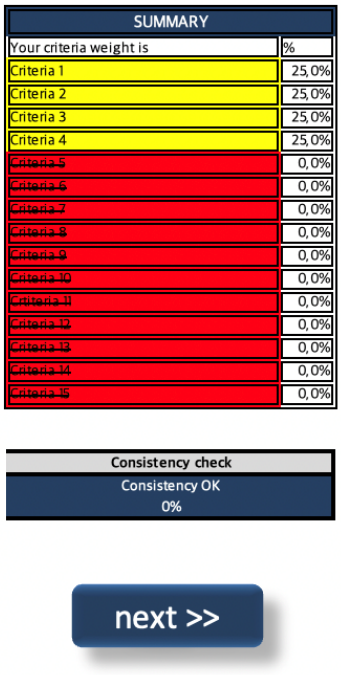

Figure 6. Interface of AHP template workbook

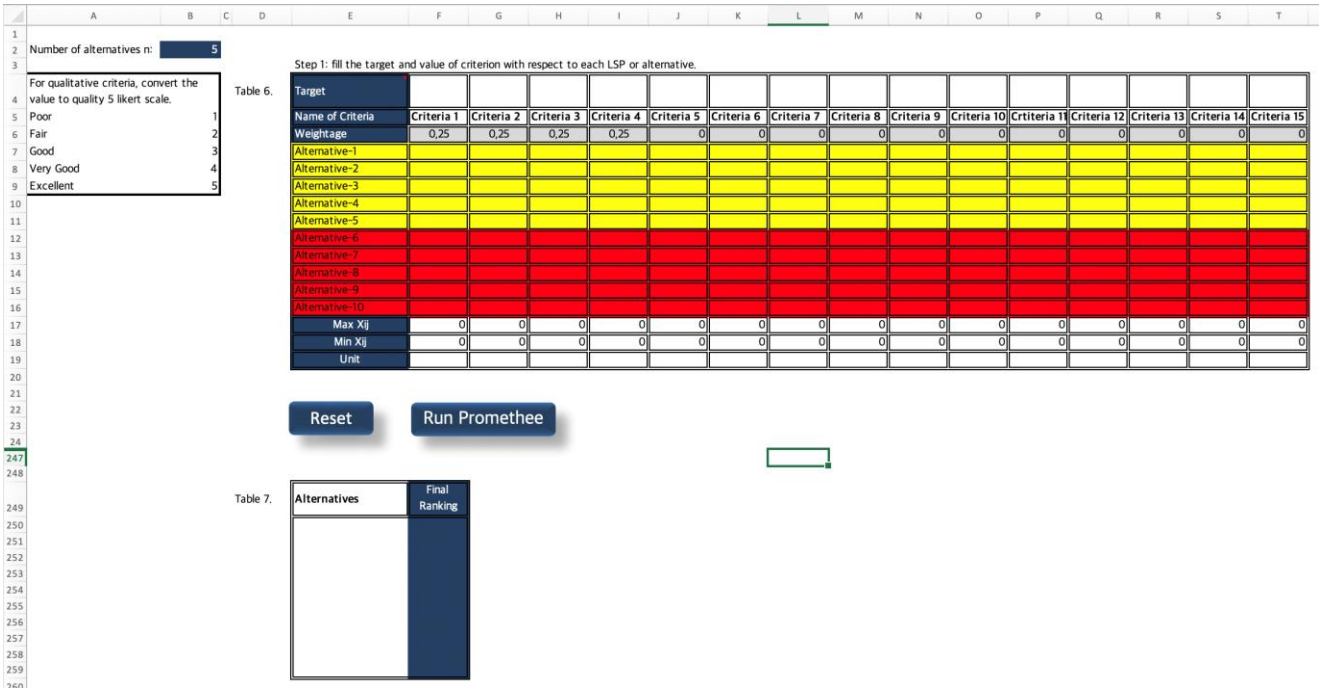

Figure 7. Interface of PROMETHEE template workbook

4.2 Model application

This section illustrates how the concept described earlier may be applied to the case company. In this study, GHD UK is used as a case company that wants to select the best LSP company to work with. The designed model is used and tested by all three decision-makers in the case company to see either the model is convenient to use or not.

4.2.1 Application of Analytic Hierarchy Process (AHP)

GHD UK, a hair care manufacturing company with headquarters in Leeds, the United Kingdom, serves as the case study for applying the proposed model. GHD UK is looking for an LSP company to work with. A total of three decision-makers in the company took part in this decision-making of logistics purchasing. Currently, there is no system for selecting suppliers in the case company. When making the decision, the case company only consider some criteria such as cost, delivery, and quality. For this reason, it is necessary to evaluate suppliers using a more advanced method. In this study, AHP-PROMETHEE II has developed an integrated method for addressing an LSP Outsourcing decision-making issue. AHP will be utilised to determine the criterion weights. In contrast, PROMETHEE II will be used to determine the comprehensive ranking of alternatives (in this case, the alternatives are LSPs).

Step 1: Develop the AHP Hierarchy

In this case, 12 criteria are selected from the literature review, reflecting the most essential and most used criteria by manufacturing companies in the past ten years to select their LSP. Finally, seven LSP companies submit their quotation to the case company in level four against each criterion.

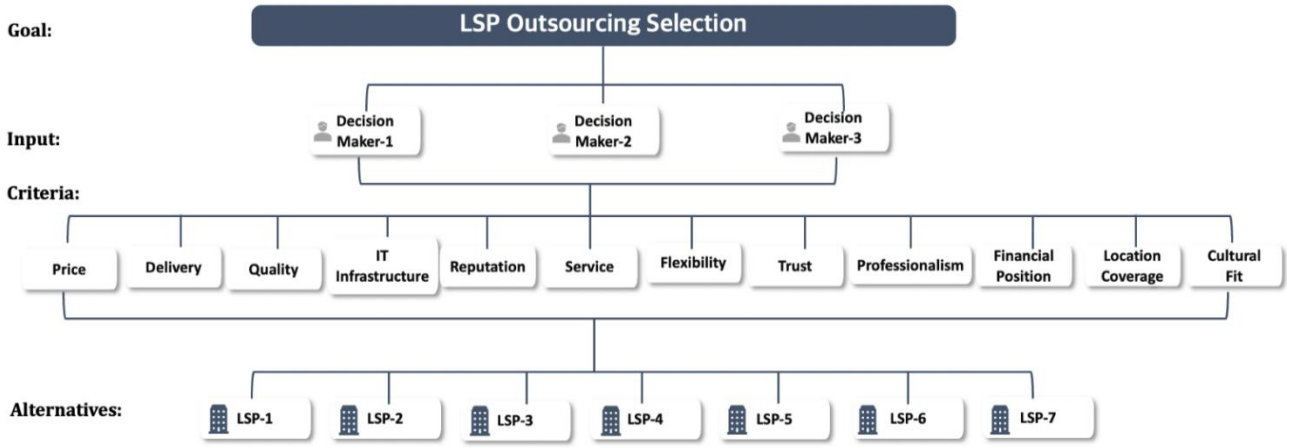

Figure 8. AHP Hierarchy for LSP Selection

Step 2: Priority Vector

Table 1. A nine-point pair-wise comparison scale (Saaty, 1994)

Value (k)	Definition	Explanation
1	Equal importance	i and j are equally important
3	Weak importance	*i* is slightly more important than *j*
5	Strong importance	i is strongly more important than j
7	Very strong importance	i is very strongly more important than j
9	Extreme importance	i is absolutely more important than j
2,4,6,8,	Intermediate values	used when a compromise is needed

As shown in Table 1, a pair-wise comparison matrix is produced using a scale of relative significance. The number of decision-making criteria used will produce a pair-wise matrix of the same length. As this LSP example includes 12 criteria, there are 12 times 12 matrices.

Step 3: Relative Importance Matrix

AHP's second stage involves determining the relative relevance of various traits or criteria concerning the objective. Once more, a 9-point scale is applied to a pair-wise comparison matrix. A normalised pair-wise matrix is the outcome of this stage. Table 2 shows the pair-wise comparison for 12 selected criteria, whereas Table 3 shows the results for the studied case.

Table 2. Matrix of pair-wise comparison for 12 selected criteria

Decision Maker	Criteria	Criteria of LSP											
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
DM-1	C1	1	1	3	1	1/4	1/3	1/4	1/2	3	1/4	1/2	1/3
	C2	1	1	2	1/3	1	1	1	1	3	1/4	1	1
	C3	1/3	1/2	1	1/3	1	1	1	1/3	3	1/5	1	1
	C4	1	3	3	1	1/2	2	4	2	5	1	5	1
	C5	4	1	1	2	1	1	1/2	1	1	1/2	2	1
	C6	3	1	1	1/2	1	1	1	1	3	1	6	2
	C7	4	1	1	1/4	2	1	1	1/2	2	1/5	6	3
	C8	2	1	3	1/2	1	1	2	1	1	1/3	6	1
	C9	1/3	1/3	1/3	1/5	1	1/3	1/2	1	1	1/3	5	1
	C10	4	4	5	1	2	1	5	3	3	1	8	2
	C11	2	1	1	1/5	1/2	1/6	1/6	1/6	1/5	1/8	1	1/7
	C12	3	1	1	1	1	1/2	1/3	1	1	1/2	7	1
DM-2	C1	1	1/5	4	1	1/5	1	2	1/5	3	2	1/4	2
	C2	5	1	1/6	6	2	1	5	1	7	2	2	3
	C3	1/4	6	1	1	1	1	1	1	1	1	1	1
	C4	1	1/6	1	1	1/2	1	1/2	1/7	5	1	1/3	1/2
	C5	5	1/2	1	2	1	1	1/5	1/8	2	2	1/4	1/3
	C6	1	1	1	1	1	1	1	1/3	7	2	2	3
	C7	1/2	1/5	1	2	5	1	1	1/5	4	5	1/4	1
	C8	5	1	1	7	8	3	5	1	7	5	2	5
	C9	1/3	1/7	1	1/5	1/2	1/7	1/4	1/7	1	1	1/3	1/3
	C10	1/2	1/2	1	1	1/2	1/2	1/5	1/5	1	1	1/2	1
	C11	4	1/2	1	3	4	1/2	4	1/2	3	2	1	1
	C12	1/2	1/3	1	2	3	1/3	1	1/5	3	1	1	1
DM-3	C1	1	6	7	3	8	2	7	8	8	8	8	9
	C2	1/6	1	6	7	7	6	5	4	5	9	9	9
	C3	1/7	1/6	1	4	5	4	7	8	6	9	8	7
	C4	1/3	1/7	1/4	1	4	5	3	4	2	6	4	4
	C5	1/8	1/7	1/5	1/4	1	1/3	1/5	1/4	1/6	1/3	1/2	1/4
	C6	1/2	1/6	1/4	1/5	3	1	5	6	4	7	4	2
	C7	1/7	1/5	1/7	1/3	5	1/5	1	4	3	6	2	4
	C8	1/8	1/4	1/8	1/4	4	1/6	1/4	1	2	3	1/4	5
	C9	1/8	1/5	1/6	1/2	6	1/4	1/3	1/2	1	1/3	1/2	3
	C10	1/8	1/9	1/9	1/6	3	1/7	1/6	1/3	3	1	1/2	1/2
	C11	1/8	1/9	1/8	1/4	2	1/4	1/2	4	2	2	1	1/2
	C12	1/9	1/9	1/7	1/4	4	1/2	1/4	1/5	1/3	2	2	1

*C1= Price/Cost; C2= Delivery; C3=Quality; C4=IT Infrastructure; C5= Reputation; C6= Service; C7= Flexibility; C8= Relationship / Trust; C9= Professionalism; C10= Financial Position' C11= Location Coverage; C12= Cultural Fit.

Based on the sum of the weighted averages of three decision-makers, the Delivery criterion with a weight of 0.145 has the most significant weight value, followed by Price with a weight of 0.12 and Service with a weight of 0.107. The findings of this study's data processing indicate that delivery, Price, and Service are the most significant factors for selecting LSP service providers in GHD UK.

Table 3. The outcome of AHP model from solver template for GHD UK

Criteria	Symbol	Weight
Delivery	C2	0,145
Price/ Cost	C1	0,120
Service	C6	0,107
Quality	C3	0,098
Relationship / Trust	C8	0,097
IT Infrastructure	C4	0,097
Flexibility	C7	0,081
Financial Position	C10	0,060
Cultural Fit	C12	0,058
Reputation	C5	0,052
Location Coverage	C11	0,051
Professionalism	C9	0,035

Step 4: Consistency Check

Based on the output of the AHP model, three respondents all showed consistent results, as shown in Table 4. It can be observed that the Consistency Ratio (CR) is 0.06275 < 0,15. Thus, the preference matrix inputted by the decision makers is consistent and can be further used in the second step, PROMETHEE II.

Table 4. Consistency ratio (CR)

Criteria	Criteria Weight	CA
Price/ Cost	0,120	1,139821414
Delivery	0,145	0,977826263
Quality	0,098	1,194282099
IT Infrastructure	0,097	1,070085271
Reputation	0,052	1,132658673
Service	0,107	1,160672105
Flexibility	0,081	1,175730911
Relationship / Trust	0,097	1,001091333
Professionalism	0,035	1,083997507
Financial Position	0,060	0,963950439
Location Coverage	0,051	1,043167179
Cultural Fit	0,058	1,119800421
	λmax	13,06308361
	CI	0,096643965
	CI/RI	0,062755821

4.2.2 Application of PROMETHEE II

The weight data produced from the AHP model will then be processed using the PROMETHEE-II approach. The PROMETHEE II template has been utilised to address the shown numerical model issue of LSP selection at GHD UK. Table 6 displays weights, scale, goal, and preference functions for the various criteria. The selection of preference functions is defined by the nature of the criterion, as was previously mentioned. The purpose of the preference function is to translate the difference observed between two actions on a given criterion, from the criterion scale to a normalized 0-1 degree of preference. For example, the preferred preference function for qualitative criteria is a level function. In contrast, the preferred preference function for quantitative criteria is linear.

Table 5. Preference functions of 12 selected criteria

Name of Criteria	Symbol of Criteria	Target	Weightage	Unit/Scale	Preference Function
Price/ Cost	C1	Min	0,119715	£/km/kg	Linear
Delivery	C2	Max	0,145056	%	Linear
Quality	C3	Max	0,097628	Five-point	Level
IT Infrastructure	C4	Max	0,096659	Five-point	Level
Reputation	C5	Max	0,051674	Five-point	Level
Service	C6	Max	0,10688	#	Linear
Flexibility	C7	Max	0,080872	Five-point	Level
Relationship / Trust	C8	Max	0,097243	Five-point	Level
Professionalism	C9	Max	0,035318	Five-point	Level
Financial Position	C10	Max	0,059588	£ billion /year	Linear
Location Coverage	C11	Max	0,051482	# Countries	Linear
Cultural Fit	C12	Max	0,057887	Five-point	Level

Table 6. Evaluation of seven LSP Service providers against all criteria

Name of Criteria	Price/ Cost	Delivery	Quality	IT Infrastructure	Reputation	Service	Flexibility	Relationship / Trust	Professionalism	Financial Position	Location Coverage	Cultural Fit
LSP-1	1,4	3,0%	Good	Good	Good	Good	Good	Good	Very Good	12.712	3	Good
LSP-2	1,6	4,0%	Good	Fair	Good	Very Good	Good	Good	Very Good	10.363	4	Good
LSP-3	2,1	5,0%	Very Good	Fair	Fair	Excellent	Good	Good	Very Good	11.770	15	Good
LSP-4	2,2	6,0%	Excellent	Fair	God	Good	Very Good	Very Good	Very Good	800	8	Very Good
LSP-5	2,3	7,0%	Excellent	Very Good	Very Good	Excellent	Very Good	Very Good	Good	980	25	Good
LSP-6	1,4	8,0%	Good	Very Good	Very Good	Good	Good	Fair	Good	9.000	30	Good
LSP-7	1,9	1,0%	Good	Excellent	Good	Good	Very Good	Fair	Fair	12.000	24	Good
Unit	£/km/kg	%	qualitative	qualitative	qualitative	#	qualitative	qualitative	qualitative	£ billion /year	# Countries	qualitative

Table 7. Outcome of PROMETHEE II model from XML template for GHD UK

Alternatives	Final Ranking
LSP-1	6
LSP-2	7
LSP-3	4
LSP-4	2
LSP-5	1
LSP-6	3
LSP-7	5

The AHP-PROMETHEE II methodology is applied to evaluate the various LSP company possibilities. The data above is adopted into the model, then the model will automatically run the calculation and present the result as shown in Table 7. The total amount of outranking decides the ranking. From the model, it can be seen that the best available LSP service provider is LSP-5, followed by LSP-4 and LSP-6. There are total of seven LSP service providers available.

4.2.3 Consistency analysis

As part of the sensitivity analysis, the test of the consistency of the ranking by shifting the criteria was conducted. For example, when the C1 weight is shifted to the C2 weight. The result can be seen in Figure 9 below.

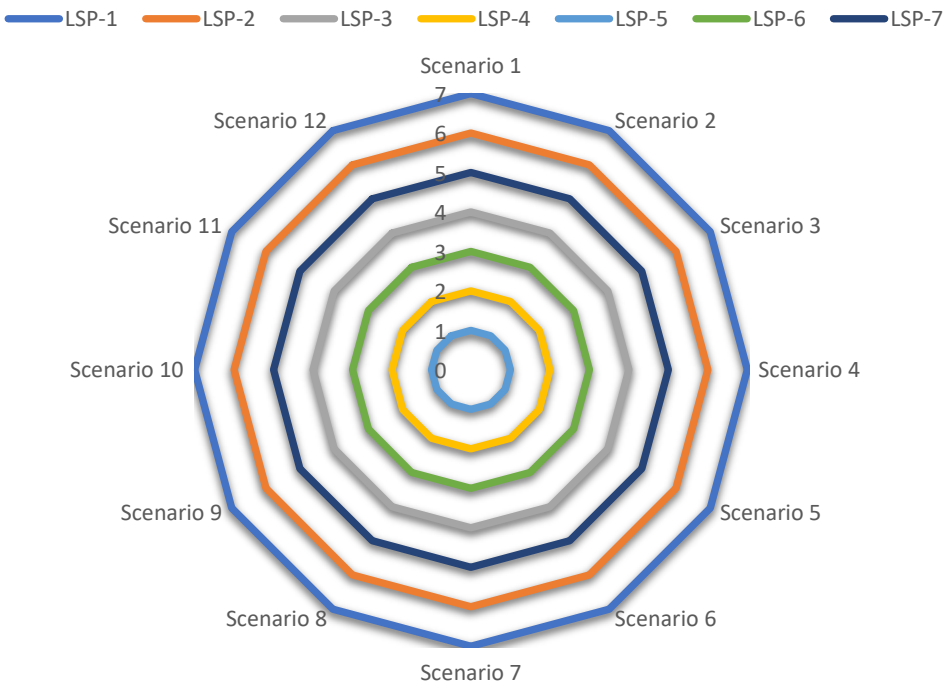

Figure 9. Results of consistency analysis

The consistency analysis results show that LSP-5 has the highest consistency under all conditions. To sum up, out of 12 scenarios, the order ranking remains the same despite shifting from one particular criterion to another. It indicated that the proposed model is robust and reliable.

5. Discussion

5.1 Decision-making framework

The MCDM model is particularly significant for selecting the best LSP companies and evaluating the performance of LSPs since it can be utilised in both ways. The approach may be used in any decision-making situation, no matter how basic or complicated, as long as it incorporates many qualitative and quantitative criteria. In this part, some practical advice will be demonstrated to facilitate the applicability of our selection framework to other decision-making contexts that are analogous to strategic decisions.

First, the 3PL provider selection process is an MCDM problem, including subjective value judgments. Although AHP is the most used technique for MCDM challenges, it is insufficient and imprecise in capturing a decision maker's subjective assessments of the interpretation of qualitative assessment criteria. To compensate for this restriction in the conventional AHP's clear pair-wise comparison, a hybrid technique combining the AHP methodology with

PROMETHEE II has been proposed and used for a real-world case study involving the selection of the best suitable 3PL supplier.

Second, the objective of our application was to facilitate the selection of the best suitable LSP company by merging the opposing views of several stakeholders with a holistic viewpoint. Each organisation has its own internal and external stakeholders. Each stakeholder has distinct concerns due to differences in knowledge, experiences, business positions, and preferences during the identification of the evaluation matrix, criteria weights, and preference functions. Therefore, it is necessary to carefully examine which stakeholders should be involved in the selection process, as this differs from business to business. For instance, in our case, the internal stakeholders included the director of the supply chain department (DM1), who had a better understanding of the company's overall strategic development goals, the logistics department (DM2), which was responsible for delivery, and a panel of senior operations managers (DM3), who were responsible for operations.

Third, in the preliminary screening phase, 12 exclusion criteria centred on logistics service providers were utilised to screen qualified service providers. Notably, exclusion criteria were established to eliminate service providers who could not achieve the minimum requirements. This approach can save an amount of time and work. However, in other cases, the criteria used may differ depending on the circumstances. In this case, the cost is considered, while in other cases, it may not be as the primary company's goal is to improve efficiency and service. Fortunately, the model is flexible for any criteria.

Fourth, defining assessment criteria was the first task the DMs should have taken. The task of defining relevant criteria was challenging yet essential. A thorough assessment of the selection's overarching objectives and mapping these objectives to particular goals was crucial to constructing the criterion specification. Finding essential characteristics, such as cultural fit, is incredibly beneficial. As a distinctive and vital aspect of British culture, solid relationships and network-building would facilitate cooperation across organisations and is crucial for dealing with difficult situations. It is conceivable that using our approaches in different circumstances might provide additional significant criteria.

Lastly, establishing a decision matrix and weights required considerable subjective judgement on the part of the stakeholders based on the 3PL providers' information. Even when the stakeholders possess appropriate experience, knowledge, and competence in the logistics field, certain judgments may be unsatisfactory owing to insufficient information or imprecise description. Therefore, it is crucial to acquire as much complete and accurate information as possible about the 3PL suppliers before the selection process.

5.2 Insights from the studied case

This study developed a framework for the LSP outsourcing decision problem based on a real case company in the UK. A few insights and key lessons about the study case will be discussed in this section. First, applying the AHP and PROMETHEE II model to the real-world decision issue of LSP selection shows that these methods are helpful because of the consistent results they provide when ranking the firms and picking the best LSP company. This demonstrates their effectiveness in solving real-world decision problems. In this study, seven different LSP companies serve as potential candidates. Researchers apply 12 criteria to select the most suitable one.

The second observation is that in most organizations, decision-makers (DMs) have the challenge of assessing many LSPs alternatives, and they have to select the best based on multiple competing criteria. The examination of the criteria plays a significant role in determining whether the decision-making process is successful. This is because the criteria have a direct influence on the efficiency and effectiveness of the business and the services it provides. Therefore, additional efforts need to be made to identify the most important and influential criteria that impact the alternative for the complex decision-making problem. This will allow for the elimination of alternatives that are not important and the selection of the alternative that is best suited to strengthen the selection procedures that are currently in place. Three decision makers from the case company will choose the importance of each criterion using pair-wise comparison methods based on their preferences. There is no one option that is superior to all others. The particular preferences of each decision-maker as the “brain” also play a role in determining which answer represents the most excellent compromise. The case study used three decision-makers as the “brain” of the decision-making process from the case company.

Third, it is crucial to evaluate the model by comparing it to the other MCDM models that are already available, even though different approaches to the same case study might provide varying results depending on the approach and measurement of the model used, as explained in Figure 8. However, this study performs a comparative study to compare the result between PROMETHEE II and VIKOR. The comparison between PROMETHEE II and VIKOR demonstrated the efficacy of PROMETHEE II. Furthermore, according to Velasquez and Hester (2018), several researchers utilize VIKOR to validate the solutions offered by various MCDM approaches.

In this study, comparisons between three MCDM models and PROMETHEE II indicated that PROMETHEE II is an excellent ranking algorithm. This research demonstrates the robustness of the Hybrid AHP- PROMETHEE II methods for rating alternatives. It is clear from the findings of the sensitivity analysis that the final rankings are sensitive enough with the criteria weight. Hence, the model is comprehensive and trustworthy enough to be utilised by managers or decision-makers in any organisation to solve any decision-making issue. The summary of the weakness and strength of the built model, along with recommendation for future research as shown in Figure 10.

Strength	**Weakness**
• User Friendly with explicit instruction. • Simple. The decision-makers do not need to calculate manually. The model will generate the outcome with a single 'click' button. • The preference function of criteria can be set up. • The model is reliable and robust. • Effective group decision-making involves many decision-makers judgments and opinions. • The model has been proven to be able to resolve conflicting criteria.	• The AHP assumes that the criteria and alternatives are linearly independent. • This model is limited to only 15 criteria and ten alternatives. The template needs to be modified for more effective alternatives or criteria. • Need some efforts to assess the essential criteria of the alternatives.
Recommendations for Further Research	
• The ranking is sensitive to the Criteria weights. Therefore, the expert selection should be addressed to the right person. • To compare the final ranking with other MCDM methods. • to utilise Fuzzy AHP with PROMETHEE • It involved more decision-makers outside the case company. • Implement the model in another nature of industry/real-life decision-making problem.	

Figure 10. Summary of key lessons

6. Conclusion

The main objective of the present study is to design a decision-making model to support businesses in selecting the most suitable LSP suppliers from among several available options. The study proposed decision-making tool deploying hybrid AHP and PROMETHEE II, which was implemented using VBA programming in Microsoft Excel in XML format. The tool is designed in such a way as to be user-friendly and easy to use by managers or decision-makers. The contribution of the study lies in a multi-perspective approach which helps the case company better understand the essential requirement from many departments such as logistics, procurement, operations, and finance department. The decision-making model can facilitate decision-maker's different perspectives and preferences.

Twelve main criteria based on the literature review, i.e., prices, delivery, quality, IT infrastructure, reputation, service, flexibility, trust, professionalism, financial position, location coverage and cultural fit, were used to select the best LSPs in these past six years. The decision-making model helped the company choose the best LSP by ranking the best to the worst LSPs. The result is that LSP-5 is the best company, followed by LSP-4 and LSP-6. Thus, the proposed model serves as a resource or tool for the industry in establishing its logistics strategy and applications and defining a mechanism for assessing LSP performance. Furthermore, the model not only can help the company to select the best LSPs. The company can also use the model to evaluate their existing suppliers or LSPs after using the service providers for quite some time. In addition, LSP companies that partner with manufacturing industries may use this research's results to comprehend their client demands better and adjust accordingly. Consequently, from a manager's perspective, this article offers insight to decision-makers in LSP's user industry and logistics providers. The model's capability is not limited to solving LSP Outsourcing decision-making. However, it can also assist decision-makers in resolving a wide variety of multi-criteria decision-making problems, such as the selection of facilities, the selection of equipment, and many more.

To test the consistency of the proposed model, consistency and sensitivity analysis are performed separately. The result from the consistency tests is that the model is robust and reliable as the proposed model results in the same prominent ranking as the other method, VIKOR. Therefore, the proposed model is not only capable of serving as a guideline to the managers within the company who used to deal with the decision-making problem but also can help individuals to solve any real-life multi-criteria decision problems.

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