International Journal on Robotics, Automation and Sciences

IMPLEMENTATION OF THE BEST-WORST METHOD FOR SUPPLIER SELECTION OF PRODUCTS TRANSPORTATION SERVICE IN A PHARMACEUTICAL COMPANY

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Supplier selection is an important aspect that must be carried out properly to ensure that the company's supply chain can run well. PT. XZ is a pharmaceutical company that regularly require product transportation service from a dedicated supplier. Currently the supplier selection process in the company is a general process that can be applied for any supplier selection case yet does not have an adjustable criteria and weight to accommodate different evaluation standard for different case. The company prefer to simplify the selection process by neglecting the criteria selection and weight calculation. Numerous studies in the field of multi-criteria decision-making (MCDM) have delved into methods to enhance the supplier selection process and minimize errors. This research aims to assess supplier selection, identify relevant criteria, and incorporate the best-worst method to optimize the choice of the most suitable supplier for product transportation services. The best-worst method (BWM) is employed to assign weights to criteria by utilizing user preference ratings, resulting in a refined and accurate criterion weighting process. With the determined criteria, the alternatives are evaluated by individual assessment form. The evaluation score is normalized and multiplied by the weight with the respect of the specific criteria to find the final weighted score. The result is one of the logistic company's scores is higher than the other alternatives which indicates that alternative is the best to be chosen.

Keywords: Supplier Selection, Product Transport, Best-worst Method, MCDM, Criteria, Alternatives

I. INTRODUCTION

The process of supply chain is the integration between product development, marketing, operation, distribution, finance, and customer service of the company [1]. In the process of supply chain, a company may require support from other companies as the strategic choice in supply chain relationship. The companies that involve within a supply chain of a certain business can be defined as supplier or vendor. The support from suppliers can be in the form of providing raw material, equipment, or outsourcing services [2]. Logistics is a process to move and position inventory across the supply chain's phase. Time and position of inventory are the values generated in a logistic process. The logistic process consists of warehousing and transportation. Warehousing is focused on the position arrangement of the inventory, while the transportation is focused on the product movement in the supply chain [2].

Outsourcing for logistic services is becoming popular in today's supply chain with many third party logistic (3PL) companies offering various services such as warehousing, transporting, and distribution. The increasing market competition pushes company business to be able to reach a certain level of responsiveness that can meet customer's demand. In order to reach the supply chain responsiveness, the role

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International Journal on Robotics, Automation and Sciences (2023) 5,2:33-42
https://doi.org/10.33093/ijoras.2023.5.2.4
Manuscript received: 7 July 2023 | Accepted: 28 August 2023 | Published: 30 September 2023

Published by MMU PRESS. URL: http://journals.mmupress.com/ijoras

of outsource logistic services needed. By utilizing outsource logistic service, the company can reduce supply chain complexities and cost, while more focus on executing the business process [3].

PT. XZ is a well-established pharmaceutical company that is involved actively in the medicine supply in Indonesia. The supply chain process for imported finished goods of PT. XZ in Indonesia is supported by third party logistics companies. The logistic company that supports PT. XZ in terms of transporting products from the warehouse to the distributor is proposing a new arrangement for business agreement as the current contract wil be ended. PT. XZ sees the condition as an opportunity to also consider alternatives from other logistic companies. A failure to select the best supplier alternatives will expose the company with the risk of high cost and less beneficial added value in the logistic process. Therefore, a supplier selection process for logistic service providers on products transportation is conducted as an effort to rank up the alternatives of suppliers based on certain criteria and find the best choice among possible alternatives.

The previous selection was conducted on 2018. With the changed condition and preferences of the user and the company, the weight of the criteria for the selection process must be reconsidered. This research will observe the current supplier selection process for logistic service providers for products transport in PT. XZ, and propose supporting tools that will help to reconstruct the criteria and its weight with recent preferences by using best-worst method (BWM). With most recent preferences, the research aim to provide a better weight formulation that suitable with the current condition in the company and the expectation of the decision maker.

Best-worst method is one of recently developed MCDM tools that build on the base of pairwise comparison calculation. BWM was introduced by Rezaei in 2015 as a simpler pairwise base MCDM technique with a smaller number of pairwise comparison processes and higher consistency rate than another pairwise comparison method [4]. The smaller number of pairwise comparisons used in the BWM offers time efficiency during the formulation process and is seen as a suitable method to support the selection process in pharmaceutical companies where time is crucially important to fulfill the needs of patients.

The pairwise comparison will be performed by using the deciding factor which will be defined in this research. The criteria for the supplier selection will be determined by analyzing the requirement and expectation from the user. The pairwise will be used to find out the weight value of each criterion by using BWM formulation [4]. After the weight of the criteria is found from the pairwise process of BWM method, the available alternatives will be assessed by the user by reflecting the defined criteria. The matrix result of the criteria's weight pairwise and the assessment result of each alternative will be used to find out the final value of the alternatives.

II. Literature Review

A. Supplier Selection

Supplier selection holds significant importance in the realm of supply chain management, encompassing both manufacturing and process-oriented sectors. In many sectors, selecting the right suppliers and reducing purchasing costs are frequently critical tasks for the purchase department. The performance of the organization's supply chain might be negatively impacted by improper evaluation and selection of supplier. Also, the process of choosing a supplier involves a multi-criteria decision-making process that takes both qualitative and quantitative aspects into account [5].

The process of supplier selection is quite complicated because there are many criteria involved, which might change depending on the product and include both qualitative and quantitative variables. Supplier selection can therefore be thought of as a MCDM problem including qualitative and quantitative criteria because it incorporates various and at times conflicting metrics [6]. The ranking of these alternatives and the selection of the best suitable alternative(s) from a group of alternatives have both been addressed using MCDM techniques. In the decision-making process for supplier selection challenges, conflicting qualitative and/or quantitative criteria have been employed [6].

B. Multi-criteria Decision-making in Supplier Selection

The supplier selection process will be more complicated align with more vary criteria required by the company to evaluate the supplier alternatives. A study by Punniyamoorty *et al.* [7] categorized the criteria as quality, technical capability, production facilities and capacities, financial position, delivery, service, relationship, safety and environment concern, and cost. Yadav and Sharma [8] use quality, cost, delivery, service, long-term relationship, and flexibility as the criteria on their supplier selection study. Modibbo *et al.* [6] classified the criteria in their research as cost, quality, services, delivery, supplier details, and personnel capabilities. In 2023, Sharma and Tripathy [9] defined supplier capacity, sector experience, innovation level, financial position, technological skills, flexibility, order fulfilment, and reputation as the criteria. Yadav and Sharma [8] stated that the decision criteria on the supplier selection process could be different on every organization by looking several factors which are the demographic characteristic of the purchasing managers, the size of the organization, the firm strategy for sourcing and supply chain, and the type of products or services they want to purchase.

The method used on the study for supplier selection using multi-criteria decision-making are also varied. The interesting step that differs a method and another is the way each try to find the weight vector ($\{w_1, w_2, \dots w_2\}$) for the criteria. Analytic hierarchy process (AHP) and technique for others reference by similarity to ideal solution (TOPSIS) are the most popular technique to support multi-criteria decision-making by generate the

weight for each criterion. The idea of AHP is based on weighted aggregation where the criteria and alternatives weight will be calculated using pair-wise comparison from the decision maker/s preferences. The TOPSIS method is based on the distance between the alternatives and the assumed ideal and non-ideal solution, with the goal to find the shortest distance to the ideal solution and the furthest distance to the non-ideal solution.

C.Best-worst Method

The best-worst method (BWM) is one of the popular MCDM method. This technique is invented and published by Razei in 2015. The base calculation in this method is using pairwise comparison. The number of pairwise comparison used in BWM is smaller than another popular method such as AHP, while the consistency rate higher than other weighting methods. Those things become the main advantage of BWM [10].

In pairwise comparison, the decision maker is required to states both the direction and the strength of the criterion. Generally, the decision maker involved in the decision-making process will not have any problem in expressing the direction of the comparison between criteria. On the other hand, expressing strength comparison between the criteria may become a difficult task. This challenge can be the main source of inconsistency in the pairwise comparison of decision making.

The steps of best worst method to derive the weights for the criteria is easy to implement on cases. The steps of BWM are:

1. Step 1: Determine the decision criteria.

The first step is to determine the set of criteria $\{c_1, c_2, \dots c_n\}$ that will be used to select the decision. The criteria are free to be determined as the preference. For examples there can be $\{quality(c_1),\ cost(c_2), service(c_3)\}$.

2. Step 2: Determine the best criterion as the most important, and the worst criterion as the less important from the criteria set.

The second step require the decision maker to identifies the best and worst criterion between all of the criteria in general. In this step, no comparisons are made yet. For example, the decision maker may state quality (c_1) is the best and cost (c_2) is the worst criteria.

3. Step 3: Determine the preference score of the best criterion over all other criteria using scale number between 1 and 9.

In the third step, the decision maker is asked to determine the preference score for the best criterion over all criteria respectively. The result on this step is known as Best-to-Others vector:

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})$$

From the vector, a_{Bj} is the preference of the best criterion B over criterion j. Therefore, $a_{BB} = 1$.

4. Step 4: Determine the preference score of all criteria over the worst criterion using scale number between 1 to 9.

In the fourth step, the decision maker is asked to determine the preference score for all criteria over the worst criteria respectively. The result on this step is known as Others-to-Worst vector:

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T$$

From the vector, a_{jW} indicates the preference of criterion j over the worst criterion W. Therefore, $a_{WW} = 1$.

5. Step 5: Find the optimal weights for all criteria $(w_1^*, w_2^*, \dots, w_n^*)$

We can clarify that for each pair of w_B/w_j and w_j/w_W we have $\frac{w_B}{w_j} = a_{Bj}$ and $\frac{w_j}{ww} = a_{jW}$. To satisfy these conditions for all j, a solution should be found where the maximum absolute differences $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all j will be minimized. The following optimization model is created in order to find the optimum weights as equation (1) below:

$$\min \max_j \left\{\left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right|\right\}$$

s.t.

$$\sum_j w_j = 1 \qquad (1)$$

$w_j \geq 0$, for all j

D.Consistency Ratio

Consistency ratio (CR) is proposed by Razei on the BWM to check the consistency of the calculation results. Consistency ratio is a metric used to measure how reliable an MCDM method's output is. Liang et al. [11] in 2020 offer a new study of input-based consistency measurement that can be measured after the pairwise comparison scale is determined on the BWM process. The formula to calculate the input-based consistency ratio are:

$$CR = \begin{cases} \frac{|a_{Bj} x a_{jW} - a_{BW}|}{a_{BW} x a_{BW} - a_{BW}} & a_{BW} > 1 \\ 0 & a_{BW} = 1 \end{cases} \qquad (2)$$

The consistency ratio result (CR) then will be compared with the thresholds on the study of Liang et al. [11] to check whether the assessment result for importance level from each alternative is acceptable or not. The threshold for consistency ratio check is determined by how many criteria within the selection process and the maximum scales given from the user's scoring with the details on the Table 1 below. Any CR result that equal or greater than the thresholds indicate that the pairwise comparison consistency is inappropriate for the BWM process [11].

TABLE I. CONSISTENCY TRESHOLD [11]

Max Scales	Criteria						
	3	4	5	6	7	8	9
3	0.167	0.167	0.167	0.167	0.167	0.167	0.167
4	0.112	0.153	0.190	0.221	0.253	0.258	0.268
5	0.135	0.199	0.231	0.255	0.272	0.284	0.296
6	0.133	0.199	0.264	0.304	0.314	0.322	0.326
7	0.129	0.246	0.282	0.303	0.314	0.325	0.340
8	0.131	0.252	0.296	0.315	0.341	0.362	0.366
9	0.136	0.268	0.306	0.334	0.352	0.362	0.366

This consistency measurement will be applied in this study to ensure that there are no criteria pairwise comparison that exceed the acceptable threshold. If the CR exceed the threshold, the pairwise comparison scoring must be repeated until the logic's consistency is validated by the consistency calculation and threshold. After all of the CR from the pairwise comparisons are valid to be stated as consistent, the BWM calculation can be proceed.

III. RESEARCH METHODOLOGY

The outline of the research approach used in this study is shown on Figure 1.

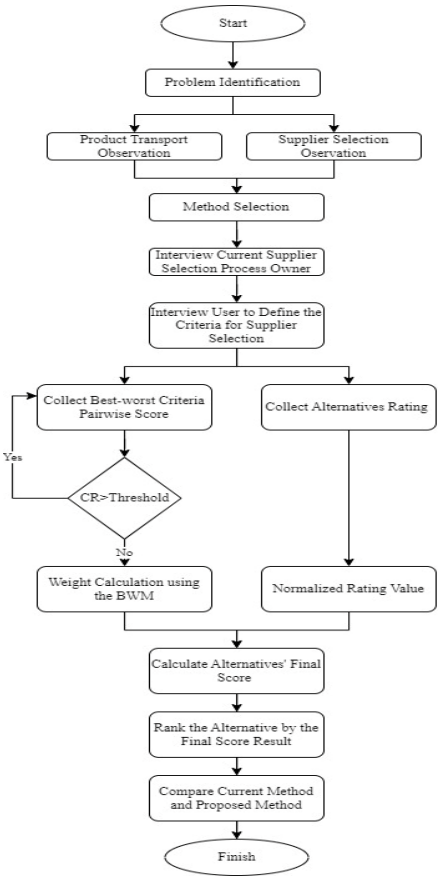

Figure 1. Research Flow

The study is initiated by identify the problem in the supplier selection process for product transportation vendor. The identification can be detailed by conducting the observation both on the product transportation process and the supplier selection process. The observation found that the company is in need to conduct a supplier selection process to the find the best alternatives that suitable with the condition and practice required in the product transport process. Since the supplier selection process in the company has not been updated for a long time, there is an opportunity to update the current procedure by implement a more reliable selection method.

The best-worst method is chosen to be implemented in this study by considering the situation in the pharmacy company which require a time efficient method that can maintain a high level of reliability. Best-worst method as a pair-wise based MCDM method with a fewer pairwise calculation offers a higher consistency and reliability result, also shorter time.

To begin the process of the best-worst method, the study is continued by interviewing both the procurement department as the process owner and the product transportation user. This interview is conducted to determine the set of criteria and also the available alternatives that will be used on the following process.

With the set of criteria is determined, the related person on product transportation and supplier relation will be asked to give their opinion related with the criteria of transportation supplier for the step 2, 3, and 4 of the BWM method. The respondents are from the supply chain supervisor, logistic supervisor, supply and distribution supervisor, logistic specialist, and distribution unit. These 5 respondents are also had daily coordination with the suppliers on previous working relation, therefore they will also be asked to give score for each alternative based on the determined criteria by using an assessment form. The online assessment form had two sections, first as the priority scale assessment for criteria, while the second as the scoring assessment for the suppliers.

The supplier alternatives are the company that already registered as the logistic vendor in PT. XZ. There are PT. GW, PT. YL, and PT. DL. They support the company on various logistic movement such as import and export forwarder. These logistic companies are already known by the global team of PT. XZ as the overall standard is acceptable with the company's requirement. This study will focus to assessed these three companies to select the best one as the product transportation provider.

The assessment result for the priority scale of the criteria will be checked on the consistency check first. When the check is passed, the scale score can be used to find the weight of each criterion as the step 5 in BWM. The average alternative rating score will be multiplied with the weight for each criterion on each alternative to find the final assessment score.

A. Observation on Product Transportation

The goods or product transportation in PT. XZ is the process to move the product from storage location to another location with a specified purpose. Mainly, the

goods transportation is conducted from the 3PL warehouse as the main storage for saleable finished goods, to the distributor's national distribution center warehouse. Besides that, the truck will also have occasional routes from PT. XZ in-site warehouse to the 3PL warehouse, and from the 3PL warehouse to PT. XZ in-site warehouse. The company's requirements from logistic perspective are summarized on the Table II below.

TABLE II. REQUIREMENT ON TRANSPORT PROVIDER

Requirement	Standard
Temperature Control	Able to maintain on 2-25° Celsius
Cleanliness	No smell occurs in the truck on daily delivery
Safety	No physical damage occurs during the delivery process
Availability	Backup fleet with same standards (size, capacity, and cooler) on emergency
Responsive	Supplier able to respond under in the same hour for complaint and feedback
License and legal	Driver and vehicle have valid license and permit to operate
Skill	Familiar to handle pharmaceutical products
Communicative	Actively report and communicate issue

From the quotation and the bidding by these companies this study can summarize the offering of each alternative. The information of the alternatives is presented on the Table III below.

TABLE III. OFFERINGS FROM AVAILABLE ALTERNATIVES

Offering	Logistic Company		
	PT. YL	PT. GW	PT. DL
Dedicated Truck Size	CDD Truck	Fuso Truck	CDD Truck
Monthly Price	IDR 31,000,000	IDR 46,200,000	IDR 31,250,000
Monthly Trip per Price	22 Trip	22 Trip	20 Trip
Add-on Trip Price	IDR 1,200,000/trip	Undetailed	IDR 1,720,850/trip
Tracking System	GPS on fleet	GPS on fleet	GPS on fleet
Back-up Fleet	Available	Undetailed	Undetailed
Insurance Policy	Max. 10 x Single Trip Price	0.15% of shipper invoice value	Max value: Goods value + Total freight charges)*1.1

B. Observation on Current Supplier Selection

From the observation on the supplier selection process and the interview with the procurement department, it is found that the process to select a suitable supplier in PT. XZ already implements a multi-criteria decision-making method by doing simple weighting on the criteria in the scoring assessment phase. The criteria's weight can be adjusted by the procurement or department head. However, the adjustment is conducted by only verbal discussion without any detailed mathematical calculation and detailed scoring. The bidding form itself is a general form that is used by every department when they have a purchasing plan with more than one alternative to choose. The supply and distribution itself as the user in this case, used the bidding form to compare alternatives in 2018 or 5 years ago. The criteria and its weight on the bidding form may already be irrelevant and unreliable in current situations. A more specific scoring assessment could be developed to support a more up to date criteria, weight and rating score that is relevant with current situations and more focused on the product transportation service supplier selection. The summary of current process is presented on Table IV below.

TABLE IV. SUMMARRY OF CURRENT SUPPLIER SELECTION

Current Supplier Selection Process	
Strength	**Weakness**
User's familiarity with the process	Process scope is too general and may not satisfy on some cases
Designed for general selection process	A decision maker is more possible to influence others while assessing the alternatives
Assessment scoring can be done in one time discussion	The criteria used on the assessment form may out of date and irrelevant with the user's preferences
	Limited and very subjective criteria weight determination
	More managerial centric than the user's needs

C. Observation on Supplier Selection Criteria

From the interview and observation with the user, the criteria propose by the user are capability, service, price, responsiveness, personnel skills, and partnership experience. The criteria are taken from the experience of product transportation process and the current supplier results.

1. Capability: Capability is the criterion that evaluate how capable the supplier to conduct the main task required by PT. XZ, which is to transport medicine products. The user expects that the evaluation of the supplier capability will be determined by considering the possible number of standard requirements that can be fulfilled by the supplier. Capability used in previous research of supplier selection by Punniyamoorty *et al.* [7]. Technical capabilities of suppliers have been indicated to have a substantial impact on choosing the suitable supplier from the group of suppliers [7].
2. Service: Service is the criterion for assessing the number of services offered as supporting services for the main service of product transportation. The supporting services can be in the form of the delivery capacity, backup fleet, safety warranty for damaged during the delivery, and any other convenience that the company will received during the service. On the supplier selection for product in previous study, service refers to the after sales, spare parts, or technical support that also arguably is one of the most influenced criteria in supplier selection [7].

3. Price: Price is the criterion that will assess the amount of payment that the company must pay in exchange for the product transportation service offered by the logistic company in a monthly basis. Lower price from the offering for transportation service is more desired by the user. In previous study, financial expenses such as price or cost is commonly used as one of the influenced criteria to determine supplier selection. In this case of study, the expense is more likely as price since the expense will not have any impact to the product's cost.
4. Responsiveness: Responsiveness is the criterion that evaluate how fast the supplier able to response on issues or complaints raised by the user. In the process of product transportation as part of the supply chain, sometimes there are adjustment of delivery plan and scheme. To be able to execute the plan, user need a responsive supplier that can cooperate by responding the idea. In previous study of supplier selection by Yadav and Sharma [8], they use flexibility as the criteria to evaluate the ability to respond to changes. The user prefers to use responsiveness criteria because the ability to respond in this case of the research is also considered the response of complaints that may occur during the transport services [8].
5. Personal skill: Personal skill is the criterion to assess the ability of the trucking crew as the responsible team that transport the product and the client service team as the responsible team that responsible for the service. The evaluation of the abilities will be about the understanding of the instruction in daily delivery plan, understanding the procedure to handle pharmaceutical product, understanding to raise any issue found during the loading, delivery, and unloading process, and the competency to solve issues and problems occurs during the service. In previous supplier selection study, the similar criterion is used by Modibbo *et al.* in 2022 as personnel capabilities which evaluate their skills and experiences [6].
6. Partnership experience: Partnership experience is the criterion that will assess the past partnering experience and how the working relation has been created between the company. This criterion evaluation is expected to prefer the logistic company that have a better partnering experience with the user in the aim to build a long-term relation in the product transportation service. Previous study of supplier selection by Punniyamoorty *et al.* [7] stated that level of trust and understanding can be one of the basic parameters to build a long-term business relationship that can be beneficial in the future [7].
7. Experience in local market1: Experience in local market is the criterion that will evaluate the growing sentiment in local market regarding with the supplier company's reputation in the logistic transportation sector. The user is expected to rate the supplier based on their preferences of familiarity and brand awareness. Previous study of supplier selection by Sharma and Tripathy also used the similar criteria. They used the criteria about the sector experience and reputation to evaluate the potential alternatives [9].

TABLE V. PROPOSED SET OF CRITERIA

Criteria	Explanation	Parameter
Capability (C1)	The evaluation will be determined by looking the possible number of standard requirements that can be fulfilled by the supplier.	Higher score refers to the ability to fulfill more requirement
Service (C2)	The evaluation reflects to the number of offered supporting service by the logistic company	Higher score refers to more supporting services that will be provided by the logistic company
Price (C3)	The evaluation to rate the offered amount of payment with the exchange for the transportation service in monthly basis	Higher score refers to lower price
Responsiveness (C4)	The evaluation to rate how fast the supplier able to response on issues or complaints raised by the user	Higher score refers to the faster response time
Personal skill (C5)	The evaluation to rate the ability of trucking crew and the client service team to understand the instruction, procedure, and competency to rise and solve issues and problems	Higher score refers to more satisfying and preferable personnel competencies of the logistic company
Partnership experience (C6)	The evaluation to rate the past partnering experience and the working relation between the logistic company and the user	Higher score refers to more satisfying and preferable partnering experience and relation
Experience In local market (C7)	The evaluation will be determined by looking the reputation from user preferences of familiarity and brand awareness about the logistic company in transportation sector	Higher score refers to higher reputation known about the logistic company

IV. RESULT AND DISCUSSION

A. BWM Weight Calculation

1. Step 1: Best and worst criteria selection
   The respondents are asked to select their best (most important) and worst (least important) criterion from the given set of criteria. The result is shown on Table VI below.

TABLE VI. SELECTED BEST AND WORST CRITERIA

Respondent	Selected Criteria	
	Best	Worst
Supply and Distribution Supervisor (R1)	Capability (C1)	Personal Skill (C5)
Logistics Specialist (R2)	Capability (C1)	Experience in Local Market (C7)

Logistic Supervisor (R3)	Service (C2)	Experience in Local Market (C7)
Supply Chain Supervisor (R4)	Service (C2)	Partnership Experience (C6)
Supply and Distribution Unit (R5)	Capability (C1)	Personal Skill (C5)

2. Step 2 and 3: The respondents are asked to rate the importance level in pairwise comparison. The pairwise comparison in best-worst method is only compare the best over other criterion and other criterion over the worst. This rating process is also conducted within the questionnaire form in the criteria section. The scoring scale used to rate the pairwise comparison between the criterion will use the scale on Table VII. The best over other criterion pairwise is presented on Table VIII, and other criterion over the worst pairwise is presented on Table IX.

TABLE VII. RATING SCALE FOR CRITERIA PAIRWISE COMPARISON [4]

Importance Rating	Definition
1	**Equal** importance
2	Somewhat between equal and moderate
3	**Moderately more** important
4	Somewhat between moderate and strong
5	**Strongly more** important
6	Somewhat between strong and very strong
7	**Very strongly** important
8	Somewhat between very strong and absolute
9	**Absolutely more** important

TABLE VIII. BEST OVER OTHER IMPORTANCE PAIRWISE

Respondent	Best	Pairwise						
		C1	C2	C3	C4	C5	C6	C7
R1	C1	1	2	6	6	9	7	7
R2	C1	1	2	4	7	8	6	9
R3	C2	2	1	3	2	5	3	9
R4	C2	2	1	3	2	2	9	4
R5	C1	1	2	8	8	9	8	7

TABLE IX. OTHER OVER WORST IMPORTANCE PAIRWISE

Respondent	Worst	Pairwise						
		C1	C2	C3	C4	C5	C6	C7
R1	C5	9	8	5	5	1	3	3
R2	C7	9	8	8	3	2	4	1
R3	C7	6	9	7	7	4	6	1
R4	C6	8	9	7	8	8	1	4
R5	C5	9	8	2	2	1	2	3

3. Step 3: From previous steps, it is known that the criteria used in this study is 7, while the highest scales exist as the importance rate is 9. Therefore, the CR threshold will be used to check the consistency refers to Table I is 0.352. To proceed the assessment result on the next step, the consistency ratio must be below the threshold. Any response's consistency ratio that higher than 0.352 indicates unacceptable consistency and require the respondent to re-fill the assessment form. To calculate the consistency ratio, use the Formula (2).

TABLE X. CONSISTENCY CHECK

Respondent	Consistency Ratio						
	C1	C2	C3	C4	C5	C6	C7
R1	0.000	0.097	0.292	0.292	0.000	0.167	0.167
R2	0.000	0.097	0.319	0.167	0.097	0.208	0.000
R3	0.042	0.000	0.167	0.069	0.153	0.125	0.000
R4	0.097	0.000	0.167	0.097	0.097	0.000	0.097
R5	0.000	0.097	0.097	0.097	0.000	0.097	0.167

The consistency ratio calculation in Table X shows that all of the pairwise importance rated by the respondents are acceptable and below the consistency threshold. With this result, the BWM to generate weight can be proceeded.

4. Step 5: The data collected in Table VIII and Table IX will be used to calculate the criteria weights from each respondent. The formulation of weight calculation in best-worst method will use the equation (1) as the initial calculation. The result of the weight calculation presented on Table XI.

TABLE XI. CRITERIA WEIGHT RESULT FROM EACH RESPONDENTS

Resp.	Weight						
	C1	C2	C3	C4	C5	C6	C7
R1	0.407	0.249	0.083	0.083	0.035	0.071	0.071
R2	0.382	0.248	0.124	0.071	0.062	0.083	0.030
R3	0.181	0.299	0.121	0.181	0.072	0.121	0.026
R4	0.168	0.277	0.112	0.168	0.168	0.024	0.084
R5	0.439	0.255	0.064	0.064	0.041	0.064	0.073

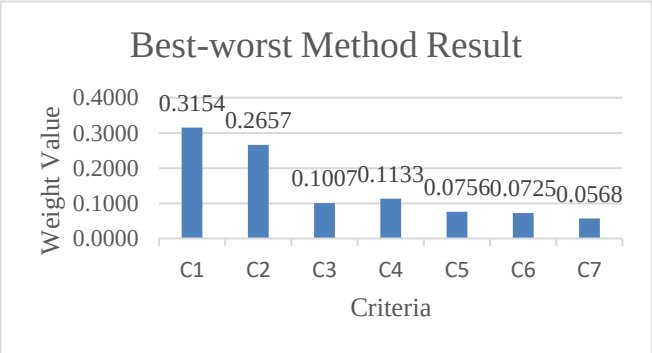

Figure 2. Final Weight Result Using Best-worst Method

B. Alternatives Assessment Scoring

After the weight of criteria has been calculated by using the best-worst method, the respondents are asked to assess the alternatives. The scoring scale preferences are shown on Table XII.

TABLE XII. SCORING SCALE PREFERENCE FOR ALTERNATIVE ASSESSMENT

Scoring	Criteria						
	Capability	**Service**	**Price**	**Responsiveness**	**Personal Skill**	**Partnership Exp**	**Exp in Local Market**
1	The company cannot fulfil the requirement and not possible to fulfil in near future	Less service(s) are offered than others without any significant service offered	>60,000,000 per month	More than one working day response	The ability of the team are low and require many training	Previous partnership was unsatisfying and not prefer to have a long-term relation	The brand is new or uncommon in logistic service and no information about their client
2	The company cannot fulfil the requirement and have possibility to achieve it in the future	Less service(s) are offered than others with one service is more beneficial	56,000,000 until 60,000,000	One working day response	The ability of the team are low and require a few trainings	Previous partnership was unsatisfying and unsure to have a long-term relation	The brand is new or uncommon in logistic service but hired by few companies
3	The company cannot fulfil the requirement but confident to achieve it in the future	Less service(s) are offered than others with several more beneficial services	51,000,000 until 55,000,000	<24 hours response(within same working days)	The ability of the team are low but meet the standard requirements	Previous partnership was unsatisfying but preferred to have a long-term relation	The brand is new or uncommon in logistic service but hired by many companies
4	The company is only able to fulfil several requirements and unsure to able fulfil it in near future	Same amount of service(s) with others are offered without significant difference	46,000,000 until 50,000,000	8 hours until <12 hours response	The ability of the team are adequate and require many training	Previous partnership was adequate but not preferred to have a long-term relation	The brand is known in providing logistic service but no information about their client
5	The company is only able to fulfil several requirements but possibly able to fulfil the remaining in the future	Same amount of service(s) with others are offered with one service is more beneficial	41,000,000 until 45,000,000	5 hours until <8 hours response	The ability of the team are low and require many training	Previous partnership was adequate but unsure to have a long-term relation	The brand is known in providing logistic service and hired by few companies
6	The company is only able to fulfil several requirements and confident to fulfil the remaining requirement in the future	Same amount of service(s) with others are offered with several more beneficial services	36,000,000 until 40,000,000	3 hours until <5 hours response	The ability of the team are low and require a few trainings	Previous partnership was adequate and preferred to have a long-term relation	The brand is known in providing logistic service and hired by many companies
7	The company is experienced in handling pharma product but unsure to fulfil the requirement in near future	More services are offered without any significant difference between the similar service(s)	31,000,000 untill35,000,000	1 hour until <3 hours response	The ability of the team are low but meet the standard requirements	Previous partnership was satisfying but not preferred to have long-term relation	The brand is well known in logistic service but no information known about their client
8	The company is experienced in handling pharma product and possibly able to fulfil the requirement in the future	More services are offered with one of the similar service(s) are more beneficial	26,000,000 until 30,000,000	30 minutes until <1 hour response	The ability of the team are adequate and require many training	Previous partnership was satisfying but unsure to have a long-term relation	The brand is well known in logistic service and hired by few known companies
9	The company is experienced in handling pharma product and confident to fulfil the requirement	More services are offered with similar service(s) are more beneficial	21,000,000 until 25,000,000	<30 minutes response	The ability of the team are low and require many training	Previous partnership was satisfying and preferred to have long-term relation	The brand is well known in logistic service and hired by many companies

The scoring of each alternative by the respondents are presented on Table XIII.

TABLE XIII. ASSESSMENT SCORING RESULT BY RESPONDENT

Resp.	Alt.	Criteria						
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
R1	PT. YL	9	8	7	8	8	9	9
	PT. GW	9	8	4	8	8	9	9
	PT. DL	9	8	7	8	8	8	9
R2	PT. YL	6	7	7	6	4	5	9
	PT. GW	7	8	4	7	7	8	8
	PT. DL	7	6	7	5	6	7	8
R3	PT. YL	7	8	7	6	7	5	6
	PT. GW	7	8	4	7	7	8	7
	PT. DL	7	9	7	8	7	8	8

Resp.	Alt.	Criteria						
		C1	C2	C3	C4	C5	C6	C7
R4	PT. YL	8	9	7	9	8	8	8
	PT. GW	8	7	4	8	8	8	8
	PT. DL	8	8	7	8	8	1	9

After the rating of each alternative over the set of criteria, normalization on the rating score is conducted. Normalization will convert the data into measurable and comparable data. The normalization in this study aims to convert the value of score rating of alternative I over the maximum score on the criterion j for each respondent. The formula to calculate the normalization rating is presented below.

$$p_{ij}^{norm} = \frac{p_{ij}}{p_j^{max}}$$

The normalized rating scores from the calculation on each respondent's preferences for each alternative are presented on Table XIV.

TABLE XIV. NORMALIZED ALTERNATIVES RATING SCORE

Resp	Alt	Criteria						
		C1	C2	C3	C4	C5	C6	C7
R1	PT. YL	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	PT. GW	1.00	1.00	0.57	1.00	1.00	1.00	1.00
	PT. DL	1.00	1.00	1.00	1.00	1.00	0.89	1.00
R2	PT. YL	0.86	0.88	1.00	0.86	0.57	0.63	1.00
	PT. GW	1.00	1.00	0.57	1.00	1.00	1.00	0.89
	PT. DL	1.00	0.75	1.00	0.71	0.86	0.88	0.89
R3	PT. YL	1.00	0.89	1.00	0.75	1.00	0.63	0.75
	PT. GW	1.00	0.89	0.57	0.88	1.00	1.00	0.88
	PT. DL	1.00	1.00	1.00	1.00	1.00	1.00	1.00
R4	PT. YL	1.0	1.00	1.00	1.00	1.00	1.00	0.89
	PT. GW	1.00	0.78	0.57	0.89	1.00	1.00	0.89
	PT. DL	1.00	0.89	1.00	0.89	1.00	0.13	1.00
R5	PT. YL	1.00	1.00	1.00	0.78	0.88	1.00	0.89
	PT. GW	1.00	0.89	0.57	1.00	1.00	1.00	0.89
	PT. DL	1.00	0.78	1.00	1.00	0.88	0.75	1.00

The normalized rating score from all respondents are averaged by using arithmetic mean to find the final rating score. The rating score of each alternative over the criteria are presented on Table XV.

TABLE XV. AVERAGE ALTERNATIVES RATING SCORE

Resp.	Alt.	Criteria						
		C1	C2	C3	C4	C5	C6	C7
R5	PT. YL	8	9	7	7	7	8	8
	PT. GW	8	8	4	9	8	8	8
	PT. DL	8	7	7	9	7	6	9

Alternatives	Criteria						
	C1	C2	C3	C4	C5	C6	C7
PT. YL	0.971	0.953	1.000	0.877	0.889	0.850	0.906
PT. GW	1.000	0.911	0.571	0.953	1.000	1.000	0.908
PT. DL	1.000	0.883	1.000	0.921	0.946	0.728	0.978

The averaged rating score then will be calculated to find the final result of the proposed method. The final calculation is using the formula (2-4) with the normalized p_{ij} (p_{ij}^{norm}). The final score results for the alternatives assessment are presented on Table XVI.

TABLE XVI. PROPOSED METHOD SELECTION RESULT

Alt	Criteria							Final Scoring	Rank
	C1	C2	C3	C4	C5	C6	C7		
PT. YL	0.306	0.253	0.101	0.099	0.067	0.062	0.051	0.940	1
PT. GW	0.315	0.242	0.058	0.108	0.076	0.073	0.052	0.923	3
PT. DL	0.315	0.235	0.101	0.104	0.072	0.053	0.056	0.935	2

From the selection result, it is found that PT. YL is the best alternatives based on the preferences of the respondents that involved in the product transportation supplier selection in PT. XZ with final score 94% preferred. The second most preferred supplier is PT. DL with total score 93.5%. And the third most preferred supplier is PT. GW with 92.3%. With this final result, by using the best-worst method to determine the reliable weight for the set of criteria used in the supplier selection process, PT. XZ should chose PT. YL as the supplier for product transportation vendor.

V. CONCLUSION

The implementation of best-worst method in the selection process can be an improvement to have a reliable and suitable criteria and weights before used it to assess the alternatives. The study has provided the company with new possible method to be implemented within the supplier selection process. Based on the interview and observation within supply and distribution department and the procurement department, this study presents seven criteria for evaluate the potential alternatives of product transportation provider. There

are capability, service, price, responsiveness, personal skill, partnership experience, and experience in local market. The importance level of each criterion will be evaluated by the decision maker and processed using the best-worst method to find the final weight mean from all the respondents.

The result of the criteria weight is the capability criterion as the highest weight with 0.3154. The second highest criterion weight is service with 0.2657, followed by responsiveness with 0.1133, price with 0.1007, personal skill with 0.0756, partnership experience with 0.0725, and experience in local market with 0.0568 as the lowest weight criterion. With the weight determined using the BWM, the rating score for each alternative from the respondents' preferences can be proceed to find the final score value. The final result of the analysis in previous chapter, the capability criterion is the most determining criteria on the supplier selection for product transport service, and the highest rank from the calculation is the second alternative PT. YL.

ACKNOWLEDGEMENT

No funding agencies are supporting this work.

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