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Selecting the Best Broiler Chicken Supplier of PT Sentral Unggas Perkasa Using Analytical Hierarchy Process and Weighted Product Methods

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Abstract. *PT SUP is one of the companies engaged in trading broiler chicken products. Supplying broiler chickens to PT SUP sometimes results in product instability, and some conditions are inadequate; the financing process is not by income or obstacles that occur when serving customers. So this can disappoint the customers of PT SUP. This study aims to select suppliers for 4 out of 6 breeders chosen as the best suppliers and will get a reward from PT SUP to improve the performance and product results of the suppliers. The selection of the best supplier is based on the criteria that have been owned, namely Based on Curriculum Vitae (CV), location of the cage, capital, and service. The six suppliers come from 3 (each city has two suppliers), namely Lumajang, Lamongan, and Kediri. In this study, the author uses the AHP (Analytic Hierarchy Process) method to produce a consistent value of comparison results. It can be continued with the WP (Weighted Product) approach to get the value of the V vector for ranking alternatives. PT SUP will beard the results of the selection of the best four suppliers. The best supplier of PT SUP are Y1, Y4, Y2 dan Y3. Combining these two methods is a form of contribution to the MCDM enrichment.*

Keywords: *Supplier Selection, MCDM, AHP, WP.*

I. INTRODUCTION

The type of poultry farm that continues to multiply is broiler chicken farming because it has many advantages over other chickens and is much in demand by the community. Based on data obtained from the Central Statistics Agency, Indonesia's number of poultry farming companies according to legal entities or businesses from 2016 to 2018 consistently increased by 4% every year (BPS, 2020). Factors that trigger the increasing productivity of broiler chickens are the growing number of urban populations, the increasing level of income at the end, and the high consumer preferences of the community. In addition, the cultivation process is easy and able to create jobs for those around him. Broiler chicken is used meat to be consumed to support the growth of human nutrition. Compared to the type of meat derived from beef or goat, broiler chicken meat is preferred because it has a texture, low f, taste, and aroma is more delicious, so all ages favor it. The price of cheap chicken meat and easy to get anywhere, such as in traditional markets and supermarkets, provides high consumption interest value for the community (Mir et al., 2017). This encourages farmers to continue to increase the number of broiler chicken populations to meet the demand in the market.

On the other hand, the increase in the number of broiler chickens also has risks for farmers if produced in large quantities, such as providing basic production materials for less than the selling price of production so that farmers choose partnership patterns as a solution to the problem (Irnanda Pratiwi & Hermanto MZ, 2018). The partnership pattern is defined as cooperation between two or more mutually beneficial parties. Partnership patterns are business strategies to overcome resource limitations and increase profits for those who carry out partnerships (Clarke & Crane, 2018). In the pattern of alliances, usually, the company helps in the capital, marketing, and management of cultivation,

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provision of seedlings, animal feed, and livestock vaccine to help broiler chicken farmers during the production process. Through partnerships with companies, broiler chicken farmers become the company's suppliers to supply livestock products. This research case study is PT Sentral Unggas Perkasa (PT SUP), a Sidoarjo regional company engaged in trade-in livestock products, namely broiler chickens. The company implements a pattern of Agribusiness Operational Cooperation (AOC) partnerships. The partnership pattern of PT SUP helps provide livestock capital, the cost of raising livestock, and other means to support chicken cultivation. At the same time, farmers provide livestock land and energy to care for livestock and become a supplier of companies to supply broiler chickens.

Supplier is an activity where there are parties who supply resources in the form of raw materials or services to other parties, such as companies or individuals, to be reprocessed. Suppliers have an essential role in providing goods or services to partnered companies. Suppliers support the process of forming the company's quality from the quality of the final product, so the company needs to implement supply chain management within a certain period to get suppliers who have superior product quality. (Sepadyati, 2019).

The selection of the right supplier becomes the most important thing so that the company develops well. The purpose of selecting suppliers is to find suppliers who can provide quality products or services according to the amount and time of demand. In some cases, the company gets a supplier that is not satisfactory both in terms of quality, several products, or services, when suppliers are unable to meet the company's demand resulting in losses, product supply shortages, less effective work systems, and others (LeBaron, 2021). In the case study of PT SUP, some of the problems that have been faced include the legality of the completeness of livestock permits (suppliers) that are no longer valid, in terms of unstable quality in each shipment, and the location of cages that are difficult to reach by large-charged vehicles, and slow service.

The provision of supplier criteria is the key to success in supply activities (Purnomo et al., 2019). The company must have the proper steps in shaping the supply chain, such as through the particular characteristics of the distributed product. Supplier criteria have become a competitive priority for companies (Wieland, 2021). Suppliers cannot meet the company's demand resulting in losses, product supply shortages, less effective work systems, etc. Therefore, periodic evaluation of suppliers is needed to ensure that the results of their suppliers have standards that are by the company's criteria. In this case, PT SUP already has four criteria that are considered to get the best supplier, among others:

Regulatory compliance is the ability of suppliers to meet the company's needs by the company's demands. PT SUP has applied this criterion in determining the best supplier based on Curriculum Vitae (CV).

Quality is the ability of a supplier to ship a product that has high quality. PT SUP has applied this criterion in determining the best supplier based on CV.

Cost is the cost that the company must bear to get the product the company needs. PT SUP has applied this criterion in determining the best supplier based on capital criteria.

Service is the supplier service level that usually consists of delivery time and ease of communication. PT SUP has applied this criterion in determining the best supplier based on service criteria.

Supplier profile is a criterion that includes supplier reputation, flexibility, capacity, financial condition and production, and facilities. PT SUP has applied this criterion in determining the best supplier based on the location of the cage.

PT SUP has 6 suppliers from 3 different cities, namely Lamongan Lumajang City and Kediri City. To activate the performance of its suppliers to be even better, PT SUP will give awards to suppliers who have the best performance. Through this best supplier selection, this supplier is ultimately expected to be able to provide maximum benefits for the company. The best supplier selection will be made based on PT SUP criteria based on CV,

cage location, capital, and service. To help PT SUP choose the best supplier objectively, the author proposed a method with many criteria (MCDM).

MCDM is divided into two models based on the objects used, namely Multiple Criteria Attribute Making (MADM) and Multiple Objective Decision Making (MODM). Several alternatives will be selected in limited quantities in choosing the best suppliers to apply the MADM model (Komsiyah et al., 2019). The use of several features such as alternatives, criteria, weights of interests, and decision matrix on MADM can provide results with an exemplary process of compatibility (Fiarni et al., 2019). There are several settlement methods owned by MADM, such as Simple Additive Weighting Method (SAW), Weighted Product (WP), Electre, Technique For Order Preference By Similarity To Ideal Solution (TOPSIS), and Analytic Hierarchy Process (AHP) (Ataei et al., 2020).

This study uses two (2) MADM methods to select the best suppliers, namely the AHP method and the WP Method. The AHP (Analytic Hierarchy Process) method is a decision-making method using many criteria based on paired comparisons according to the essential standards of the problem. (Saaty, 1987; Yuniarti et al., 2018). The relative weight of the criteria is a component needed when comparing a decision with a specified scale or ratio (Abrahamsen et al., 2020). The use of the AHP method results in criteria and subcriteria that are weights based on the choice of the supplier because the method can solve problems in a complex and hierarchical structure. The AHP method can also evaluate or consider the level of priority importance on each criterion with hierarchy. Still, the AHP method only relies on expert thinking given, so it requires subjectivity from the expert. In addition, if the assessment given by the expert is not precise, the resulting model becomes meaningless (Abdulvahitoglu & Kilic, 2022).

WP (Weight Product) is a method with a multiplication technique for sorting an attribute. Each attribute used is done by lifting weights in the design of its characteristics (Duarte Alonso et al., 2018). The WP method is included in the simple MADM method in determining the preferences of an expert resulting in inconsistent values for a research object. In WP method optimization to provide good results, incorporating other methods can optimize experts' preference value, such as using the AHP method as a preference assessment optimization through calculation of ratio consistency values and index consistency.

The previous research applied the AHP method in selecting significant cargo transport routes from the city of Szczecin to reduce damage to the town (Wolnowska & Konicki, 2019). The choice of electricity suppliers for developing household energy supplier strategies in Poland (Miciuła & Nowakowska-Grunt, 2019). While the WP method is applied to stock selection to determine investments based on the sector to be ranked (Melia, 2016), measurement of employee performance (Aminudin et al., 2018).

In this study, the author was interested in using the AHP and WP methods to solve problems based on Decision-making theory, namely choosing the four best suppliers from 6 breeders, where breeders who have partnered act as a choice.

II. RESEARCH METHOD

The AHP and WP methods were chosen as problem-solving methods because the two methods have primary objectives, namely SPK, to be combined. In this study, the AHP method was used to generate the level of interest in the criteria and subcriteria of each supplier to get the value of each preference weight (Nugroho et al., 2021). Then the WP method is applied to calculate the initial relative weight value to produce a breeder recommendation rating based on the largest to lowest alternative relative preference value. The AHP and WP methods were chosen as problem-solving methods because the two methods have primary objectives, namely SPK, to be combined. In this study, the AHP method was used to generate the level of interest in the criteria and subcriteria of each supplier to get the value of each preference weight. Then the WP method is applied to calculate the initial relative weight value to a breeder

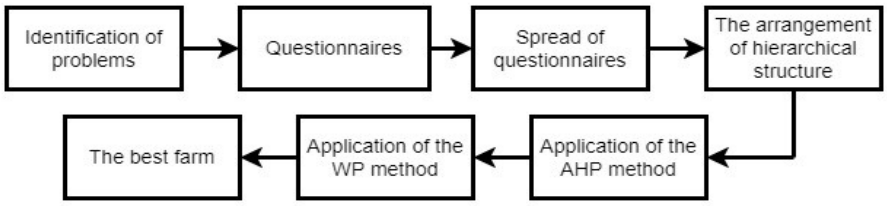

Figure 1. Stages of the best supplier selection

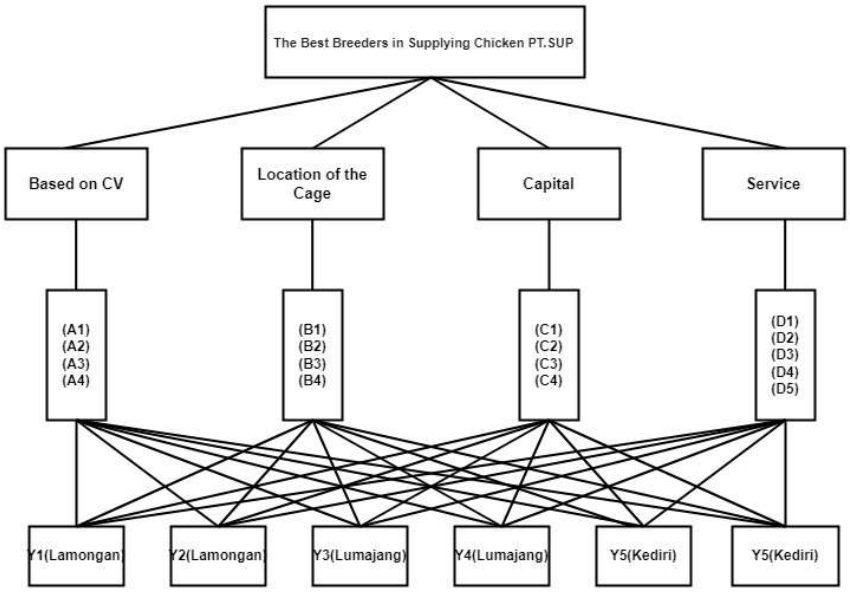

Figure 1. Structural hierarchy of the best supplier selection

recommendation rating based on the largest to lowest alternative relative preference value.

The following are the stages of choosing the best supplier of PT SUP by applying the AHP and WP methods that can be seen in Figure 1.

In Figure 1, several stages must get the best supplier results. Initially identifying the problem, six suppliers will be selected as the best supplier of PT SUP. Selection of the best supplier by evaluating the performance of suppliers using criteria and sub-criteria based on the company's terms and conditions. To get an overview of their performance are given questionnaires to two parties, namely the company (considered an expert) and the supplier (the party that is judged performance). The questionnaire results calculated the validation value by dividing the total score, and the maximum questionnaire score was then multiplied by one hundred percent (100%). The results were obtained from the total questionnaire value of 43, and the top score used by 50, so the validation value (NV) received is 86. Then it can be concluded that the questionnaire that has been formed is worth using without making improvements because the validation value gets a category of 75 ≤100. After the valid questionnaire results, the data process is carried out using AHP and WP. The hierarchy of criteria and sub-criteria in the AHP is shown in Figure 2.

In general, there are four stages of the AHP method (Saaty, 1987):

a. Decomposition is a principle of solving complex problems in a more straightforward form.
b. Comparative judgment is a process of assessment that measures relative importance through several aspects of criteria with other criteria in the levels. Estimate based on the Saaty scale in Table 1 to please compare matrix (Saaty, 1987).

Table 1. Importance Scale (Saaty, 1998)

The intensity of importance scale	Definition
1	Both criteria are equally important.
3	Criteria are slightly more important than other criteria.
5	Criteria are more important than other criteria.
7	Criteria are critical to other standards.
9	Criterion one is critical of the other criteria
2,4,6,8	An intermediate value between the two approaches

Table 2. Random index table

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Through this scale is formed a pairwise matrix comparison $M = [m_{ij}]$ Like equation 1 (Miciuła & Nowakowska-Grunt, 2019).

$$\boldsymbol{M} = \begin{bmatrix} \mathbf{1} & \boldsymbol{m_{12}} & \cdots & \boldsymbol{m_{1n}} \\ \frac{\mathbf{1}}{\boldsymbol{m_{12}}} & \mathbf{1} & \cdots & \boldsymbol{m_{2n}} \\ \cdots & \cdots & \mathbf{1} & \cdots \\ \frac{\mathbf{1}}{\boldsymbol{m_{1n}}} & \frac{\mathbf{1}}{\boldsymbol{m_{2n}}} & \cdots & \mathbf{1} \end{bmatrix} \boldsymbol{m_{ji}} = \mathbf{1}/\boldsymbol{m_{ij}} \quad (1)$$

c. Synthesis of priority is a process for obtaining an eigenvector through normalization of the M paired comparison matrix by dividing between the elements of the ratio matrix in pairs m_ij by the number of columns, then taking the average value for each row and then applying it to equation 2. (Sael et al., 2019).

$$\begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \vdots & \frac{w_n}{w_n} \end{bmatrix} . \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = n . \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \quad (2)$$

d. Local consistency s an assessment of the character of relative importance between one criterion and another that requires λ_{maks}. The priority vector can be obtained by equation 3. Then calculate the Consistency Index (CI) to evaluate the consistency of the comparison matrix; there is a value of n as a matrix measure. Consistency Ratio (CR) to measure the inconsistency value of the paired comparison matrix (Sael et al., 2019).

$$\boldsymbol{M}.\boldsymbol{W} = \boldsymbol{\lambda_{maks}}.\boldsymbol{W} \quad (3)$$

$$\boldsymbol{CI} = \frac{\boldsymbol{\lambda_{max}} - \boldsymbol{n}}{\boldsymbol{n-1}} \quad (4)$$

$$\boldsymbol{CR} = \frac{\boldsymbol{CI}}{\boldsymbol{RI}} \quad (5)$$

Random Index (RI) is a random index value based on the size of a matrix in Table 2. The CR value produced by the comparison matrix is consistent with the CR ≤ 10% or 0.1. If the CR value is still more conditioned, it must be done to form a comparison matrix until it qualifies.

In the application of the WP method, the first step is the determination of the relative value of the initial weight (W_j); there is an initial weight value (W_0) to show the relative importance of each criterion, then normalized using equation 6. The total relative value of the initial weight is $\sum W_j = 1$ (Aminudin et al., 2018).

$$W_j = \frac{W_0}{\sum W_0} \quad (6)$$

Alternative preference value determination S_i (vector S) with the value of the i-criterion against the j-criterion (X_{ij}) given weight to each alternative option using equation 7 (Aminudin et al., 2018).

$$S_i = \prod_{j=1}^{n} X_{ij}{}^{wj} \quad (7)$$

Alternative relative preference determination V_i (vector V) to determine a war. Preference value S_i It is divided by the standard weight of the number of multiplication results per alternate order, such as equation 8 (Aminudin et al., 2018).

$$\boldsymbol{V_i} = \frac{\prod_{j=1}^{n} \boldsymbol{X_{ij}}{}^{\boldsymbol{wj}}}{\prod_{j=1}^{n} \left(\boldsymbol{w_{j^*}}\right)^{\boldsymbol{wj}}} \quad (8)$$

Next, an alternative option is based on the results of vector V calculations by being sorted by the highest values defined as the best alternative to the lowest value defined as the worst alternative. So it was ranked in the top 4 as the best farm that can join as a supplier of broiler chickens PT. SUP.

III. RESULT AND DISCUSSION

Analysis of criteria relationships using AHP

The calculation process of the AHP method begins by forming a matrix of paired comparisons between criteria. Matrix determination is based on the results of respondents' assessment of questionnaires that have been given. Respondents were asked to compare standards with each other and then generate a matrix of paired comparisons.

In comparing pairs according to respondents' criteria, one assesses if the requirements based on the CV are more influential than the service criteria by providing a scale of 5. In contrast, respondent two judged that based on the CV is slightly more important than the service criteria by providing a scale of 3. Then both scales in the average result in a scale value of 4 placed in position (1,4). By the nature of the matrix that is the opposite, the value of the comparison between services and based on the CV is 1/4 or 0.25 entered in the translation position (4,1) more described in Table 3. Comparison pairs of sub-criteria are also treated the same, so it is welcome such as Table 4, Table 5, Table 6, and Table 7.

Table 3. Paired Comparison Matrix between Criteria

Comparison Assessment Based on Level of Interest Criteria				
Criterion	Based on CV	Location of the Cage	Capital	Service
Based on CV	1	3	3	4
Location of the Cage	0.33	1	2	4
Capital	0.33	0.50	1	5
Service	0.25	0.25	0.2	1

Tabel 4. Normalized Matrix Results Sub-Criteria Based on CV

Sub-criteria Interest Level Comparison Assessment Based on CV				
Sub criteria	A1	A2	A3	A4
A1	1	5	3	3
A2	0.2	1	1	3
A3	0.33	1.00	1.00	3
A4	0.33	0.33	0.33	1

Table 5. Normalized Matrix Results Sub-Criteria for Cage Location

Assessment of Interest Level Comparison Sub-criteria for cage location				
Sub criteria	B1	B2	B3	B4
B1	1	2	2	2
B2	0.5	1	1	3
B3	0.5	1	1	4
B4	0.5	0.33	0.25	1

Table 6. Normalized Matrix Results Submodalan Sub-criteria

Assessment of Interest Level Comparison Submodal criteria				
Sub Criteria	C1	C2	C3	C4
C1	1	1	3	3
C2	1	1	3	6
C3	0.33	0.33	1	4
C4	0.33	0.17	0.25	1

Table 7. Normalized Matrix Results Service Sub-criteria

Assessment of Interest Level Comparison Sub-service criteria					
Sub Criteria	D1	D2	D3	D4	D5
D1	1	3	5	5	4
D2	0.33	1	2	3	5
D3	0.20	0.50	1	2	1
D4	0.20	0.33	0.5	1	3
D5	0.25	0.2	1	0.33	1

The next stage gives priority weights obtained through vector Eigen and normalizes the results. The Eigenvector receives a relative weight vector based on CV, Cage Location, Capital, Service in calculations as follows:

$$W_{criteria} = \begin{pmatrix} 0.4865 \\ 0.2501 \\ 0.913 \\ 0.0722 \end{pmatrix}$$

Based on the results of the comparison of pairs, each sub-criterion also obtained a form of priority weight for the criteria based on CV (1), Location of Cage (2), Capital (3), and Service (4).

$$W_{(1)} = \begin{pmatrix} 0.5200 \\ 0.1828 \\ 0.2006 \\ 0.0966 \end{pmatrix} \; W_{(2)} = \begin{pmatrix} 0.3565 \\ 0.2407 \\ 0.2720 \\ 0.1041 \end{pmatrix}$$

$$W_{(3)} = \begin{pmatrix} 0.3618 \\ 0.4154 \\ 0.1742 \\ 0.0739 \end{pmatrix} \; W_{(4)} = \begin{pmatrix} 0.4707 \\ 0.2398 \\ 0.1107 \\ 0.1044 \\ 0.0744 \end{pmatrix}$$

Consistency of comparison matrix

Before calculating the value of CI and CR, a maximum Eigen Value is required (λ_{max}) to relate the comparison of pairs with priority weights. In practice λ_{max} Value is used to construct priority vectors larger than the size of the paired comparison matrix.

Table 8. Priority synthesis

Matrix	λ_{max}	CI	CR
Between criteria	4.2248	0.0749	0.0833
A	4.2654	0.0885	0.0983
B	4.2089	0.0696	0.0774
C	4.2089	0.0620	0.0689
D	5.3779	0.0945	0.0844

The synthesis of the priority of this study is shown in Table 8, where using n = 4. All CR values have qualified < 0.1. Thus, it can be concluded that the comparison matrix of paired criteria has been consistent.

Alternative options

In the WP method, the priority weight criteria that fall into cost or cost will be multiplied by -1. In this study, the requirements included in the cost category are criterion C. Sub-criteria priority vectors containing costs are also multiplied by -1 for sub-criteria C. Alternative preference values are required to fill in the weight of each alternative criterion and sub-criteria based on the performance assessment shown in Table 9.

The following calculation is to find the vector S and vector V as a stage of warfare on available alternatives. Vector S is ranked through an alternative assessment rated by the weight of the criteria to produce, such as table 10 and the results of vector v as shown in Table 11.

Table 11 shows that the alternative Y1, 0.2081, owns the value of vector V in Table 11 of the highest value. In contrast, the lowest value is owned by the alternative option Y5, which is 0.1894, so the first supplier is given to the alternative Y1, the second supplier is given to the alternative Y4, the third supplier is given to the alternative Y2, the fourth supplier is shown on the alternative Y3, The fifth supplier is given to the Y6 alternative, and the sixth supplier is given to the Y5 option.

Analysis of research discussions

The results of selecting the best supplier using the AHP method followed by the WP method have been presented in Table 11. The experts respond that the results are also by the

Table 9. Alternative performance assessment of options

Alternative Performance Assessment						
C/S	Y1	Y2	Y3	Y4	Y5	Y6
Based on CV	4.3	3.7	3.7	4.3	3.3	3.7
Location of the Cage	4.3	4.0	4.0	4.0	4.0	4.0
Capital	2.7	2.7	3.3	3.7	3.3	3.3
Service	3.7	3.7	3.3	4.0	3.0	3.0
A1	4.3	4.3	4.3	4.3	3.7	3.0
A2	4.7	4.3	3.7	4.3	3.0	3.7
A3	4.0	4.3	3.7	4.7	3.3	4.3
A4	3.3	4.3	3.7	4.3	4.3	4.3
B1	4.0	4.0	3.7	3.7	3.7	4.3
B2	3.7	3.3	4.0	4.0	4.0	4.0
B3	3.7	3.3	3.3	3.3	3.3	4.0
B4	4.7	3.7	3.7	3.0	4.0	2.7
C1	4.7	3.3	3.7	3.3	4.0	3.3
C2	4.7	3.7	2.7	3.7	4.0	4.3
C3	4.0	3.7	4.0	4.0	4.0	4.0
C4	3.7	3.3	4.0	3.3	3.3	3.3
D1	3.7	4.3	4.0	3.7	3.3	3.3
D2	4.7	3.7	3.3	3.0	3.7	2.7
D3	3.7	3.0	3.3	3.3	3.0	3.3
D4	3.7	2.3	2.7	3.7	3.7	4.3
D5	3.7	3.3	2.7	4.0	2.7	3.0

Table 10. Vector V of Each Alternative

Criteria	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**
Based on CV	2.0408	1.8815	1.8815	2.0408	1.7962	1.8815
Location of the Cage	1.4430	1.4144	1.4144	1.4144	1.4144	1.4144
Capital	0.8289	0.8289	0.7943	0.7800	0.7943	0.7943
Service	1.0983	1.0983	1.0908	1.1052	1.0825	1.0825

conditions on the ground through the results obtained. Alternative Y1 has the highest assessment of each criterion and sub-criteria given by experts, making alternative one the most superior to others. Alternative Y4 excels in standards based on CV and has a sound service system compared to other breeders. Alternative Y2 excels in the criteria of a good cage location so that it is easy to be reached by the transportation of broiler chicken unemployed. Alternative Y6 excels in terms of experience because it has previously established a partnership with PT. Tama Santuso stars. Alternative Y5 is a reasonably new farm but already has more adequate facilities than alternative six, which was established first.

Table 11. Vector V of Each Alternative

Alternatives	Vector V
Y1	0.2081
Y4	0.2038
Y2	0.2018
Y3	0.1969
Y6	0.1930
Y5	0.1894

IV. CONCLUSION

The best supplier of PT SUP using the AHP and WP method obtained the four highest vector values from alternative options, namely 0.2081; 0,2038; 0,2018; 0.1969. It can be concluded that four alternative options have been mentioned to be the four best breeders from 6 other breeders will be awarded by PT SUP; the farm is owned by Y1, Y4, Y2, and Y3.

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