Analysis of Coding Machine Purchase Decisions Using the Analytical Hierarchy Process (AHP) Method

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ABSTRACT

The increasing public awareness of taking medicines, especially during the COVID-19 pandemic, has made the pharmaceutical industry grow very rapidly. Therefore, the company is trying to increase its production, so it needs to add a coding machine. The choice of machine has a long-term impact because it will be used to assist the production process in the next few years, so it is necessary to use a method that is able to solve problems involving the consideration of company leaders, namely the Analytical Hierarchy Process (AHP) method. The order of priority of the coding machine selection criteria is the ability to print codes (33.6%), maintenance and repair costs (29.6%), the convenience of spare parts, solvents or make-up. and ink (16.2%), price (12.5%), and ease of use (8.1%). Based on the respondent's questionnaire, the order of the best alternative coding machines is Supplier A at 49.12%, Supplier B at 27.28%, and last Supplier C at 23.60%.

1. INTRODUCTION

The increase in public awareness in consuming medicines, especially during the COVID-19 pandemic, has made the growth of the pharmaceutical industry in Indonesia develop very rapidly, so that it can contribute to the 4th national economy. During the COVID-19 pandemic in 2020, the pharmaceutical industry contributed 0.17 % of the Indonesian economy (DPR RI expertise body, 2021). Meanwhile, in the first quarter of 2021 IKFT grew positively by 11.46% and contributed 2.01% to the Indonesian economy (Industri & Hulu, 2021). Therefore, Indonesia needs to increase the production of high-quality medicines to improve the level of public health, which is an indicator of the welfare of a country's population.

PT XYZ is one of the pharmaceutical industries that is aware of the high demand for pharmaceutical products. Therefore, the company is trying to increase its production so that it requires the addition of several production machines, one of which is a coding machine.

The choice of this machine will have a long-term impact on the company itself, because it will be used to assist the production process in the next few years. Therefore, an appropriate decision making model is needed, namely the Analytical Hierarchy Process (AHP) method. According to Saaty in (Fahrozi, 2016) Analytical Hierarchy Process (AHP) is a measurement using pairwise comparisons of expert assessments to obtain choice weights. So that the use of the AHP method can accommodate the opinions of experts in the company to get the best decisions.

The use of the Analytical Hierarchy Process (AHP) method already exists in several decision-making studies such as creating a system for determining used cars in Gemilang Mobil showrooms (Saputra & Kusuma, 2020), choosing maintenance strategies in Indonesian Shipyards (Vito & Perdana, 2016), measuring quality and brand as an influencing intangible factor determining the price of laundry services (Hapsari, 2018), choosing alternative solutions to improve the quality of electrical cable products at the PT Ewindo 1 Bandung Factory (Kartaman & Rahmawati, 2018), decision making in choosing a school (Narti et al., 2019), assessing landslide hazards in India's National Highway 5 (Panchal & Shrivastava, 2022), development of protocols for Malaysia's Important Crop Areas (Hamidah et al., 2022), plastic waste management (Balwada et al., 2021), identification of security risks and prioritization of forest logging activities (Unver & Ergenc, 2021), and an assessment of mineralization potential in the Ilesha Schist Belt of Nigeria (Akinlalu et al., 2021).

Of all the research that has been carried out, none of it involved a coding machine, apart from that, several studies used the Analytical Hierarchy Process (AHP) method as the basis for developing decision support systems.

2. LITERATURE REVIEW

2.1. Coding Machine

A coding machine is a tool to make it easier and faster to provide codes such as production codes, batch numbers, barcodes, qrcodes, expiry dates, manufacturing dates and so on, so that they can help improve the production process many times over. The materials that can be printed by this coding machine are product packaging in the form of aluminum foil, paper, plastic, leather and others (Perbawani et al., 2018). The use of this coding machine can be adjusted to your wishes because it can print many symbols, letters and numbers. The coding machine can output ink continuously with excellent accuracy and speed

2.2. Analytical Hierarchy Process (AHP)

AHP is a decision-making method designed to solve complex problems involving qualitative criteria, especially through pairwise comparisons of experts to obtain priority values (Putra, 2019). AHP was first introduced by Thomas Saaty (1980) as a tool for defining decision making that takes into account qualitative aspects, namely data collection that is easy to obtain and quantitative aspects are very systematic calculations (Vito & Perdana, 2016). According to Saaty in (Kartaman & Rahmawati, 2018), decision making in the AHP method is based on the main principles, namely:

1. Arranging a Hierarchy

   Arranging a hierarchy is a step to identifying complex problems in more detail. The terms used in the AHP hierarchy are as follows: Objectives, Criteria, Subcriteria and Alternatives.

2. Priority Determination

   The priority of criteria elements can be considered as the weight or contribution of these factors to the decision making objective. Determining priorities is done by pairwise comparison of 2 elements so that all elements are included and depend on the opinions of decision-making experts, which is done directly (discussion) and indirectly (questionnaire).

3. Logical Consistency

   The consistency of responses from respondents in determining the priority scale for each element determines the validity of the data and the results of decision making. In general, respondents must be consistent in comparing one item with another.

3. METHOD

3.1. Application of the Analytical Hierarchy Process (AHP) Method

According to Kusrini in (Syamiruddin, 2014), in processing and analyzing data using AHP, the following steps are required:

1. Defining the problem and determining the desired solution, then establishing a hierarchy of problems faced.

   Developing a hierarchy begins with establishing system goals. The next level includes the criteria that are taken into account when evaluating the lower level, namely the available alternatives. Here's an example:

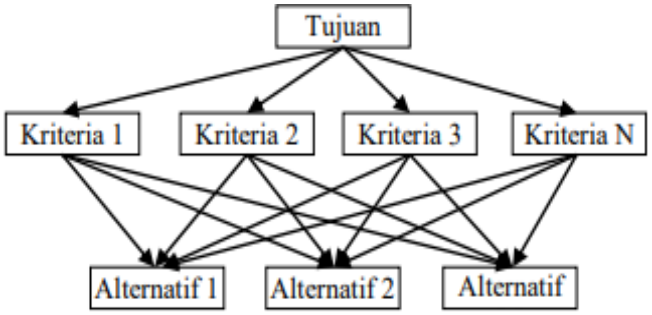

Fig 1. Example of Hierarchy in Analytical Hierarchy Process (AHP)

2. Determines element priority

a. Create a pairwise comparison matrix

b. The matrix contains numbers to represent the importance of one item relative to other items. The significance value of the comparison scale can be measured using the following table:

Table 1. Paired Comparison Rating Scale

Intensity of Interest	Information
1	Both elements are equally important
3	One element is slightly more important than the other elements
5	One element is more important than the other elements
7	One element is clearly more important than the other elements
9	One element is absolutely more important than the other elements
2,4,6,8	The values between two adjacent consideration values
The opposite	If activity i gets one point compared to activity j, then j has the opposite value compared to i.

Source: (Syamiruddin, 2014)

3. Synthesis

Evaluation of the pairwise comparison matrix is synthesized to obtain a priority scale, with the following steps:

a. Add up the values in each column of the matrix

b. Divide the value of each column by the number of respective columns to get a normalized matrix

c. Add up the values in each row and divide by the total elements to get the average value.

4. Measuring Consistency

a. Multiply each value in the first column by the relative priority of the first item, and so on

b. Add up the values for each row

c. The resulting number of rows is divided by the corresponding priority element

d. Add the above points to the number of elements, the result is called lambda max (λ max)

5. Calculate the Consistency Index (CI) using the formula:

$$CI = \frac{(\lambda max - n)}{n-1}$$

Where n : number of elements

6. Calculate the Consistency Ratio (CR) with the formula:

$$CR = \frac{CI}{IR}$$

Where :

CR : *Consistency Ratio*

CI : *Consistency Index*

IR : *Index Random Consistency*

7. Check Hierarchy Consistency

If the consistency ratio (CR) value is ≥ 0.1 or greater than 10%, then the assessment must be corrected. However, if the value is ≤ 0.1 or less than 10%, then the calculation results are said to be correct. The following table is a list of IR (Random Consistency Index):

Table 2. List of Random Consistency Indexes

Matrix Size	Mark IR
1,2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48
13	1.56
14	1.57
15	1.59

4. RESULTS AND DISCUSSION

After the required datacollected, the next step is to process the data according to the AHP method steps to get the best alternative coding machine.

4.1. Determining the AHP Hierarchy Structure

The AHP hierarchy consists of 3 parts, namely:

1. Objective
2. Criteria
3. Alternatives

The hierarchy forms a picture like the following:

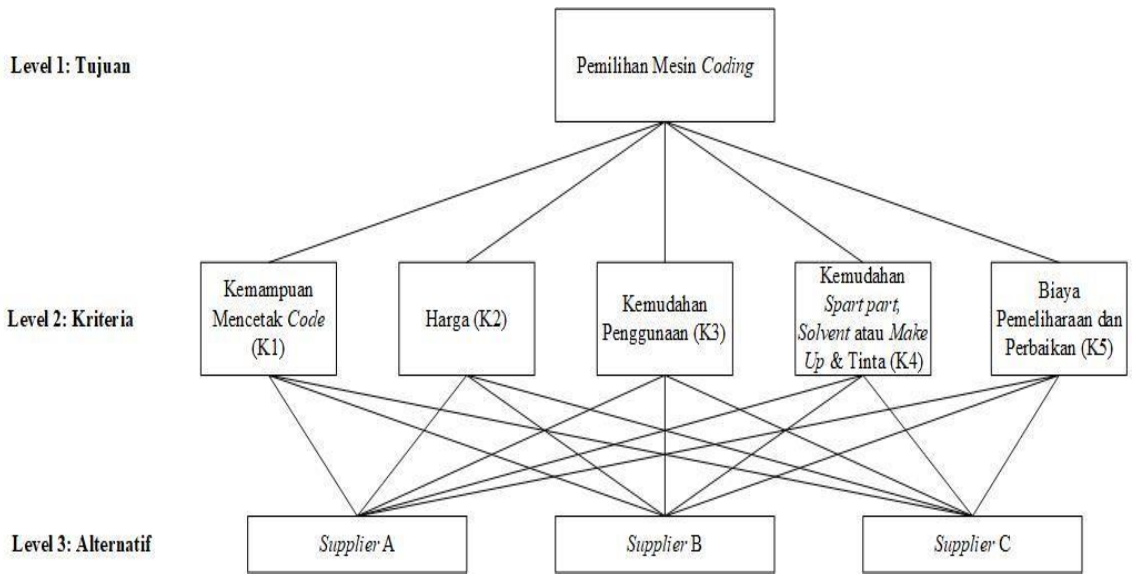

Fig 2. Hierarchy of AHP Coding Engines

4.2. Perform Criteria Comparison Scores

To obtain comparison scores between criteria, questionnaires were distributed to operators, supervisors and managers and in the Black Packaging department at PT. XYZ with assessments

according to the Pairwise Comparison Assessment Scale then the data is combined with the geometric mean. The results are then displayed in a matrix table and compared with the five criteria above:

Table 3. Criteria Comparison Score

Criteria	K1	K2	K3	K4	K5
K1	1.00	4.16	4.16	1.59	1.00
K2	0.24	1.00	1.82	0.63	0.63
K3	0.24	0.55	1.00	0.69	0.23
K4	0.63	1.59	1.44	1.00	0.50
K5	1.00	1.59	4.38	2.00	1.00
Total	**3.11**	**8.89**	**12.80**	**5.91**	**3.36**

4.3. Criteria Calculation

Table 4. Criteria Priority Table

Criteria	K1	K2	K3	K4	K5	Total	Priority
K1	0.32	0.47	0.33	0.27	0.30	1.68	0.336
K2	0.08	0.11	0.14	0.11	0.19	0.63	0.125
K3	0.08	0.06	0.08	0.12	0.07	0.40	0.081
K4	0.20	0.18	0.11	0.17	0.15	0.81	0.162
K5	0.32	0.18	0.34	0.34	0.30	1.48	0.296
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**5.00**	**1.00**

If the total criterion value = 1 then the calculation is said to be correct. According to the table, the priority order for each criterion is starting with the criteria: Ability to print code (K1), Maintenance and repair costs (K5), Ease of spare parts, solvent or make-up & ink (K4), Price (K2) and Ease of use (K3).

Table 5. Table Eigen Value and Lamda Max (λ) Criteria

Criteria	Total	Priority	*Eigenvalues*
K1	3.11	0.336	1,046
K2	8.89	0.125	1,112
K3	12.80	0.081	1,031
K4	5.91	0.162	0.960
K5	3.36	0.296	0.993
Lamda (λ) max			**5.1417**

Consistency Index (CI) Criteria

$$CI = \frac{(\lambda max - n)}{n-1}$$

$$CI = \frac{5.1417-5}{5-1}$$

$$CI = 0.0354$$

Consistency Ratio (CR) Criteria

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0.0354}{1.12} = 0.0316$$

From the calculation above, the Consistency Ratio (CR) result is $0.0316 \leq 0.1$, so the result is the calculation is said to be correct.

The following is a graph of the coding machine criteria assessment:

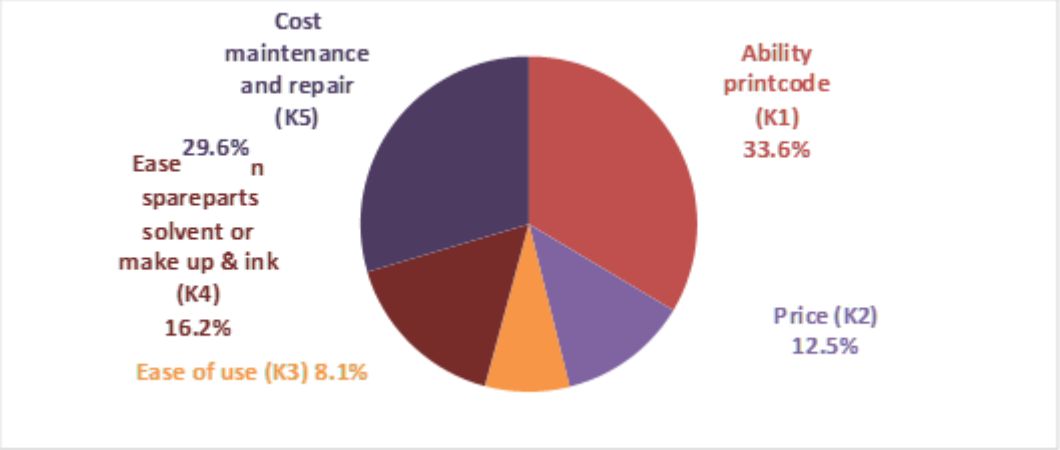

Fig 3. Coding Engine Criteria Assessment Chart

4.4. Alternative Calculation for Code Printability Criteria (K1)

Table 6. Alternative Priority Table for Q1

Alternative	*Suppliers* A	*Suppliers* B	*Suppliers* C	Total	Priority
***Suppliers* A**	0.69	0.70	0.67	2.06	0.69
***Suppliers* B**	0.19	0.19	0.21	0.59	0.20
***Suppliers* C**	0.12	0.11	0.12	0.34	0.11
Total	**1.00**	**1.00**	**1.00**	**3.00**	**1.00**

If the total criterion value = 1 then the calculation is said to be correct. According to the table, the priority order for the Ability to print code (K1) criteria is Supplier A, Supplier B and Supplier C.

Table 7. Eigen Value and Lamda Mac (λ max) Table for K1

Alternative	Total	Priority	*Eigenvalues*
***Suppliers* A**	0.996	0.69	0.996
***Suppliers* B**	1,027	0.20	1,027
***Suppliers* C**	0.980	0.11	0.980
***Lamda* (λ) max**			**3.0032**

Consistency Index (CI) for Code Print Ability Criteria (K1)

$$CI = \frac{(\lambda max - n)}{n-1}$$

$$CI = \frac{3.0032-3}{3-1}$$

$$CI = 0.0016$$

Consistency Ratio (CR) for Code Print Ability Criteria (K1)

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0.0016}{0.58} = 0.0028$$

From the above calculations, the results obtained are Consistency Ratio (CR) 0.0028 ≤ 0.1, so the results the calculation is said to be correct.

4.5. Alternative Calculations for Price Kriteria (K2)

Table 8. Alternative Priority Table for K2

Alternative	***Suppliers* A**	***Suppliers* B**	***Suppliers* C**	**Total**	**Priority**
***Suppliers* A**	0.26	0.25	0.30	0.81	0.27
***Suppliers* B**	0.50	0.46	0.43	1.39	0.46
***Suppliers* C**	0.24	0.29	0.27	0.80	0.27
Total	**1.00**	**1.00**	**1.00**	**3.00**	**1.00**

If the total criterion value = 1 then the calculation is said to be correct. According to the table, the priority order for Price criteria (K2) is Supplier B, then Supplier C and Supplier A.

Table 9. Eigen Value and Lamda Max (λ max) Table for K2

Alternative	Total	Priority	*Eigenvalues*
***Suppliers* A**	3.79	0.27	1,021
***Suppliers* B**	2.16	0.46	1,001
***Suppliers* C**	3.69	0.27	0.986
***Lamda* (λ) max**			**3.0085**

Consistency Index (CI) for Price Criteria (K2)

$$CI = \frac{(\lambda max - n)}{n-1}$$

$$CI = \frac{3.0085-3}{3-1}$$

$$CI = 0.0042$$

Consistency Ratio (CR) for Price Criteria (K2)

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0.0042}{0.58} = 0.0073$$

From the calculation above, the Consistency Ratio (CR) is 0.0073 ≤ 0.1, so the calculation results said to be true.

4.6. Alternative Calculations for Ease of Use (K3) Criteria

Table 10. Alternative Prioriity Table for K3

Alternative	***Suppliers* A**	***Suppliers* B**	***Suppliers* C**	**Total**	**Priority**
***Suppliers* A**	0.69	0.67	0.71	2.07	0.69
***Suppliers* B**	0.17	0.17	0.14	0.48	0.16
***Suppliers* C**	0.14	0.17	0.14	0.45	0.15
Total	**1.00**	**1.00**	**1.00**	**3.00**	**1.00**

If the total criterion value = 1 then the calculation is said to be correct. According to the table, the priority order for the Ease of Use (K3) criteria is Supplier A, Supplier B and Supplier C.

Table 11. Eigen Value and Lamda Max (λ max) Table fo K3

Alternative	Total	Priority	*Eigenvalues*
***Suppliers* A**	1.45	0.69	1,001
***Suppliers* B**	6.00	0.16	0.966
***Suppliers* C**	6.93	0.15	1,041
***Lamda* (λ) max**			**3.0077**

Consistency Index (CI) for Ease of Use Criteria (K3)

$$CI = \frac{(\lambda max - n)}{n-1}$$

$$CI = \frac{3.0077-3}{3-1}$$

$$CI = 0.0038$$

Consistency Ratio (CR) for Ease of Use Criteria (K3)

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0.0038}{0.58} = 0.0066$$

From the calculation above, the Consistency Ratio (CR) results are 0.0066 ≤ 0.1, so the results the calculation is said to be correct.

4.7. Alternative Calculations for Convience Criteria for Spare Parts, Solvent of Make-Up and Ink (K4)

Table 12. Alternative Priority Table fo Q4

Alternative	*Suppliers* A	*Suppliers* B	*Suppliers* C	Total	Priority
***Suppliers* A**	0.58	0.63	0.55	1.76	0.59
***Suppliers* B**	0.14	0.15	0.18	0.47	0.16
***Suppliers* C**	0.28	0.22	0.27	0.76	0.25
Total	**1.00**	**1.00**	**1.00**	**3.00**	**1.00**

If the total criterion value = 1 then the calculation is said to be correct. According to the table, the priority order for the criteria for ease of spare parts, solvent or make-up & ink (K4) is Supplier A, Supplier C and Supplier B.

Table 13. Eigen Value and Lamda Max (λ max) Table for K4

Alternative	Total	Priority	*Eigenvalues*
***Suppliers* A**	1.72	0.59	1,011
***Suppliers* B**	6.60	0.16	1,045
***Suppliers* C**	3.77	0.25	0.959
***Lamda* (λ) max**			**3.0156**

Consistency Index (CI) for Ease of Spare Parts, Solvent or Make-Up & Ink (K4)

$$CI = \frac{(\lambda max - n)}{n-1}$$

$$CI = \frac{3.0156-3}{3-1}$$

$$CI = 0.0080$$

Consistency Ratio (CR) for Ease of Spare Parts, Solvent or Make-Up & Ink (K4)

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0.0080}{0.58} = 0.0130$$

From the above calculations, the results obtained are Consistency Ratio (CR) 0.0130 ≤ 0.1, so the results the calculation is said to be correct.

4.8. Alternative Calculation for Maintenance and Repair Cost Criteria (K5)

Table 14. Alternative Priority Table for K5

Alternative	***Suppliers* A**	***Suppliers* B**	***Suppliers* C**	**Total**	**Priority**
***Suppliers* A**	0.25	0.20	0.32	0.77	0.26
***Suppliers* B**	0.45	0.36	0.30	1.11	0.37
***Suppliers* C**	0.30	0.45	0.38	1.12	0.37
Total	**1.00**	**1.00**	**1.00**	**3.00**	**1.00**

If the total criterion value = 1 then the calculation is said to be correct. According to the table, the priority order for maintenance and repair costs (K5) criteria is Supplier B and Supplier C, then Supplier A.

Table 15. Eigen Value and Lamda Max (λ max) table for K5

Alternative	Total	Priority	*Eigenvalues*
***Suppliers* A**	4.00	0.26	1,021
***Suppliers* B**	2.81	0.37	1,041
***Suppliers* C**	2.64	0.37	0.988
***Lamda* (λ) max**			**3.0497**

Consistency Index (CI) for Maintenance and Repair Cost (K5)

$$CI = \frac{(\lambda max - n)}{n-1}$$

$$CI = \frac{3.0497-3}{3-1}$$

$$CI = 0.0250$$

Consistency Ratio (CR) for Maintenance and Repair Cost (K5)

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0.0250}{0.58} = 0.0430$$

From the calculation above, the Consistency Ratio (CR) results are 0.0430 ≤ 0.1, so the results the calculation is said to be correct.

4.9. Alternative Ranking

The following shows the complete hierarchy with pre-calculated priority weights:

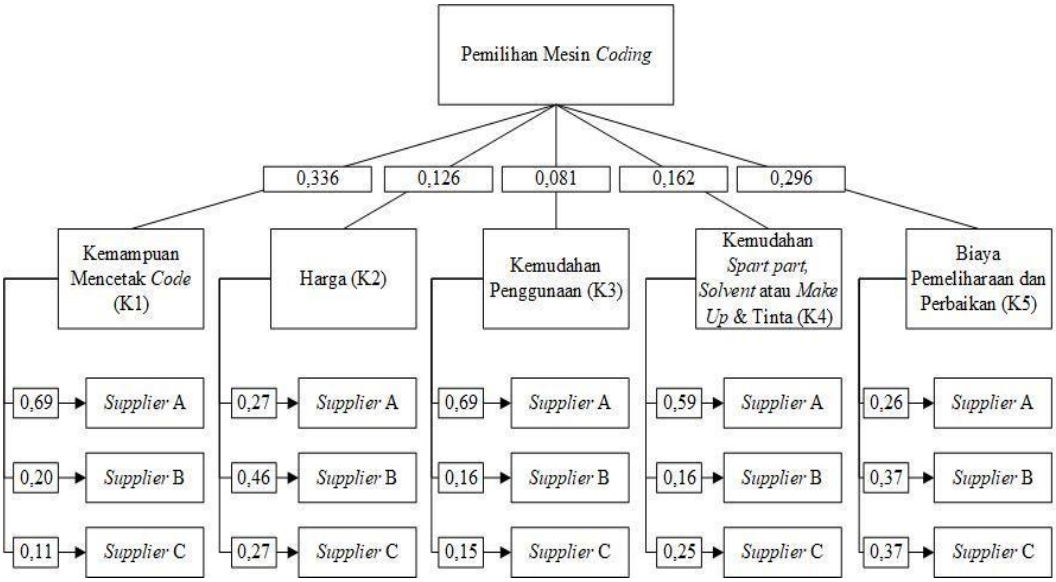

Fig 4. AHP Hierarchy of Coding Engine Ranking

Table 16. Priority Weight Table for Each Alternative

Alternative	K1 Priority	K2 Priority	K3 Priority	K4 Priority	K5 Priority
***Suppliers* A**	0.69	0.27	0.69	0.59	0.26
***Suppliers* B**	0.20	0.46	0.16	0.16	0.37
***Suppliers* C**	0.11	0.27	0.15	0.25	0.37

Table 17. Coding Engine Alternative Ranking Table

Alternative	K1	K2	K3	K4	K5	Total	Ranking
***Suppliers* A**	0.231	0.034	0.056	0.095	0.076	49.12%	1
***Suppliers* B**	0.067	0.058	0.013	0.026	0.110	27.28%	2
***Suppliers* C**	0.038	0.033	0.012	0.041	0.111	23.60%	3

From the AHP calculations, it can be concluded that the best alternative coding machine is Supplier A with a priority weight of 49.12%, then Supplier B with a weight of 27.28% and finally Supplier C with a weight of 23.60%. The following is a graph of the criteria weights for each alternative:

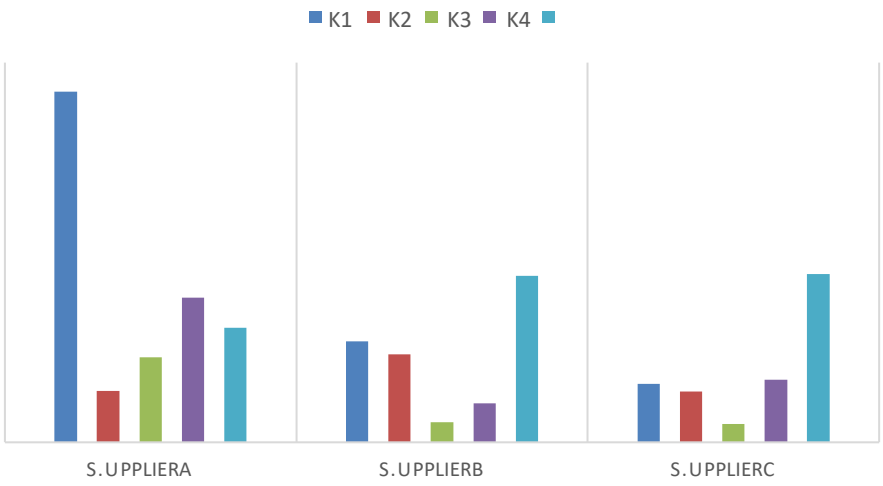

Fig 5. Alternative Criteria Weight

5. CONCLUSION

Based on data processing and calculations, the coding machine selection method uses AHP at PT. XYZ can be concluded:

1. Priority order of criteria in selectioncoding machine, starting with the criteria: Ability to print code (K1) with weight (33.6%), Maintenance and repair costs (K5) with weight (29.6%), Ease of spare parts, solvent or make-up & ink (K4) with weight (16.2%), Price (K2) with weight (12.5%) and Ease of use (K3) with weight (8.1%).
2. The alternative ranking order based on the respondent's questionnaire that has been calculated is first place, namely Supplier A with a total priority weight of 49.12% with Ability to print codes (K1) (0.231), Price (K2) (0.034), Ease of use (K3) (0.056) , Convenience of spare parts, solvent or make-up & ink (K4) (0.095) and maintenance and repair costs (K5) (0.076). Second place is Supplier B with a total priority weight of 27.28% with ability to print code (K1) (0.067), price (K2) (0.058), ease of use (K3) (0.013), ease of spare parts, solvent or make-up & ink (K4) (0.026) and Maintenance and repair costs (K5) (0.110). While the last place is Supplier C with a priority weight of 23.60% with the ability to print code (K1) (0.038), Price (K2) (0.033), Ease of use (K3) (0.012), Ease of spare parts, solvent or make-up & ink (K4) (0.041) and Maintenance and repair costs (K5) (0.111).

Acknowledgment

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g.” Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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