Multi Criteria Supplier Selection Rapid Diagnostic Test Antigen (RDT-Ag) Test Kit Using AHP TOPSIS Methods (A Case Study in "X" Laboratory)

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Abstract

Covid-19 pandemic has caused an increasing burden on the health system and an economic crisis. The Indonesian government has made a policy through the Decree of the Minister of Health of the Republic of Indonesia Number HK.01.07/MENKES/446/2021 regarding the use of rapid diagnostic test antigen (RDT-Ag) in the examination of Covid-19. This regulation stipulates that the use of RDT-Ag is one of the Covid-19 screening methods for contacts tracking, diagnostic enforcement and examinations under certain conditions. The supplier selection of this multi-criteria RDT-Ag test kit was carried out at the "x" laboratory. Laboratory "x" only uses the tender method, it only reviews the criteria, quality, and legality in the evaluation process for selecting RDT-Ag test kit suppliers. therefore, improvements are needed in evaluating supplier selection with multiple criteria (adding criteria/sub-criteria), the more criteria and sub-criteria used in the supplier selection process will provide a more objective supplier ranking. The main challenge in supplier selection is to formulate appropriate criteria. This research integrates the approach using the Analytical hierarchy process (AHP) and Technique for other references by similarity to ideal solution (TOPSIS). The AHP method is used to weight each criterion and sub-criteria, while the TOPSIS method is used to determine the suppliers rangking. This study uses 7 criteria and 16 sub-criteria; the criteria used are price, quality, delivery, supplier profile, flexibility, service and warranty. The weight of the three highest criteria are the supplier profile (0.434), quality (0.181) and price (0.142), with three highest supplier rangking are supplier 2 (0.664), supplier 8 (0.648) and supplier 1 (0.620).

Keywords:
Supplier selection, Covid-19, RDT-Ag test kit, AHP, TOPSIS

1. Introduction

The Covid-19 pandemic has caused an increasing burden on the health system and an economic crisis. Efforts are being made to reduce the increase in the rate of spread of Covid-19, including limiting travel, maintaining distance, prohibiting many people in one place, using personal protective equipment (PPE) such as masks (Malmir and Zobel 2021). Indonesian government follows three standards issued by WHO to reduce the spread rates of Covid-19. The first criterion is epidemiology, or the effective reproduction rate (Rt) with an Rt value of < 1 for two consecutive week, The second criterion is the ratio of the number of hospital beds used for treatment to the number of cases requiring treatment must be > 1.2, the third criterion is surveillance, namely the number of people who test for Covid-19 per 1 million population is ≥ 3500 and WHO recommends carrying out weekly tests of 1 person out of every 1000 people, therefore Indonesia is projected to conduct atleast 270 thousand tests for Covid-19 per week (Muhyiddin 2020). The Indonesian government has made a policy through the Decree of the Minister of Health of the Republic of Indonesia Number HK.01.07/MENKES/446/2021 regarding the use of rapid diagnostic test antigen (RDT-Ag) in the examination of Covid-19. This regulation stipulates that RDT-Ag is one of the methods in the Covid-19 examination for contact tracking, diagnostic enforcement, and Covid-19 screening under certain conditions. On July 14, 2021, the Indonesian Republic experienced a very significant increase in Covid-19 cases, with a total of 54,517 cases per day. This is due to the spread of the new Covid-19 variant, namely the Delta variant (B.1.617.2). The Delta variant (B.1.617.2) was 60% more infectious than the Alpha variant (B.1.1.7) (Thye et al.2021). The Indonesian government's effort to deal with the Delta variant of Covid-19 (B.1.617.2) or the second wave is to reduce the price of Covid-19 inspections, one of which is the Covid-19 examination using RDT-Ag. The policy to reduce Covid-19 examinations with RDT-Ag was conveyed through Circular Letter Number HK 02.02/1/3065/2021 regarding the maximum price limit for RDT-Ag examinations as of September 1, 2021. This Circular is issued by the Ministry of Health of the Republic of Indonesia. The hope is that the decrease in the price of the Covid-19 examination will increase the awareness and enthusiasm of the Indonesian population to carry out the Covid-19 test independently so that national Covid-19 tests will increase and simplify the contact tracking process, making RDT-Ag a much-needed commodity. Procurement is the process by which companies acquire raw materials, components, products, services or other resources from suppliers that will be

used to carry out their operations. According to Azimifard et al. (2017), supply chain management prefers to use suppliers that are few but reliable or have a long duration of cooperation. Suppliers have an essential or fundamental role. Criteria in supplier selection is an important point in the supplier selection process; the criteria must describe the supply chain strategy or describe the characteristics of the items to be supplied (Pujawan &Mahendrawati 2017). Dickson (1966) conducted research on supplier selection using 23 criteria with a scale ranging from 0 to 4, a scale of 0, which has an unimportant purpose and goes to a scale of 4, which has a very important purpose. The supplier selection activity is considered an MCDM (multi-criteria decision making) problem. The main challenge in selecting suppliers is to formulate appropriate criteria; the criteria that are often used are price, quality, production capacity and financial condition (Yu et al. 2019). Decision making in selecting a single supplier (single sourcing) or several suppliers (multiple sourcing) includes problems in supplier selection and order allocation (Wetzstein et al. 2016).

In this study, the selection of a multi-criteria RDT-Ag supplier in the "X" laboratory was classified into a single supplier, so the experts or respondents had to determine the RDT-Ag supplier according to the rules issued by the Ministry of Health of the Republic of Indonesia. Laboratory "X" does not have a special method in the procurement process. Procurement in laboratory "X" uses a tender system; the laboratory will provide a list of product specifications to be used to several suppliers, then several suppliers will provide price quotes. The old criteria used in the supplier evaluation process are price, quality and supplier profile. Improvement efforts in procurement activities evaluate supplier selection with multi-criteria (adding criteria/sub-criteria). The more criteria and sub-criteria used in the supplier selection process, that will be more objective supplier ranking.

The approach used to solve the supplier selection problem is to use AHP and TOPSIS. This AHP approach is very interesting because of its easy mathematical nature, the input for this method is easy to obtain, it can be used to measure quantitatively and qualitatively. This method has the disadvantage that it is not appropriate as a ranking method where there are many alternatives, this is because it has implications for the calculation of pairwise comparisons (Azimifard et al.2017). TOPSIS is a multi-criteria decision-making method that previous researchers have widely used. TOPSIS has the advantage of easy application, considering all types of criteria (subjective and objective), rational so that it is easy to understand, an easy computing process, and the framework in determining the best alternative is obtained from simple mathematical calculations (Bhutia and Phipon 2012). Therefore, this study focuses on the problem of suppliers of rapid diagnostic test antigen (RDT-Ag) in laboratory "X", by weighting each criterion and sub-criteria using the AHP method and the TOPSIS method being used to determine the order of ranking or ranking of suppliers.

2. Literature Review

Supply chain management (SC) prefers to use a few suppliers but reliable or have a long duration of cooperation (Azimifard et al.2017). According to Pujawan and Mahendrawati (2017), choosing suppliers or suppliers is part of the activities that are fundamental in determining the company's success. Dickson (1966) conducted research on supplier selection with 23 criteria and using a scale of 0-4. A scale of 0 means the criteria is not essential, and a scale of 4 means the criteria is essential. Hwang and Yoon (1981) divide multi-criteria decision making into 2, namely multi-objective decision-making (MODM) and multiple-attribute decision-making (MADM). According to Ghorabaee et al. (2017) the main objective of the supplier selection problem is to find quality and reliable suppliers. Supplier selection can be categorized into multi-attribute decision making (MADM). Chi and Trinh (2016) conducted a study on selecting multi-criteria suppliers in a rubber manufacturing company using the AHP-TOPSIS method and goal programming. The advantages of the analytical hierarchy process (AHP) are the correct method for support systems and can be applied in various sectors; the AHP method is simple. The disadvantage of the AHP method is that the number of items cannot exceed nine in each level, so it cannot deal with complicated conditions (Chi and Trinh 2016). Hwang and Yoon (1981) stated that the TOPSIS method is often used in multi-criteria decision-making problems. Yildiz (2019) conducting research that aims to select green suppliers using the TOPSIS method, with the object of research in the automotive industry. This research uses this method because it has a large capacity and is simple in the calculation, easy to understand, and easy to integrate with other methods. The advantage of using the TOPSIS method is the easy computational process, rational, and the process of determining the best alternative criteria is described by an easy mathematical model (Bhutia and Phipon 2012).

3. Methods

3.1 Identification of Alternative Suppliers

Laboratory "X" obtains the RDT-Ag test equipment through a tender system, which has three stages; the first stage is for the laboratory to determine the specifications for the rapid diagnostic test antigen (RDT-Ag) test equipment to be used. The second stage is the list of RDT-Ag specifications that will be given to suppliers who

are already registered in the database in the research and development (R&D) division. The third stage is the supplier provides an offer to the laboratory. This RDT-Ag test-style supplier comes from a trader or major pharmaceutical supplier (PBF). The list of suppliers is obtained from field observations in the R&D division and results from the interviews with respondents. This study uses ten alternative suppliers.

3.2 Determining Respondents

Respondents used in this research were experts and stakeholders related to the procurement process of the rapid diagnostic antigen test (RDT-Ag) style. This study used four respondents: senior health analysts, process supervisors, process managers and laboratory owners.

3.3 Designing a Questationnaire

Three questionnaires will be given to respondents; the first questionnaire is that respondents must choose new criteria and sub-criteria that will be used to select suppliers of RDT-Ag test equipment in the next period. New criteria and sub-criteria will be selected if at least three respondents agree to the new criteria and sub-criteria. The second questionnaire is that respondents provide pairwise comparison assessments on the new criteria and sub-criteria. This pairwise comparison process is based on the knowledge and experience of the respondents; this second questionnaire uses a Saaty scale (scale 1 to scale 9). The third questionnaire is the respondent provides the size of each criterion and sub-criteria used in each alternative supplier.

3.4 Determining the Weight Using the AHP Method

Analytical hierarchical process (AHP) is one of the methods in multi-criteria decision making. AHP was developed by Saaty which aims to solve complex decision problems using subjective and objective evaluations, the way to solve complex problems is by making hierarchies or levels (Dweiri et al. 2016). The selected criteria and sub-criteria are weighted using the AHP method, the steps from the AHP method are as follows (Chi and Trinh 2016) (Azimifard et al. 2017):

a. Create a decision hierarchy
b. Create a pairwise comparison matrix

$$A_{n\times n} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{matrix}\begin{bmatrix} 1 & \alpha_{12} & \cdots & \alpha_{1n} \\ 1/\alpha_{12} & 1 & \cdots & \alpha_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/\alpha_{1n} & 1/\alpha_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

c. Create a normalized decision matrix

$$C_{ij} = \alpha_{ij} \Big/ \Sigma_{j=1}^{n} \alpha_{ij} \quad (2)$$

$$with: \ i = 1,2,3 \cdots n, j = 1,2,3 \cdots n$$

d. Create a weighted normalized decision matrix

$$w_i = \Sigma_{j=1}^{n} c_{ij}/_n \quad (3)$$

e. Calculating Eigenvector and row matrix

$$E = N^{th}rootvalue \Big/ \Sigma N^{th}rootvalue \quad (4)$$

$$row\ matrix = \Sigma_{j=1}^{n} \alpha_{ij*e_{j1}} \quad (5)$$

f. Calculating the maximum Eigenvector

$$\pi_{max} = row\ matrix/_E \quad (6)$$

g. Calculating consistency index and consistency ratio

$$CI = (\pi_{max} - n) \Big/ (n-1) \quad (7)$$

$$CR = \frac{CI}{RI} \quad (8)$$

3.5 Determining Supplier Rangking Using TOPSIS Method

TOPSIS method easy to apply and useful in ranking alternatives and selecting several selected alternatives (Leksono 2015). The principle is to determine the distance from the optimal solution position to the positive ideal solution (PIS) and the negative solution distance (NIS). The best distance is optimal solution is the closer the distance to the positive ideal solution and the farther from the negative ideal solution, it will obtain the higher value (Hasan et al. 2020). the steps from the TOPSIS method are as follows (Bhutia and Phipon 2012) (Chi and Trinh 2016) :

a. Create decision matrix

$$D = \begin{bmatrix} & X_1 & X_2 & \cdots & X_j \\ A_1 & X_{11} & X_{12} & \cdots & X_{1j} \\ A_2 & X_{21} & X_{22} & \cdots & X_{2j} \\ \cdot & \cdot & \cdot & \cdots & \cdot \\ A_i & X_{i1} & X_{i2} & \cdots & X_{ij} \end{bmatrix} \quad (9)$$

b. Calculating normalized decision matrix

$$r_{ij} = {x_{ij}} \Big/ \sqrt{\Sigma_{j=1}^{j} x_{ij}^2} \quad (10)$$

c. Calculating the weighted normalized decision matrix

$$\mathcal{V}_{ij} = w_{ij} r_{ij} \quad (11)$$

d. Calculating the positive ideal solution and negative ideal solution

$$A^* = \{(max\ \mathcal{V}_{ij} | \ j \in J), (min \mathcal{V}_{ij} \ | \ j \in J')\} \quad (12)$$

$$A^- = \{(min \mathcal{V}_{ij} | \ j \in J), (max\ \mathcal{V}_{ij} | \ j \in J')\} \quad (13)$$

e. Calculating separation measure

$$S_i^* = \sqrt{\Sigma_{j=1}^{n} (\mathcal{V}_{ij} - \mathcal{V}_j^*)^2} \quad (14)$$

$$S_i^- = \sqrt{\Sigma_{j=1}^{n} (\mathcal{V}_{ij} - \mathcal{V}_j^-)^2} \quad (15)$$

f. Calculating relative closeness to the ideal solution

$$C_i^* = {S_i^-} \Big/ {S_i^* + S_i^-} \quad (16)$$

$0 \leq C_i^* \leq 1,$

g. Calculating the total score and supplier rangking

4. Result and Discussion

4.1 Alternative Suppliers and Respondents

This alternative supplier of RDT-Ag comes from a company or major pharmaceutical supplier (PBF). The RDT-Ag supplier assessment process uses judgments from experts related to the RDT-Ag procurement process. There are 4 experts, consisting of senior health analysts, process supervisors, process managers, and laboratory owners. The details of the experts are as follows:

Table 1. Respondents

The Experts	R1	R2	R3	R4
Position	Senior Analyst	Supervisor	Manager	Laboratory owner (Owner)
Work Devision	Process	Process	Process	-
Experience	5 years	9 years	12 years	16 years

4.2 The Weight of Criteria and Sub-Criteria with AHP Methods

The current laboratory "X" condition uses three main criteria, namely supplier profile, quality, and price. The three old criteria will be added with new criteria and sub-criteria, which are approved or agreed upon by a minimum of three respondents. The new criteria and sub-criteria were compiled based on the references used by researchers. The four respondents agreed to use 7 main criteria and 16 new sub-criteria used in the RDT-Ag selection process. The 7 main criteria are price, quality, delivery, supplier profile, flexibility, service/service and

warranty. Respondents conducted a pairwise comparison assessment, this assessment aims to get the weight of the main criteria and sub-criteria. This pairwise comparison assessment data processing uses the analytical hierarchy process (AHP) method, based on processing using the AHP method, the main criteria are weighted as follows: supplier profile (0.434), quality (0.181), price (0.142), warranty (0.080), delivery (0.071), flexibility (0.053) and service (0.039). The results of the weighting of the main criteria and sub-criteria can be seen in the following table:

Table 2. The Weight of the main criteria and sub-criteria

Code	Criteria	Criteria weight	Code	Sub-Criteria	Sub-Criteria weight
K1	Price	0,142	K1.1	Price	0,142
K2	Quality	0,181	K2.1	Sensitivity	0,057
			K2.2	Specificity	0,048
			K2.3	Ergonomic	0,029
			K2.4	Examination result time	0,019
			K2.5	Expired	0,014
			K2.6	Content of each box	0,008
			K2.7	Faulty products (per100 pieces)	0,007
K3	Delivery	0,071	K3.1	Lead time	0,057
			K3.2	Delivery on time	0,014
K4	Supplier profile	0,434	K4.1	Legal / registered in the government (KEMENKES)	0,271
			K4.2	Supplier reputation	0,097
			K4.3	Past performance	0,066
K5	Flexibility	0,053	K5.1	Payment due	0,053
K6	Service	0,039	K6.1	Effective & Efficient communication	0,007
			K6.2	Business ethics	0,027
			K6.3	Responsive	0,004
K7	Warranty	0,080	K7.1	Warranty	0,080
Total					1,000

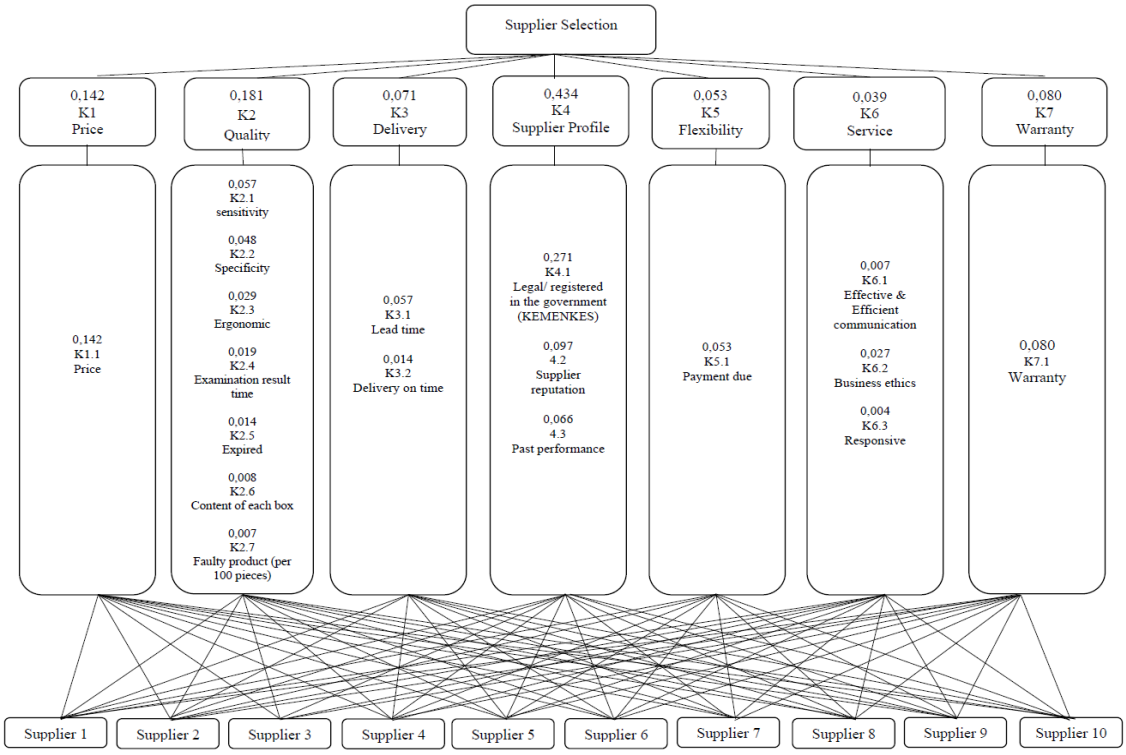

Figure 1. Ilustration the weight of the main criteria and sub-criteria

The next step is to calculate the consistency index (CI), the function of the consistency index (CI) is to determine the level of consistency of the experts or respondents in determining the assessment in pairwise comparisons of the main criteria and sub-criteria. According to Franek and Kresta (2014) the pairwise comparison matrix is perfect when the CI value = 0, and if there is an increase in the number of pairwise comparisons, the error rate will increase. Therefore, Saaty (1980) made another parameter, namely consistency ratio (CR), consistency ratio (CR) < 0.1. The results of the consistency ratio (CR) measurement are as follows: main criteria (0.083), quality sub-criteria (0.075), supplier profile sub-criteria (0.033), service sub-criteria (0.025). There is no consistency ratio (CR) for the delivery sub-criteria because the consistency index (CI) = 0. The consistency index (CI) is 0 because, in the delivery sub-criteria, there are only two sub-criteria, namely lead time and on-time delivery. In this study, it can be concluded that the CR value is <0.1, so it can be said that the pairwise comparison assessment carried out by the experts is quite consistent. The CI and CR measurements results can be seen in table 3. Illustration of the graphic calculation of the image can be seen in Figure 2

Table 3. Result consistency index and consistency ratio

Criteria and sub-criteria		Score
Main criteria	CI	0,109
	CR	0,083
Quality sub-criteria	CI	0,094
	CR	0,075
Delivery sub-criteria	CI	0,000
	CR	-
Supplier profile sub-criteria	CI	0,019
	CR	0,033
Service sub-criteria	CI	0,015
	CR	0,025

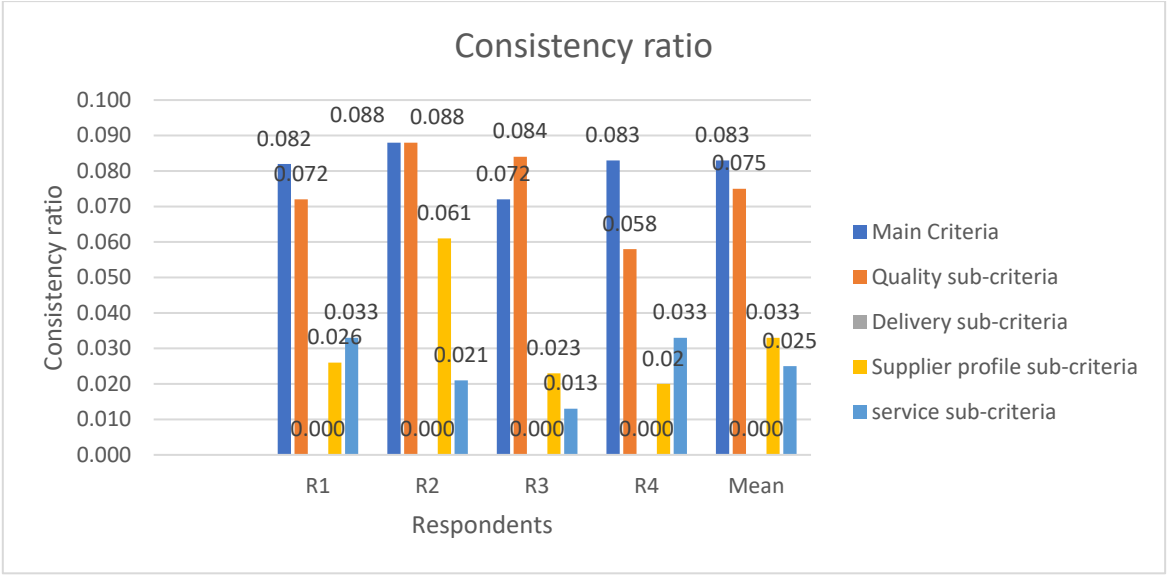

Figure 2. Results consistency ratio

4.3 Supplier Rangking Using TOPSIS Method

TOPSIS method requires two inputs; the first is the weight of each criterion and sub-criteria, second is the size of each main criterion and sub-criteria for each alternative supplier. The measures used for the decision matrix for each main criterion and sub-criteria are as follows:

- Price: thousand rupiah
- Sensitivity, Specificity: percentage (%)
- Time of examination result: Minutes
- Expiration, lead time, payment due, warranty: Days
- Contents of each box, damaged products (per 100 seeds): seeds / pcs

• Ergonomic, on-time delivery, legally registered in the government (KEMENKES), supplier reputation, past performance, effective & efficient communication, business ethics, responsive: Likert scale (1-5).
Based on the calculation of relative closeness to the ideal solution, the final value of each supplier is obtained. The alternative values for RDT-Ag suppliers are supplier 2 (0.664), supplier 8 (0.649), supplier 1 (0.619), supplier 4 (0.616), supplier 6 (0.559), supplier 3 (0.549), supplier 9 (0.545), supplier 7 (0.388), supplier 5 (0.386) and supplier 10 (0.376). An illustration of the alternative value of suppliers can be seen in the following figure:

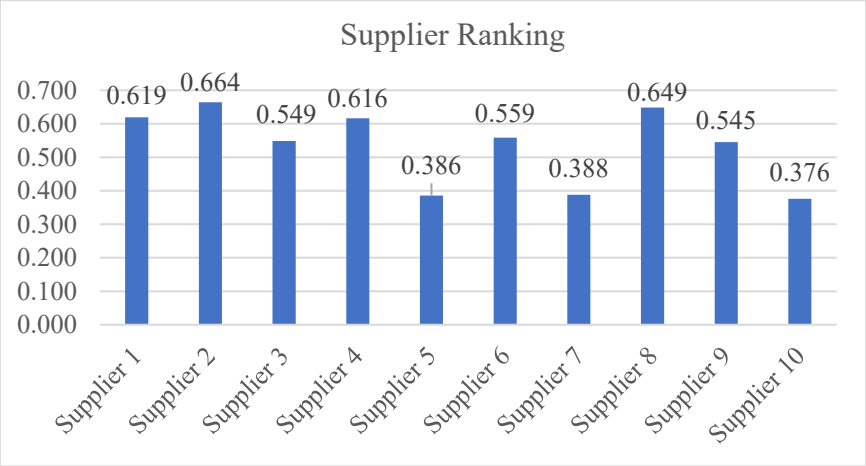

Figure 3 Supplier ranking

5. Conclusion

The selection of the supplier of the rapid diagnostic test antigen (RDT-Ag) test kit at the "X" laboratory uses 7 main criteria and 16 sub-criteria. Weighting criteria and sub-criteria using pairwise comparisons using the AHP method. The results of the weighting of the criteria are supplier profile (0.434), quality (0.181), price (0.142), warranty (0.080), delivery (0.071), flexibility (0.053) and service (0.039). The supplier ranking process uses the TOPSIS method. Supplier rangking are supplier 2 (0.664), supplier 8 (0.649), supplier 1 (0.619), supplier 4 (0.616), supplier 3 (0.549), supplier 9 (0.545), supplier 7 (0.388), supplier 5 (0.386), and supplier 10 (0.376).

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