Combining the Fuzzy AHP and TOPSIS to Evaluate Service Quality of E-commerce Website

Wismar R. Wijayanti
Department of Industrial Engineering, Diponegoro University
Jl. Prof. Soedarto, S.H., Tembalang
Semarang, Indonesia 50275
+62 24 7460052
wismarrizkiwij@student.undip.ac.id,
winirossa@gmail.com

Wini R. Dewi
Department of Industrial Engineering, Diponegoro University
Jl. Prof. Soedarto, S.H., Tembalang
Semarang, Indonesia 50275
+62 24 7460052
wismarrizkiwij@student.undip.ac.id,
winirossa@gmail.com

Fahmi Ardi
Department of Industrial Engineering, Diponegoro University
Jl. Prof. Soedarto, S.H., Tembalang
Semarang, Indonesia 50275
+62 24 7460052
fahmiardi66@yahoo.co.id,
azrinolfajri28@gmail.com,

Azrinol Fajri
Department of Industrial Engineering, Diponegoro University
Jl. Prof. Soedarto, S.H., Tembalang
Semarang, Indonesia 50275
+62 24 7460052
fahmiardi66@yahoo.co.id,
azrinolfajri28@gmail.com,

M. Mujiya Ulkhaq
Department of Industrial Engineering, Diponegoro University
Jl. Prof. Soedarto, S.H., Tembalang
Semarang, Indonesia 50275
+62 24 7460052
wismarrizkiwij@student.undip.ac.id,
winirossa@gmail.com

Pradita Y. Akshinta
Department of Industrial Engineering, Diponegoro University
Jl. Prof. Soedarto, S.H., Tembalang
Semarang, Indonesia 50275
+62 24 7460052
wismarrizkiwij@student.undip.ac.id,
winirossa@gmail.com

ABSTRACT

With the aid of the Internet and its rapid global growth, companies struggled to enhance their competitive advantages through the use of electronic commerce (e-commerce) to interact with their customers. Currently, the e-commerce becomes one of the primary modes of purchasing products. In fact, customers are spoiled by the abundant services available on an e-commerce website. As times goes by and as competition increases, the service providers have been competing to provide the best service quality to pursue customer satisfaction. This research tried to evaluate as well as to compare the service quality of e-commerce website using seven criteria of E-S-QUAL and E-RecS-QUAL, namely, efficiency, fulfillment, system availability, privacy, responsiveness, compensation, and contacts. The combination of the fuzzy analytic hierarchy process (FAHP) and technique for others reference by similarity to ideal solution (TOPSIS) are used here to accomplish the objective of the research. The FAHP is employed to determine the weights of each criterion, while TOPSIS is used to identify the ranking of all alternatives to be considered. Two largest customer-to-customer e-commerce websites in Indonesia are selected to be evaluated as well as to exhibit the applicability of the methods.

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CCS Concepts

• **Applied computing → Operations research → Decision analysis.**

Keywords

E-Commerce; Fuzzy Analytic Hierarchy Process; Multi-Criteria Decision Making; Service Quality; TOPSIS; Website.

1 INTRODUCTION

The Internet usage continues to escalate every day and becomes a primary needs in worldwide. About 54.4% of the global population is known as internet users [1]. The Internet could allow everyone to do other activities more efficiently, even capable to perform new activities that are impossible to be done at the previous time [2]. In business sector development, the Internet is used for expanding the line of distribution, trade, and communication electronically for more efficient business [3]. Due to an encouragement from market competition worldwide, the effect of the Internet on business triggered the successful implementation of e-commerce [4].

E-commerce is an internet based transaction processing which can facilitate various needs, such as buying and selling products and services [5]. It is a tool for sharing business information, maintaining business relationships, and leading a business through the Internet [6]. The e-commerce offers various benefits both for retailers as well as for buyers; such as: it might increase sales, reduce costs; boost customer awareness of products or services (for retailers), it saves time, offers a greater product selection, and allows for cost saving in terms of transportation, taxes, and the price of the product as well (for buyers) [7], [8].

As competition increases, the buyers have been attempting to find the best online shop that can satisfy their needs [9]; thus, various e-commerce offer their best services in order to compete with others. Buyers might shop in e-commerce by comparing several websites. Hence, it is essential to apply an effective tool for recognizing and prioritizing relevant criteria to develop a systematic service quality measurement process—it is considered as a critical factor for the success of the service provider due to its close connection with customer satisfaction [10], [11]. This tool also should develop consensus decision making. Therefore, the multi-criteria decision making (MCDM) theory could be applied in analyzing the performance of service quality of some alternatives. This MCDM theory is a discipline that takes aim at supporting decision makers who are faced with formulating various and conflicting evaluations.

The analytic hierarchy process (AHP) [12] is one of the most popular and powerful MCDM tools that has been used for years. Despite of the advantages as seeking consistency in judgment, being user friendly, allowing users to structure complex problems in the form of a hierarchy levels, and relatively easy to handle multiple attributes, the AHP has been criticized for its inability to adequately handle the ambiguity of the concepts that are associated with human being's subjective judgment. It is represented as precise, yet in real life situations, the linguistic assessment of human feelings and perceptions are fuzzy. The fuzzy set theory [13] is designed to model the vagueness of human cognitive processes and provide a formalized tool for dealing with the imprecision intrinsic to many problems. This fuzzy set theory has been combined with the AHP to present the fuzzy AHP (FAHP); see [14] for the example of the application of the FAHP.

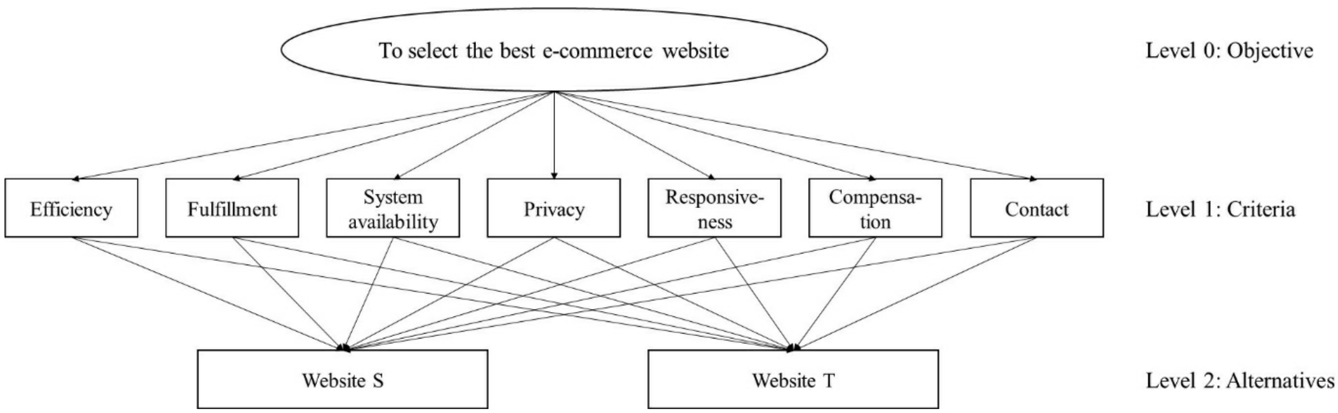

Figure 1. The hierarchy for evaluating service quality of e-commerce website

In this study, we attempted to combine the FAHP with technique for order preference by similarity to ideal solution (TOPSIS) [15] to determine the important criteria and the best alternative with respect to the customers' needs. The inclusion of TOPSIS is to identify the ranking of all alternatives. This technique has high flexibility so it can accommodate further extensions to make better choices in various situations. The combination of the FAHP and TOPSIS is widely used, see for example [16].

In order to demonstrate the applicability of the methods, a case study was conducted to evaluate two largest customer-to-customer (C2C) e-commerce websites in Indonesia. They are called Website S and Website T. Both of them are considered as the leader of the e-commerce market in Indonesia. Besides, they are C2C e-commerce websites which are included in 10 e-commerce list of Indonesia in the category of Top Digital Performing Online Consumer Goods Retailer of the highest total digital population (It is 14,401,000 for Website T and 11,301,000 for Website S.) [17]

The objectives of this research are then twofold. The first is to show how to determine the importance of assessment criteria for e-commerce website service quality using the FAHP method. The second is to identify the ranking of each alternative using TOPSIS technique. The finding of this research is useful in determining the best criterion that should first be implemented by the e-commerce, which makes it easy to improve the service quality.

2 RESEARCH METHODS

In this study, to evaluate service quality of the e-commerce website, seven criteria from E-S-QUAL and E-RecS-QUAL [18] are utilized. The first, which is considered as a core of service quality scale, contains four criteria; while the second, which is used to assess the e-service quality when there is a problem in providing service to the customers, consists of three criteria.

The first criterion of E-S-QUAL is efficiency. It is described as the ease and speed of accessing and using the website. In other words, the website is easy to use, structured properly and does not require so much information to be input by the customer. The second criterion is fulfillment, which is defined as the extent to which the website's promises about order delivery and fulfillment of product's availability. Next criterion is system availability. It refers to the correct technical functioning of the website. It relates to the system reliability of the website and the ability of the company to maintain the website so that it works properly. The last criterion is privacy, which is defined as the degree of safety of the website and the protection of customer information. There are still a lot of people who do not want to purchase products from the Internet due to the risk of spreading of personal information; hence, online retailers have to increasingly recognize the importance of providing customer privacy [19].

The E-RecS-QUAL has three criterion, namely, responsiveness, compensation, and contacts. The first criterion refers to effectively handling of problems and returns it through the website. The second criterion is described as the degree to which the website compensates customers for problems. The last criterion, i.e., contact, is defined as the availability of phone assistance or online representation of the company.

Besides determining the preferable criterion, another objective of this research is to find out the best e-commerce website between two alternatives, which is considered as the largest C2C e-commerce website in Indonesia. They are, let say, Website T and Website S. Both of them are among the C2C e-commerce websites which have the highest average duration per view, i.e., 4.7 minutes for Website T and 16 minutes for Website S [17].

In order to apply the FAHP and TOPSIS methods to evaluate the service quality of two aforementioned e-commerce websites, the previous seven criteria are structured into different hierarchy levels. The decision model hierarchy is depicted in Figure 1. The objective (or Level 0) is to choose the best e-commerce website between two alternatives, i.e., Website T and Website S. Level 1 of the hierarchy is the seven criteria from E-S-QUAL and E-RecS-QUAL, and the Level 2 of the hierarchy is the alternatives.

Data were collected from four respondents, i.e., the decision makers, who are considered as experts. They are experienced retailers from both websites and experienced buyers who have involved in purchasing products from both websites.

The evaluation process is composed of two steps. The first is assessing the weights of each criterion using FAHP. The decision makers are asked to compare the elements on a pairwise basis in order to estimate their relative importance in relation to the element at the immediately preceding level, i.e., the criteria. A nine-point scale questionnaire [20] is used to show the decision makers' judgment among options as equally, moderately, up to extremely important. This nine-point scale would then be converted into triangular fuzzy numbers (see Section 3 for the detail). The second step which is performed using TOPSIS technique is run after the weights of each criterion was identified. It is a calculation step to rank the alternatives. The detailed computations and processes involved in each step are described in the following subsections.

3 THE FUZZY AHP

This research employed the fuzzy AHP approach to evaluating the service quality of e-commerce Website. To be simple, the fuzzy AHP extends the AHP [12] by combining it with the fuzzy set theory [13]. The AHP is very popular in solving MCDM problems due to its many advantages. It is considered as an intuitive method, easy to handle multiple criteria, user friendly since it allows the users to structure complex problems in the form of a hierarchy levels, and has an advantage as seeking consistency in judgments [21] (see [22]–[24] for the example of the application of the AHP).

Regardless of its some advantages, the AHP has been criticized since it cannot reflect the human thinking style. In the AHP, human's judgments are represented as a precise number. However, when the preferences of the decision makers are affected by uncertainty and imprecision, it is not reasonable to use definite and precise numbers to represent linguistic judgments [25]. In order to deal with ambiguity, the fuzzy logic by [13] is integrated into AHP to give rise to the fuzzy AHP approach. The fuzzy AHP then converts linguistic judgments in triangular fuzzy numbers (TFNs).

Let $\mathrm{M} \in F(R)$ be called a fuzzy number if exists $x_0 \in R$ such that $\mu_{\mathrm{M}}(x_0) = 1$; and for any $\alpha \in [0,1]$, $A_\alpha = [x, \mu_{A_\alpha}(x) \geq a]$ is a closed interval. $F(R)$ is represented all fuzzy number sets and R is the set of real numbers. A TFN is denoted as M = (l, m, u) if its membership function $\mu_{\mathrm{M}}(x): R \to [0,1]$ is equal to:

$$\mu_M(x) = \begin{cases} \dfrac{x}{m-l} - \dfrac{l}{m-l}, & x \in [l,m], \\ \dfrac{x}{m-u} - \dfrac{u}{m-u}, & x \in [m,u], \\ 0, & \text{otherwise,} \end{cases} \tag{1}$$

where $l \leq m \leq u$; l, u, and m are lower, upper, and mid-value of the support of M respectively. The support of M is the set of elements $\{x \in R | l < x < u\}$.

Let TFNs M_1, M_3, M_5, M_7, and M_9 represent the assessment from equally to extremely important; and M_2, M_4, M_6, and M_8 are as the middle values. Figure 2 shows the membership functions of the TFNs $M_t = (l_t, m_t, u_t)$ where t = 1, 2, … , 9.

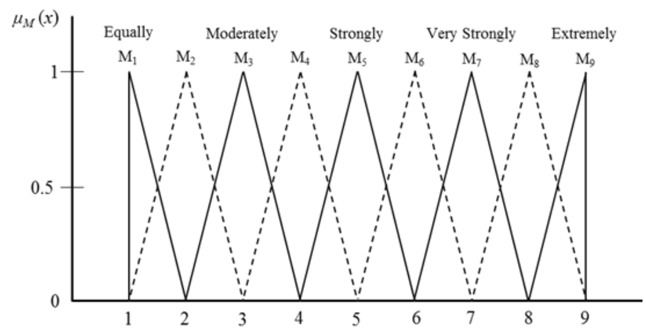

Figure 2. The membership functions of the TFNs

Let $X = \{x_1, x_2, …, x_n\}$ be an object set and $U = \{u_1, u_2, …, u_n\}$ be an objective set. Each object could be taken to perform extent analysis for each objective respectively. Then the m extent analysis values for each object can be found with the following signs: $M_{g_i}^1, M_{g_i}^2, ..., M_{g_i}^m$, i = 1, 2, …, n; where $M_{g_i}^j = (l_{g_i}^j, m_{g_i}^j, u_{g_i}^j)$, j = 1, 2, …, m, are the TFNs. The value of fuzzy synthetic extent with respect to the i-th object is defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} . \tag{2}$$

The degree of possibility of $M_1 \geq M_2$ is defined as

$$V(\mathrm{M}_1 \geq \mathrm{M}_2) = \sup_{x \geq y} \left[\min\left(\mu_{\mathrm{M}_1}(x), \mu_{\mathrm{M}2}(y) \right) \right] . \tag{3}$$

When a pair (x, y) exists such that $x \geq y$ and $\mu_{\mathrm{M}_1}(x) = \mu_{\mathrm{M}_2}(y) = 1$, then $V(M_1 \geq M_2) = 1$, iff $m_1 \geq m_2$. If $m_1 \leq m_2$, let $V(M_1 \geq M_2)$ = hgt $(M_1 \cap M_2)$, then

$$V(\mathrm{M}_1 \geq \mathrm{M}_2) = \begin{cases} \dfrac{l_2 - u_1}{(m_1 - u_1) - (m_2 - l_2)}, & l_2 \leq u_1 \\ 0, & \text{otherwise} \end{cases} . \tag{4}$$

The degree of possibility for a TFN to be greater than k TFNs M_i (i = 1, 2, …, k) can be defined as $V(M \geq M_1, M_2, …, M_k)$ = min $V(M \geq M_i)$. Assume that $d`(A_i)$ = min $V(S_i \geq S_k)$, where d is the abscissa of the highest intersection point between M_1 and M_2; and

A_i is the i-th element of the k-th level for $k = 1, 2, \ldots, n$; $k \neq i$. The weight vector of the k-th level is obtained as $W` = (d`(A_1), d`(A_2), \ldots, d`(A_n))^T$. After normalization, the normalized weight vector is $W = (d(A_1), d(A_2), \ldots, d(A_n))^T$, where W is a non-fuzzy number.

4 TOPSIS

TOPSIS technique was first developed by [15], with further developments by [26] and [27]. It is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution (PIS) and the longest geometric distance from the negative ideal solution (NIS). The steps of TOPSIS technique are presented as follows.

1). Step 1: Establish a normalized decision matrix.

Let Z denote a normalized decision matrix representing the relative performance of the generated design alternatives, with typical element Z_{ij} which can be calculated as

$$Z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{j=1}^{K} y_{ij}^2}}, \quad (5)$$

where y_{ij} is the performance score of alternative j against criterion i ($i = 1, 2, \ldots, n$ (number of criteria) and $j = 1, 2, \ldots, K$ (number of alternatives).

2). Step 2: Calculate the weighted decision matrix.

Let X_{ij} be the weighted normalized decision matrix ($i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, K$). It can be determined by

$$X_{ij} = w_i \cdot Z_{ij}, \quad (6)$$

where w_i is the weight of each criterion. These weights have been identified by using the AHP.

3). Step 3: Calculate the PIS and NIS.

The PIS and NIS are defined as

$$\text{PIS} = A_i^+ = \left\{ \left(\min_j X_{ij} \middle| i \in I \right), \left(\max_j X_{ij} \middle| i \in I' \right) \right\}, \quad (7)$$

$$\text{NIS} = A_i^- = \left\{ \left(\max_j X_{ij} \middle| i \in I \right), \left(\min_j X_{ij} \middle| i \in I' \right) \right\}, \quad (8)$$

where $I = \{i = 1, 2, \ldots, n$ and i is associated with the beneficial criterion of $X_{ij}\}$, and $I' = \{i = 1, 2, \ldots, n$ and i is associated with the cost-effective criterion of $X_{ij}\}$.

4). Step 4: Compute the distance from PIS and NIS.

Let the S_j^+ denotes the distance of each alternative from PIS and S_j^- denotes the distance of each alternative from NIS.

$$S_j^+ = \left[\sum_{i=1}^{n} \left(X_{ij} - A_i^+ \right)^2 \right]^{1/2}; \; S_j^- = \left[\sum_{i=1}^{n} \left(X_{ij} - A_i^- \right)^2 \right]^{1/2}. \quad (9)$$

5). Step 5: Compute the closeness coefficient (CCi) of each alternative.

The ranking score is calculated by employing the CC_i as follows

$$CC_i = \frac{S_j^-}{S_j^+ + S_j^-}. \quad (10)$$

6). Rank the alternatives.

The different alternatives are ranked according to the closeness coefficient in decreasing order. The best alternative is closest to the PIS and farthest from the NIS.

5 CASE STUDY: RESULTS AND DISCUSSION

The objective of this research is to evaluate service quality of two e-commerce websites. It is divided into two sequential steps; the first is to determine the preferable criterion among seven criteria (see Section 2) using the fuzzy AHP and the second is to identify the ranking of the alternatives using TOPSIS technique.

Four respondents who act as decision makers are asked to fill the pairwise comparison to express their preferences between the alternatives and criteria in a nine-point scale questionnaire. The fuzzy AHP was applied to investigate the weights for each criterion. The weights that indicate the importance of each criterion for evaluating service quality of e-commerce website are 0.145 for efficiency, 0.166 for fulfillment, 0.145 for system availability, 0.142 for privacy, 0.151 for responsiveness, 0.140 for compensation, and 0.110 for contact.

According to the result, fulfillment is considered as the most important criterion. It seems that the buyers of e-commerce website require delivery orders according to the promise of the website, ser-vice accuracy, and product availability which can satisfy their needs. Next, responsiveness rank as the second most important criterion. Buyers are more concerned about the services provided by e-commerce website when problems occur and there are no delays from the website to respond. The third most important criterion is efficiency and system availability (they have equal scores). Every buyer generally want the website to be simple, easy to be operated, satisfactory, as well as required minimum information about the buyers. This means that the buyers do not want to be bothered by trivial things in using the website. Meanwhile, system availability is also considered as the third most important criterion since the website must have reliability in its system and function properly in order to satisfy the buyer. Afterward, privacy is also considered as the fourth most important criterion. It must secure buyers' information. As a consequence, the website must protect buyer's shopping behavior information, does not share buyer's personal information with other websites, as well as protects buyer's credit card information.

After calculating the weight of each criterion, the TOPSIS technique is then applied to choose the best alternative between two e-commerce websites. The result, which is the alternative priority weights, is depicted in Table 1.

Table 1. Alternative priority weights for each criterion

Criterion	Website S	Website T
Efficiency	0.528	0.472
Fulfillment	0.524	0.476
System availability	0.506	0.494
Privacy	0.499	0.501
Responsiveness	0.516	0.484

Compensation	0.510	0.490
Contact	0.507	0.493

As we can see in Table 1, the first alternative, i.e., Website T, surpasses the second alternative for only one criterion, which is privacy (50.1% vs. 49.9%); while the first alternative exceeds the first in criterion of efficiency (52.8% vs. 47.2%), fulfillment (52.4% vs. 47.6%), system availability (50.6% vs 49.4%), responsiveness (51.6% vs. 48.4%), compensation (51% vs 49%), and contact (50.7% vs 49.3%).

Finally, TOPSIS technique ranks the best alternative according to the relative proximity to the ideal solution. The result shows that Website S comes out on top, surpassing Website T. Website S scores 0.516 while Website T 0.415. Although Website T has less value for privacy, it remains superior in the other six criteria compared to Website S.

5. CONCLUSION AND FUTURE RESEARCH DIRECTION

The study aims to develop a model to evaluate service quality of e-commerce website as a basis for the buyers to purchase products and for the retailers to sell their possessions. Data were collected from four experts who are considered to have abundant experiences in e-commerce practice. The result of this research shows that the service providers should focus on fulfillment since it has the highest weights among other criteria, i.e., 0.166 from the scale of 1.00. The second and third highest weights are responsiveness (0.151) and system availability (0.145) (see Section 3 for the detail).

The ranking of two alternatives based on the calculations is Website S with 0.516 and Website T with 0.415. Although Website S surpasses Website T, it does not mean that the first is better compared to the second. In fact, the second should improve its service quality considering the criteria which have lower scores. These findings could provide the service providers with valuable insights into the criteria that reflect buyers' perceptions when they engage in the e-commerce transaction.

For further research, it is recommended to use other MCDM tools to evaluate service quality of e-commerce website and then compare the result with this research's result. For example, if it is suspected that there are interdependent relationships among criteria, the analytic network process (ANP) [28] could be used. Comparing the results generated by that method with this research is an interesting area to be pursued.

6. REFERENCES

[1] Internet World Stats. 2017. *Internet World Stats*. Retrieved April 5, 2018 from https://www.internetworldstats.com/stats.htm.

[2] Castellacci, F. and Tveito, V. 2018. Internet use and well-being: a survey and a theoretical framework. *Res. Policy*, 47, 1, 308-325. DOI= https://doi.org/10.1016/j.respol.2017.11.007.

[3] Feizollahi, S., Shirmohammadi, A., Kahreh, Z. S., and Kaherh, M. S. 2014. Investigation the effect of Internet technology on performance of services organizations with e-commerce orientations, *Procd. Soc. Behv.* 109, 605-609. DOI= https://doi.org/10.1016/j.sbspro.2013.12.514.

[4] Huang, Z. and Benyoucef, M. 2014. Usability and credibility of e-government websites, *Gov. Inform. Q.* 31, 4, 584-595. DOI= https://doi.org/10.1016/j.giq.2014.07.002.

[5] Chintagunta, P. K., Chu, J., and Cebollada, J. 2012. Quantifying transaction costs in online/off-line grocery channel choice, *Market. Sci.* 31, 1, 96-114. DOI= https://doi.org/10.1287/mksc.1110.0678

[6] Vladimir, Z. 1996. Electronic commerce: structures and issues, *Int. J. Electron. Comm.* 1, 1, 3-23.

[7] Shin, N. 2001. Strategies for competitive advantage in electronic commerce, *J. Electron Commer. Re.* 2, 4, 164-171.

[8] Chen, Q. and Zhang, N. 2015. Does e-commerce provide a sustained competitive advantage? An investigation of survival and sustainability in growth-oriented enterprises, *Sustainability-Basel*, 7, 2, 1141–1428. DOI= https://dx.doi.org/10.3390/su7021411.

[9] Ulkhaq, M. M., Wijayanti, W. R., Kusumawati, A. Aulia, F. S., Wijayanti R. S., and Wiganingrum R. 2017. Combining the eTransQual scale and importance-performance analysis to assess service quality of online shopping. In *Proceeding of the 4th International Conference on Industrial Engineering and Applications* (Nagoya, Japan, April 21–23, 2017). ICIEA '17. SCIE, 146-150. DOI= https://dx.doi.org/10.1109/IEA.2017.7939196.

[10] Parasuraman, A., Zeithaml, V. A., and Berry, L. L. 1985. A conceptual model of service quality and its implications for future research. *J. Marketing* 49, 4, 41-50. DOI= https://dx.doi.org/10.2307/1251430.

[11] Chow, I. H., Lau, V. P., Lo, T. W., Sha, Z., and Yun, H. 2007. Service quality in restaurant operations in China: decision- and experiential-oriented perspectives. *Int. J. Hosp. Manag*. 26, 3, 698-710. DOI= https://doi.org/10.1016/j.ijhm.2006.07.001.

[12] Saaty, T. L. 1980. *The Analytic Hierarchy Process: Planning, Priority Setting*, McGraw-Hill International Book, Co., New York.

[13] Zadeh, L. A. 1965. Fuzzy set. *Infor. Control*. 8, 338-353. DOI= https://doi.org/10.1016/S0019-9958(65)90241-X.

[14] Ulkhaq, M. M., Nartadhi, R. L., and Akshinta, P. Y. 2016. Evaluating service quality of Korean restaurants: a fuzzy analytic hierarchy approach. *Industrial Engineering & Management Systems* 15, 1, 77-91. DOI= http://dx.doi.org/10.7232/iems.2016.15.1.077.

[15] Hwang, C. and Yoon, K. 1981. *Multiple Attribute Decision Making: Methods and Application*. Springer. New York.

[16] Ulkhaq, M. M., Akshinta, P. Y., Nartadhi, R. L., and Pramono, S. N. W. 2016. Assessing sustainable rural community tourism using the AHP and TOPSIS approaches under fuzzy environment. In *Proceeding of the 3rd International Conference on Industrial Engineering and Applications* (Hong Kong, April 28–30, 2016). ICIEA '16. SCIE, 9003-9007. DOI= http://dx.doi.org/10.1051/matecconf/20166809003.

[17] Ngazis, A. N. 2017. *Survei: Shopee dan Matahari Mall Juara Bisnis Online* (in Indonesian). Retrieved April 5, 2018, from https://www.viva.co.id/digital/digilife/950234-survei-shopee-dan-matahari-mall-juara-bisnis-online.

[18] Parasuraman, A., Zeithaml, V. A., and Malhotra, A. 2005. E-S-QUAL: A multiple-item scale for assessing electronic service quality. *J. Serv. Res-US*. 7, 3, 213-233. DOI= http://dx.doi.org/10.1177/1094670504271156.

[19] Ranganathan, C. and Ganapathy, S. 2002. Key dimensions of business-to-consumer web sites. *Inform. Manage.* 3, 1, 457-465. DOI= https://doi.org/10.1016/S0378-7206(01)00112-4.

[20] Saaty, T. L. and Alexander, J. M. 1981. *Thinking with Models: Mathematical Models in the Physical, Biological and Social Sciences*. Pergamon Press. London.

[21] Saaty, T. L. and Kearns, K. P. 1985. *Analytical Planning: The Organization of System*. Pergamon Press. London.

[22] Govindan, K., Kaliyan, M., Kannan, D., and Haq, A. N. 2014. Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *Int. J. Prod. Econ.* 147, 555-568. DOI= https://doi.org/10.1016/j.ijpe.2013.08.018.

[23] Akalin, M., Turhan, G., and Sahin, A. 2016. The application of AHP approach for evaluating location selection elements for retail store: a case of clothing store. *Int. J. Res. Bus. Soc. Sci.* 2, 4, 1-20. DOI= http://dx.doi.org/10.20525/ijrbs.v2i4.77.

[24] Pramono, S. N. W., Ulkhaq, M. M., Trianto, R., Rasyida, D. R., Setyorini, N. A., Setiowati, P. R., and Jauhari, W.A. 2017. Integrating the analytic hierarchy process and importance-performance analysis into ISO 14001 framework for assessing campus sustainability. *AIP Conf. Proc*. 1902, 020035. DOI= http://dx.doi.org/10.1063/1.5010652.

[25] Chan, F. T. S. and Kumar, N. 2007. Global supplier development considering risk factors using fuzzy extended AHP-based approach. *Omega*, 35, 417-431. DOI= https://doi.org/10.1016/j.omega.2005.08.004.

[26] Yoon, K. 1987. A reconciliation among discrete compromise situations. *J. Oper. Res. Soc*. 38, 277-286. DOI= http://doi.org/10.1057/jors.1987.44.

[27] Hwang, C. L., Lai, Y. J., Liu, T. Y. 1993. A new approach for multiple objective decision making. *Comput. Oper. Res.* 20, 889-899. DOI= http://doi.org/10.1016/0305-0548(93)90109-v.

[28] Saaty, T. L. 1996. *The Analytic Network Process: Decision Making with Dependence and Feedback*. RWS Publications. Pittsburgh.