Online Shop Recommendations: Decision Support System Based on Multi-Objective Optimization on the Basis of Ratio Analysis

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***Abstract*— Business technological advancement facilitates human activities through online shopping. The number of online shops in the marketplace offers many kinds of products with attractive marketing strategies thus the customers are confused with the product comprising. Therefore, this research tries to provide an optimal online shop recommendation as an alternative solution. The Decision Support System (DSS) approach on management model applied Multi-Objective Optimization on the Base of Ratio Analysis (MOORA) for the analytical calculation by considering several criteria, including price, rating, discount, a product sold, and response chat. It reveals the ranking of fifty on-line shops in the marketplace as the maximum alternatives' product recommendations. Thus, the customers will be smartly guided to choose the high-quality product at the greatness services of an online shop. The mechanism of DSS based on MOORA was applied through the construction of a prototype system, namely DSS-MyProduct. DSS-MyProduct suggests the buyers with optimal products and the greatest online shop choice for shopping. The application has been tested by using Blackbox and User Acceptance Test (UAT) testing which indicated that the application can perform the functions and operational procedures appropriately. 83.4% of users agreed that this DSS-MyProduct aids them in deciding on the optimal choice preferred in shopping. The comparison of user manual selection and system calculation shows a positive outcome on the accuracy of the system. Hence, this application can be used by the marketplace as a smart recommendation tool for product selection.**

***Keywords*— *Marketplace, Multi-Objective Optimization based on Ratio Analysis, Recommendations, Decision Support System, Online Shop*.**

I. Introduction

The rise of technology and customer demands forces innovative and creative ways of e-commerce business as well as online shops thus it triggers the ease and accelerates of transaction. The online shops provide customers with various interactive product information, figures, animations, videos, discounts, promotions, digital catalogs, and interesting prices virtually in default of leaving their comfort zone area for procurement [1]. Many online shops offer a similar type of products, with various prices and discounts thus it leads to the customers' discouragement in selecting the fit product from the proper online shop. A high price of products is not guaranteed for satisfactory services instead of product quality, safe and fast delivery, ease of transaction, and vice versa [2].

An initial survey through the dissemination of questionnaires to 100 respondents from the millennial generation in Universitas Islam Negeri Sultan Syarif Kasim Riau (UIN Suska Riau) reveals that it is necessary to equip the customers with an automatic tool for products advisements. The young generation millennial was chosen due to the high usability of them on the internet for business, education, and social communication [3]. Moreover, the success of the marketplace is surrounded by the millennial generation. To grab the academic reviews on the online shop, the millennial generation was restricted to university students. Therefore, this research tries to conceptually design and develop a smart recommendations system based on the DSS approach by considering the criteria of online shop viz., price, rating, discount, the product sold, and response chat.

The determination of criteria come up from the literature reviews and observation from Indonesia's first three red-hot marketplace agents, namely Shopee, Bukalapak, and Tokopedia. Price is defined as a specific set of values commonly in digits that showed the selling price of products displayed by online shops [4]. In economic factors, price plays a significant role and deeply relates to perception, willingness to pay, price knowledge, cost of production, and intention to purchase [5]. The product rating is defined as the buyer's previous assessment of the quality of products and services provided by an online shop. Z. Cheng et al (2018) designated as the customer's overall preference or satisfaction towards the corresponding items [6]. Hence, this personalized rating becomes a significant problem in recommender systems. The discount is defined as a discounted price offered by an online shop. Maamoun (2019) explained that the deep discount appeals to a growing price-sensitive segment and win over the customers [7]. The products sold are defined as the number of products that are successfully depleted by the online shop within one day. Michel et al., (2015) found that one of the most likely strategies for salespeople to obtain overall sales targets is by focusing on product selling [8]. The

ambidextrous product selling strategy can lead to positive outcomes and greater performance stability of the company. Meanwhile, the response chat is defined as the time duration for an online shop to respond in answering the questions and complaints from customers. Baheti et al., (2020) explained that there are many acceptable ways to respond to the conversation, such as traditional dialogues system, response generation model, and neural conversation models. Due to the restricted response time, the neural conversation model can be suggested as alternative tools in responding to the customers' feedbacks [9].

DSS is an approach that suggests several alternatives solutions for management by considering the multi-attributes decision-making in complex or semi-structured problems. DSS enhances the quality of decisions thus the recommendations turn into more objectives and represent various perspectives views in making decisions [10]. Thus, DSS generates open, honest, effective dialogues, and trust among the relevant stakeholders who will be affected by the decision. DSS has been widely applied in various scientific fields. Relating to the economic business fields, Turker et al., (2019) studies the use of DSS for dynamic Job-shop scheduling using real-time data simulation [11]. Dweiri et al., (2016) designed an integrated AHP based decision support system for supplier selection [12]. Nave et al., (2018) practiced the DSS framework to track consumer sentiments in social media [13]. In a nutshell, DSS for economic business helps managers to align their business strategies and better manage their online reputation. The development of business intelligence embedded in DSS provides a pro-active understanding of the emerging opportunities for the companies in facing competitive advantages.

In calculating the optimization of statistical management models in DSS, various methods have been successfully used, such as Kaliszewski, and Podkopaev (2016) studied that the simple additive weighting method (SAW) as a metamodel for multiple criteria decision analysis model [14]. Okfalisa et al., (2018) integrated the analytic hierarchy process (AHP) with Objective Matrix for performance measurement [15]. Z. Chen et al., (2019) combined ANP with a rough-fuzzy DEMATEL for evaluating the sustainable value requirement of the product-service system [16]. Ionnou et al., (2019) applied AHP and technique for order preference by similarity to ideal solution (TOPSIS) for selecting wind farm installation location [17]. X. Yu et al., (2018) studied how Elimination Et Choix Traduisant la Realite (ELECTRE) methods can prioritize Multi-attribute Decision Making (MCDM) environment [18]. Muhamad Muslihudin et al., (2019) applied the weighted product (WP) for determining home renovation assistance [19]. The latest reviews S. K. Shihab et al., (2018) who used MOORA for multi optimization of parameters in stainless steel cladding [20].

Brauers and Zavadskas (2006) popularized MOORA as one of the methods that concentrate on the optimal decision purposes by accomplishing the various complex and conflicting decision-making issues [21]. MOORA responds to the representative alternatives concerning that particular objectives through the calculation of the square root of the sum of squares of each alternative per objective chosen [22].

Moreover, MOORA accommodates multiple criteria in simple computational procedures thus the decision matrix normalization is represented just in a particular single equation [23]. MOORA has been successfully showing the perfect correlation for order preference to the ideal solution, not affected by additional parameters [24], and undefined of the criteria weights [25]. Hence, MOORA can simultaneously consider the numbers of quantitative and qualitative selection attributes in decision making [26].

The application of MOORA in various fields of study has been discussed previously. For education, MOORA auspiciously selects the assistant lecturer working at the computer laboratory [27]. Arindia Utami et al., (2020) explored the application of MOORA for privileging the alumni scholarship foundation [28]. For the engineering field MOORA was able to carry out the optimization of welding process parameters [29]; to select the composite material for good wear resistance and structural applications point of view [30], and to ensure the proper functioning of the products based on the material option [31]. The other cases in economic management, MOORA solved the determination of strategic location marketing [32], personal assessment [33], the rank of proposed alternatives in identifying the factors that influence bicycle sharing systems [34], and the selection of the best-prepared countries for 2020 based on the most competitive and dynamic knowledge-based economy [35].

Regarding the preceding discussion on the strengths of the MOORA method and how its success in optimizing decisions in various scientific fields, this study tries to administer the DSS concept based on MOORA for figuring out the decision-making in determining the first-rate online store for product purchases. Indeed, the recommendations given can aid the customers in making-decision for the online shop. Besides, the information provided by this DSS-MOORA whether related to the product, price, rating, discount, the product sold, and response chat grows into a knowledge transformation for the community as well as the product sales transparency [36], customer loyalty [37], service quality [38], and marketing strategy [39]. Thus, it is very influential on company performance, competitive advantages [40], and business sustainability [41]. As a limitation, fifty online shops engaged in men's clothing sales are defined as an alternative sample in DSS-MOORA.

II. METHODOLOGY

The stages of the research were carried out with a series of activities, beginning with problem identification, formulation criteria, DSS-MOORA designed, DSS-MOORA implementation into a prototype system development namely DSS-MyProduct, and finally is system testing. Problem identification was conducted through a thorough literature review related to MOORA methods, possible criteria for defining cases, and DSS concepts. To define the general problem identification, a survey involving 100 respondents from young millennial students and alumni at UIN Suska Riau was asked for their opinion regarding the demand for such a tool for aiding the customer decision making in shopping online. The questionnaires with five Linkert scale were disseminated by using the google form. The millennial generation was chosen as the large role of this generation in internet usage, and online transactions whether for personal

shopping purposes or business [42]. As a result, a survey showed that 85% of respondents felt confused when they have to face various products offered by many online stores in every marketplace. Furthermore, the weight of the criteria proposed is also defined as outputs of this survey. Thus, this strengthens the criteria formulation that drawing up before from the literature reviews and internet observation at the most booming marketplaces in Indonesia [43], namely Shopee, Bukalapak, and Tokopedia. 50 online shops incorporated in the shopee marketplace are chosen to be alternatives.

Hence, the construction of DSS-MOORA is designed by following the MOORA calculation completion algorithm as follows [44]:

1. The formation of Matrix Decision

$$Xij = \begin{bmatrix} X11 & X12 & X1n \\ X21 & X22 & X2n \\ Xm1 & Xm2 & Xmn \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

xij = the result of matrix formation
x = the value of each criterion
i = the criterion value
j = the alternative value
m = the criterion value to m
n = the alternative value to n

2. Normalize matrix determination

$$\overline{xij} = \frac{xij}{\sqrt{\sum_{j=1}^{m} x^2_{ij}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

(j = 1, 2…, n)

$\overline{xij}$ = the average of the i-th criteria to the value of the j-th criteria
xij = the matrix formation
i = the value derived from the number of criteria
j = the value derived from the number of alternatives
n = the number of alternative values up to n

3. Weighted normalize matrix determination

$$yi = \sum_{j=1}^{g} Xij * \sum_{j=g+1}^{n} Wj \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

yi = the result of weighted matrix multiplication
wj = the weight value of the j-th criterion
xij = values of each matrix formation

4. Preference value determination

$$yi = \sum_{j=1}^{g} WjXij - \sum_{j=g+1}^{n} WjXij \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

yi = the result of weighted matrix multiplication
wj = the weight value of the j-th criterion
xij = values of each matrix formation

Completing the analysis of MOORA calculations on DSS, the next step is followed through the development of a prototype recommendation system specifically DSS-MyProduct. The application was established by using PHP for programming language and MySQL for the database. For the software development model, object-oriented was resolved. To show the activity flow on DSS-MyProduct, the system architecture was designed. Several interfaces are displayed to capture the slide input and output of the prototype system. The application was tested by carried out the Blackbox and UAT techniques. Twenty respondents from the millennial generation were asked to run the application and hand out their impression on the ease of use, benefits, functionality, and interfaces of the application. To attempt the accuracy of calculations, the comparison of user recommendations manually with system suggestion is performed with the Confusion Matrix formula below [45 and 46].

*A*ccuracy

$$= \frac{TP+TN}{P+N} \; x \; 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Error-rate

$$= \frac{FP+FN}{P+N} \; x \; 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

TP *(True Positive)* = The amount of correctly classified data (*Actual class (yes), Predicted class (yes)).*
TN *(True Negative)* = The amount of correctly classified data (*Actual class (no), Predicted class (no)).*
FN *(False Negatif)* = The amount of incorrectly classified data (*Actual class (yes), Predicted class (no)).*
FP *(False Positif)* = The amount of incorrectly classified data (*Actual class (no), Predicted class (yes)).*
P = Total of TP and FN
N = Total of FP and TN

III. Result And Discussion

A. Criteria Formulation

A descriptive analysis defines the weights of each criterion as Table I.

TABLE I. Criteria Weight Value

Criteria with References	Weight Value
Product Prices [1],[2],[4],[5]	23%
Product Rating [2], [6]	30%
Discount [2],[7]	12.5%
Sold Products [8]	20%
Chat response [9]	12.5%

The weights for each sub-criterion are spelled out in Table II for Product Prices. It is construed by perceiving the general range of prices in products sold. Table III explains the substance of product ratings which is performed by the number of stars as customers' appraisal. Table IV points out the percentage of discounts offered by the store. Table V discloses the number of products sold out in a day. Table VI expounds the item for response chat that describes by the length of time in response.

B. DSS-MOORA Designed

Following Equation 1 to 4 for MOORA calculation, the final rank of the online shop is resumed in Table VII. Table VII designates ten best recommended online stores from fifty alternatives provided.

TABLE II. PRODUCT PRICE SUB-CRITERIA

Sub-Criteria	Score
> 360.000 (Rp)	1
241.000 – 360.000 (Rp)	2
121.000 – 240.000 (Rp)	3
0– 120.000 (Rp)	4

TABLE III. PRODUCT RATING SUB-CRITERIA

Sub-Criteria	Score
1 star	1
2 star	2
3 star	3
4 star or more	4

TABLE IV. DISCOUNT SUB-CRITERIA

Sub-Criteria	Score
0 – 25 %	1
25% - 50%	2
51% - 75%	3
76% - 100%	4

TABLE V. PRODUCT SOLD SUB-CRITERIA

Sub-Criteria	Score
0 – 30 / day	1
31 – 60 / day	2
61 – 90 / day	3
> 90 / day	4

TABLE VI. CHAT RESPONSE SUB-CRITERIA

Sub-Criteria	Score
more than one day for a response	1
one day for a response	2
half-day for a response	3
fast response	4

TABLE VII. RECAPITULATION OF ONLINE SHOP RECOMMENDATIONS

Alternative	Max	Min	Optimum
A1-broodis_	0,2392	0,0653	0,1739
A2-affliga.id	0,1950	0,0653	0,1297
A3-gudangkemejaid	0,3010	0,0870	0,2140
A4-affliga.id	0,1950	0,0870	0,1079
A5-rava.id	0,3010	0,0870	0,2140
A6-mr.only.id	0,1693	0,0653	0,1041
A7-moncheriswear	0,1942	0,0870	0,1071
A8-ourlove0.id	0,2430	0,0870	0,1559
A9-his.room	0,1942	0,0870	0,1071
A10-baiduoyama.id	0,1942	0,0653	0,1289

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From Table VII, it can be seen that alternatives A5 and A3, namely gudangkemejaid and rava.id, are set as the highest recommended online shops for buying the shirt products with optimization values of 0,2140. It then follows by alternatives A1, A8, A2, A10, A4, A7, A9, and A6 respectively.

DSS-MOORA has been successfully defined the most optimal online shop for shopping the Shirt by considering the greatest services offers by the online shop such as the minimum product price, the maximum product rating, the maximum discount endeavor, the maximum product sold to describe the high volume of production and selling per day, and the fastest response chat in marketing services. This result is certainly supporting the economical business principle from the sides of buyers and production house [2]. The buyer's intent to receive a good quality product with minimum prices and maximum services. Meanwhile, the production house is encouraged to cutting down the procurement costs by emphasizing innovation, creativity, and efficiency within business activities.

In a nutshell, the penetration of technology digital within business activities pressurizes the emergence of a smart environment, including the smart consumer and agile production.

C. Prototype System DSS-MyProduct

To automate The DSS-MOORA, the development of the prototype DSS-MyProduct was then developed. The architecture design of DSS-MyProduct can be seen in Fig. 1. Meanwhile, the system interfaces can be depicted in Fig. 2 and 3.

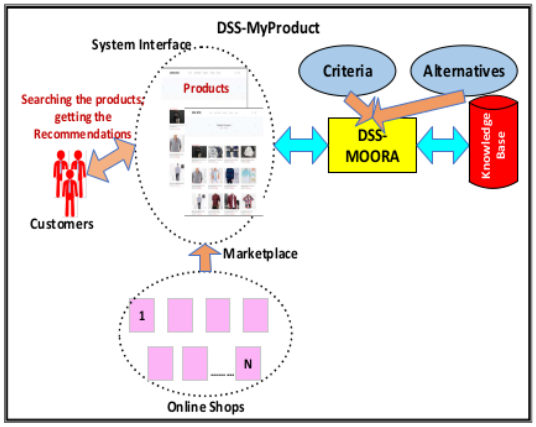

Fig. 1. DSS-MyProduct Architecture

Blackbox testing on this application found that all functions run as expected. UAT test reveals that this application is very useful and helpful (83.4%) for the customers in preferring the shirt products in an online shop. Meanwhile, the operation of Equations 2.5 and 2.6 from the simulation of twenty respondents generated the accuracy value between manual and application decisions is 95%.

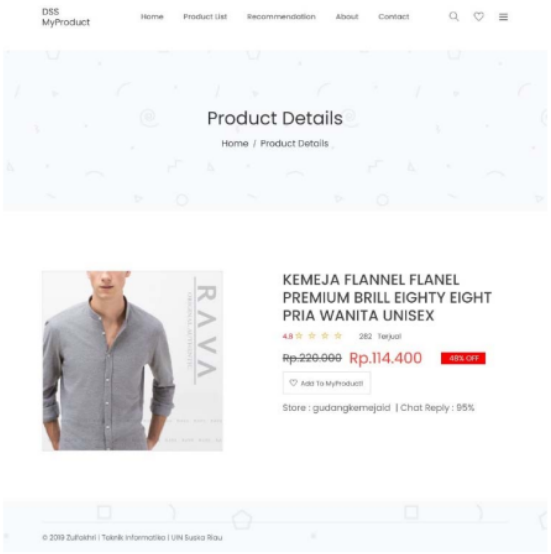

Fig. 2. Interface for Product Details

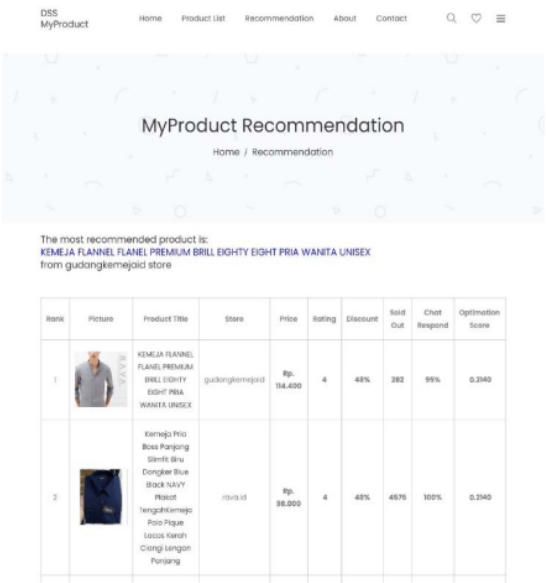

Fig. 3. Recommendations List of Online Shop based on DSS-MOORA

IV. Conclusion

The prototype of DSS-MyProduct has been successfully evolved and positively approved in suggesting the products of online shops for the customers. MOORA analysis on the DSS approach presents the choices of online shops with the optimization values based on the criteria weights of price, rating, discount, the product sold, and response chat. These online shop recommendations aside from providing an alternative to the optimal online shop also equip the customers with knowledge transfer, quality, and service assessments in the sales business. The maximum value proposed by online shops will certainly impact on increasing customer loyalty. Moreover, the recommendations analysis, and process of this prototype system will develop into a lesson learned for the customers and producers on how to conduct the online business transaction. Transparency of information in this system presents the openness and trust in doing business thus business to business (B to B) and business to customers (B to C) relationships turn into more objective, especially in business transactions. This assuredly encourages the creativity and innovation of producers/online shops to meet the online market demands and reach competitive advantages.

This concept of DSS-MOORA is restricted to men's shirt products. Nonetheless, the application of DSS-MOORA can be expanded into other types of online products. Further research is required to explore the advancement of the MOORA algorithm for multiple decision-making processes on various types of products. Hence, the constructed of DSS as intelligent systems become more delve into. In addition, this application can be embedded in the marketplace's website as an additional feature thus the customers will be guided in selecting the right online shop for shopping.

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