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Research Article

Intuitionistic Fuzzy AHP and WASPAS to Assess Service Quality in Online Transportation

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A B S T R A C T

Indonesia is currently entering a new normal era; this requires people to adapt to the clean-living habit in accordance with health standards in order to carry out normal activities. At the same time, online transportation services have reopened for activity. The service quality provided by online ride-hailing companies (i.e., ojek) such as Gojek, Grab, and Maxim must now consider matters relating to user safety. This study proposes Multi Criteria Decision Making (MCDM) as a method for assessing the service quality of online transportation service providers and uses the Pandemic-SERVQUAL 4.0 model. Pandemi-SERVQUAL 4.0 model adds two new criteria, namely "pandemic" and "industry 4.0". The addition of two new criteria that are more relevant to the current circumstances will increase the accuracy of the research. This study aims to propose the integration of Interval Valued Intuitionistic Fuzzy Analytical Hierarchy Process (IVIF-AHP) to determine the criteria weight and Interval Valued Intuitionistic Fuzzy Weighted Aggregated Sum-Product Assessment (IVIF-WASPAS) to assess the service quality of several online transportation service providers based on the obtained criteria weights. From the results of the service quality assessment using the integration of IVIF-AHP and IVIF-WASPAS, the ranking of online transportation service providers during the new normal era were Grab-car, Go-car, and Maxim-car.

INTRODUCTION

Public transportation is a facility that can be utilized by the general public. It can be said to be a basic need and an integral part of urban society. Most people use public transportation as a facility that makes it easier for them to reach their destination, especially for people who don't have private vehicles [1]. According to Munim and Noor [2], the more efficient and up-to-date the transportation system is, the higher the quality of life will be. Current technological developments in the field of transportation can be seen from the availability of online-based public transportation.

The development of online transportation in Indonesia is rapid [3]. There is a wide variety of online transportation options that can be used by consumers. Online transportation, especially online ride-hailing service (i.e., *ojek*), has become one of the top needed services and continues to be used by the public because of its more efficient ordering system [4]. Entering the new normal era, online transportation services have reopened for activity [5]. Currently, there are many online transportation service providers in Indonesia, including Gojek, Grab, Maxim, and inDriver. Referring to a survey conducted by the Association of Indonesian Internet Service Providers [6], it was revealed that Grab and Gojek were ranked as the top 2 most frequently used online transportation in Indonesia [7]. On the other hand, the new normal era has also required people to adapt to the clean-living habit in accordance with health standards in order to carry out normal activities. There are several new regulations implemented by the government to keep consumers safe from exposure to viruses. Online transportation service providers are encouraged to provide sanitation facilities and the given services must also consider matters relating to user safety.

Parasuraman et al. [8] defined service quality as the distinction between customer's expectation and perception of services delivered by companies. One of the most prominent models to assess service quality is SERVQUAL model. Parasuraman et al. [9] have refined their exploratory research conducted in 1985 with the subsequent scale named SERVQUAL to measure customer perceptions of service quality. The original ten dimensions were broken down into five dimensions, namely reliability, responsiveness, assurance, tangibles, and empathy. This model is a well-known, widely used, and important method to evaluate service quality. In the evaluation of transportation services, the biggest problems in the world related to the COVID-

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19 pandemic need to be considered. Therefore, hygiene has become a more important criterion in examining the service quality of public transportation systems. Even if the pandemic ends, the level of cleanliness will still be an important criterion to people [10]. Furthermore, technologies emerging from Industry 4.0 also ought to be implemented in the trasportation system to increase customer satisfaction. In alignment with this, Tumsekkali et al. [10] proposed the Pandemic-SERVQUAL 4.0 model (P-SERVQUAL 4.0), which adds two new criteria: the pandemic and Industry 4.0.

There is still very little research on the service quality of Indonesian online transportation service providers during the COVID 19 pandemic and the new normal era. Silalahi et al. [11] analyzed the service quality of online transportation focusing on the technology aspect. The measurement developed from previous related studies includes three dimensions, which are service quality, information quality, and system quality. Santoso and Aprianingsih [12] examined the relationship between the influence of the service quality and e-service quality toward repurchasing with customer satisfaction as the intermediate variable on Go-Ride service from Gojek Indonesia. Trisandy and Utama [13] assessed the extent to which service quality and price affect customer satisfaction for Gojek users at the Batam State Polytechnic. Furthermore, Aldino and Suroso [14] analyzed the effect of service quality and customer trust on customer satisfaction in Grab online transportation in the city of Purworejo. Marlizar et al. [15] studied the effect of service quality and use of e-service technology on customer satisfaction and customer loyalty of Maxim online transportation in Aceh. Based on these previous studies, the Multi Criteria Decision Making method has not been widely used.

The Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method (MCDM) that assists decision makers in dealing with complex problems by using conflicting and subjective criteria. According to Golden et al. [16], AHP has the characteristics of being simple, easy to use, more flexible, and has the ability to deal with complex and unstructured problems as well as having been successfully applied to various complex decision-making problems. AHP is one of the most popular methods with its comprehensive, logical, and structured system [17]. Meanwhile, WASPAS is the result of the integration of Weighted Sum Model (WSM) and Weighted Product Model (WPM) methods and it has been widely used in literature since 2012 [18]. This integration ultimately makes the WASPAS method work more precisely and comprehensively than the WSM and WPM components, resulting in a more reliable solution [19].

Intuistic Fuzzy sets (IFS) were first introduced by Attanassov in 1983 and it can be considered as an improvement over the original version of fuzzy sets proposed by Zadeh. In contrast to other types of fuzzy sets, IFS calculates both membership and non-membership degrees, making it a very effective instrument in overcoming uncertainty [20]. Wu et al. [20] proposed the Interval Valued Intuitionistic Fuzzy (IVIF)-AHP method to evaluate the weights of criteria. Zavadkas et al. [21] used IVIF-WASPAS to rank alternatives. Furthermore, Alimohammadlou and Khoshsepehr [22] proposed the integration of IVIF-AHP and IVIF-WASPAS and stated that the produced results were more accurate and transparent than other methods.

To the best of the researchers' knowledge, the assessment of service quality of online transportation service providers, especially car in the new normal era, has never been conducted in Indonesia. Therefore, this study proposes Multi Criteria Decision Making (MCDM) as a method for assessing the service quality of online transportation service providers and uses the Pandemic-SERVQUAL 4.0 model proposed by [10]. Research performed by [23] stated that the integration of Fuzzy Analytic Hierarchy Process (AHP) and Fuzzy Weighted Aggregated Sum-Product Assessment (WASPAS) is most often used because it provides ease of implementation. According to [24], fuzzy sets are applied in performance measurements to reduce ambiguity. Therefore, the Valued Intuitionistic Fuzzy Interval (IVIF) will be used in this study to overcome the uncertainty associated with subjective judgments made by online transportation users. This study aims to propose the integration of Interval Valued Intuitionistic Fuzzy Analytic Hierarchy Process (IVIF-AHP) to determine the weight of criteria and Interval Valued Intuitionistic Fuzzy Weighted Aggregated Sum-Product Assessment (IVIF-WASPAS) to assess the quality of service from several online transportation service providers based on the obtained criteria weights.

METHOD

Before we implement the proposed method to assess the quality of service from several online transportation service providers, there are several steps that must be carried out. First, we determine the criteria by referring to research conducted by Tumsekcali [10] and several other previous studies. The second step is to determine the number of respondents and the sampling technique. Third, we develop and distribute questionnaires that will be given to respondents based on predetermined criteria. After these three steps were carried out, the results of the questionnaire were processed by IVIF AHP-WASPAS to obtain a ranking of online transportation service providers during the pandemic and the new normal era.

Determination of Service Quality Evaluation Criteria

The determination of the criteria refers to the P-SERVQUAL 4.0 model, which was first introduced by Tumsekcali et al. [10]. This model is a development of SERVQUAL. The SERVQUAL model was deemed to be insufficient to evaluate service quality in a world that is already more technologically advanced and in the conditions of the current new normal era. The model created by [10] was motivated by the absence of research discussing matters related to the pandemic and Industry 4.0. The P-SERVQUAL 4.0 was proposed to evaluate the service quality of public transportation and uses 5 main criteria in SERVQUAL and two new criteria, namely digital technology and pandemic. The determination of the criteria and sub-criteria in this study refers to [10] with some adjustments for the evaluation of service quality in online transportation.

Figure 1 demonstrates the criteria hierarchical structure consisting of three levels. Level 1 states the criteria, level 2 states the sub-criteria and level 3 states the sub-sub criteria. The 7 criteria at level 1 are elaborated into 15 sub-criteria and 20 sub-sub criteria. The determination of the sub-sub criteria at level 3 refers to several previous studies, as shown in Table 1.

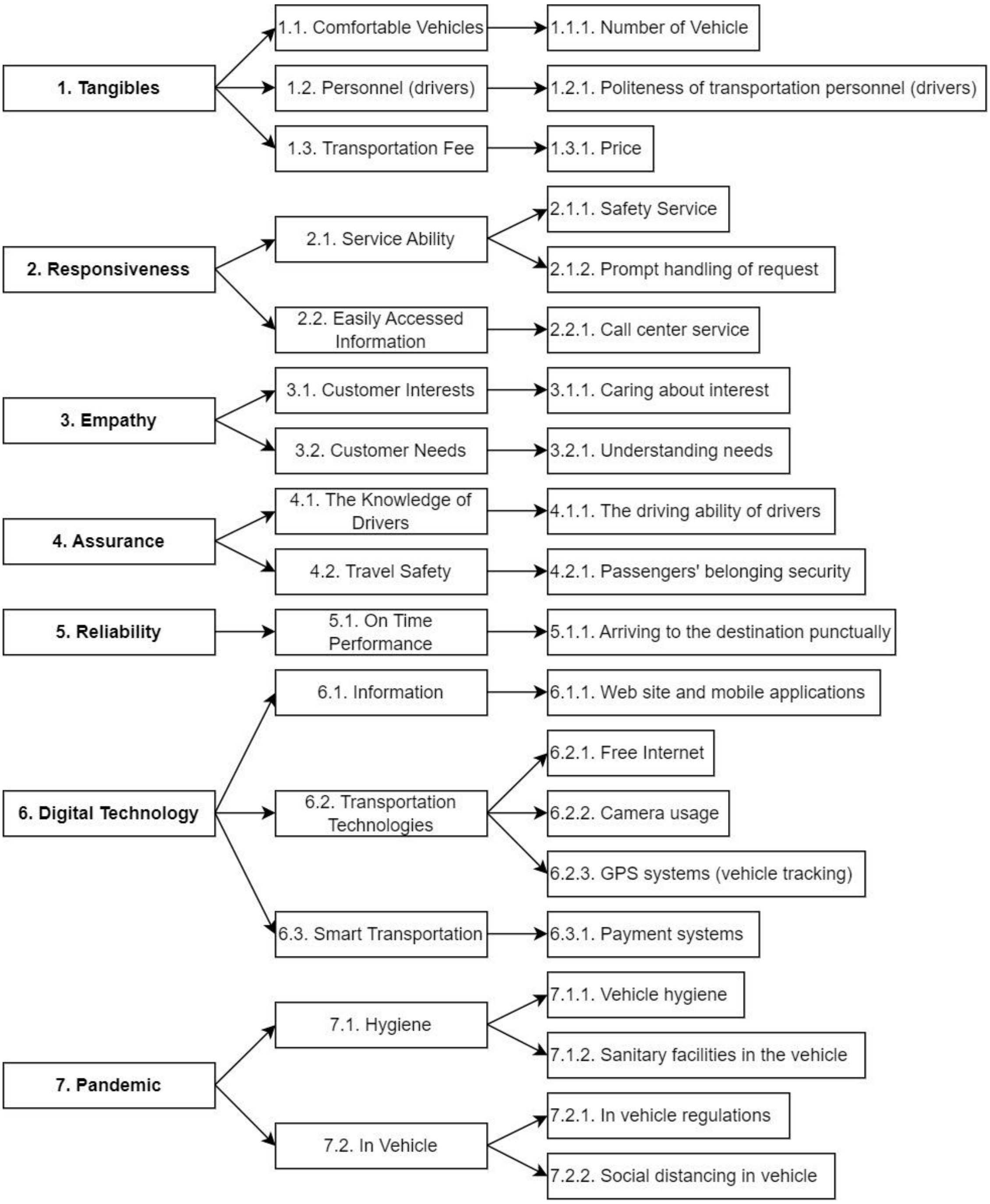

Figure 1. Three-Level Criteria Structure of Quality Assessment of Online Transportation Service Providers

Table 2. Determination of Sub-sub Criteria and the References in Use

Sub-sub Criteria	Reference	Sub-sub Criteria	Reference
1.1.1. Number of Vehicle	[24]	5.1.1. Arriving to the destination punctually	[29, 30]
1.2.1. Politeness of transportation personnel (drivers)	[31, 32]	6.1.1. Website and mobile applications	[10]
1.3.1. Price	[30]	6.2.1. Free internet	[33]
2.1.1. *Safety Service*	[34]	6.2.2. Camera usage	[35]
2.1.2. Prompt handling of request	[36]	6.2.3. GPS systems (vehicle tracking)	[37]
2.2.1. Call center service	[29, 30]	6.3.1. Payment systems	[37]
3.1.1. Caring about interest	[36]	7.1.1. Vehicle hygiene	[27, 35]
3.2.1. Understanding needs	[34]	7.1.2. Sanitary facilities in the vehicle	[35]
4.1.1. The driving ability of drivers	[32]	7.2.1. In vehicle regulations	[27]
4.2.1. Passengers’ belonging security	[32]	7.2.2. Social distancing in vehicle	[27]

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1. The Tangibles criterion refers to the appearance of physical facilities, which can be seen from the equipment and personnel at work [25]. It consists of three sub criteria, namely "Comfortable Vehicle", "Personnel (drivers)", and "Transportation Fee".
2. The Responsiveness criterion refers to the willingness to help customers and provide a fast response [25]. It comprises two sub criteria, namely "Service Ability" and "Easily Accessed Information".
3. The Empathy criterion refers to the treatment given to customers and the ability to understand the needs and desires of customers [26]. It is composed of two sub criteria, namely "Customer Interests" and "Customer Needs".
4. The Assurance criterion refers to the knowledge, courtesy of employees, and the ability to convey trust and confidence to customers [9]. Assurance is determined by two sub criteria, namely "The Knowledge of Drivers" and "Travel Safety".
5. The Reliability criterion refers to the ability to perform the promised service reliably and accurately [9]. Reliability performance is determined by one sub-criteria, namely "On Time Performance".
6. The Digital Technology criterion refers to technological advances which are also commonly called Industry 4.0. The performance of Digital Technology is determined by three sub criteria. The first sub criterion is "Information" which is detailed to one sub-sub criterion, namely "Web site and mobile applications". This sub criterion is important in the process of evaluating service quality [10] because it will later make it easier for consumers to access the desired transportation service. The second sub criterion is “Transportation Technologies”, which is elaborated into 3 sub-sub criteria. The first sub-sub criterion is “Free Internet”, which means that customers can access free internet through their smart phones and devices while inside the vehicle. Furthermore, the second and third sub-sub criteria are “Camera usage” and “GPS system (vehicle tracking)”. The technology developed in this aspect of online transportation will ultimately improve security and technological infrastructure. Monitoring of activities in the vehicle can be done by placing a camera inside it, hence increasing the customer's feeling of security. This can simultaneously be supported by the use of GPS which will track the position, speed, and route of the vehicle. Finally, the third sub criterion is "Smart Transportation" which consists of 1 sub-sub criterion, namely "Payment systems". This concerns how the payment system is carried out, whether the service provider provides options such as payment through application (cardless payment).
7. The Pandemic criterion refers to a pandemic situation that shifts society’s behaviour towards paying more attention to hygiene. Service quality regarding the Pandemic criteria is determined by two sub criteria, namely "Hygiene" and "In Vehicle". The former is composed of "Vehicle hygiene" and "Sanitary facilities in the vehicle" sub-sub criteria. "Vehicle hygiene" refers to the obligation of online transportation service providers to improve hygiene standards, since customers require better "Hygiene" during the pandemic and the new normal era. This translates to the sterilization of parts inside the vehicle that potentially have direct contact with customers [27]. Furthermore, the "Sanitary facilities in the vehicle" sub-sub criterion requires these providers to provide sanitation facilities inside the vehicle, so that customers can disinfect before touching the surface to avoid contamination [28]. On the other hand, the sub criterion “In Vehicle” is broken down into two sub-sub criteria: “In-vehicle regulations” and “Social distancing in vehicle”. The former refers to the alertness of drivers to check body temperature and remind the use of masks while the latter is a regulation that must be implemented to prevent the spread of the virus.

Sampling Technique and Determination of Sample Size

The sampling technique in this research is non-probability sampling using Purposive Sampling method. The sampling is purposive, provided that the respondents have used a car service by Gojek, Grab, and Maxim at least once during the pandemic. This is meant to prevent biased opinions since each respondent will have had experience in using all three online transportation service providers. To determine the sample size, Bernoulli's formula is used because the population size cannot be known with certainty [38]. The minimum sample size is calculated by Equation 1:

$$n = \frac{(Z\alpha/_2)^2 x\ p\ x\ q}{e^2} \tag{1}$$

Development and Distribution of Questionnaire

The questionnaire in this study consists of two parts. Part 1 contains questions related to the level of importance between criteria at levels 1, 2 and 3. The assessment of the level of importance is carried out by pairwise comparison between the two criteria using the linguistic terms given in Table 2 [10, 22]. Part 2 contains questions regarding the performance of each online transportation service provider, namely Gojek, Grab, and Maxim. The performance assessment of each online transportation service provider on each sub-sub criteria uses linguistic terms shown in Table 3 [10]. After being compiled, the questionnaire was then distributed to respondents with the conditions previously mentioned. The distribution of the questionnaire was done by accompanying the respondents one by one so that the respondents could ask questions if there were unclear about the questions.

Table 3. Linguistic Scale of Importance Level for IVIF-AHP

Linguistic Terms	**Crisp Value**	**Membership and non-membership values**			
		μ^L	μ^U	v^L	v^U
Absolutely Low Importance (AL)	1	0.10	0.25	0.65	0.75
Very Low Importance (VL)	2	0.15	0.30	0.60	0.70
Low Importance (L)	3	0.20	0.35	0.55	0.65
Medium Low Importance (ML)	4	0.25	0.40	0.50	0.60
Equal Importance (EE)	5	0.50	0.50	0.50	0.50
Medium High Importance (MH)	6	0.50	0.60	0.25	0.40
High Importance (H)	7	0.55	0.65	0.20	0.35
Very High Importance (VH)	8	0.60	0.70	0.15	0.30
Absolutely High Importance (AH)	9	0.65	0.75	0.10	0.25

Table 4. Linguistic Scale of Performance Level for IVIF-WASPAS

Linguistic Terms	Crisp Value	Membership and non-membership values			
		v^U	v^U	v_I^-	v_I^+
Extremely Bad (EB)	1	0.01	0.05	0.9	0.95
Very Very Bad (VVB)	2	0.05	0.1	0.8	0.85
Very Bad (VB)	3	0.15	0.2	0.7	0.75
Bad (B)	4	0.25	0.3	0.6	0.65
Medium Bad (MB)	5	0.35	0.4	0.5	0.55
Medium (M)	6	0.45	0.5	0.4	0.45
Medium Good (MG)	7	0.55	0.6	0.3	0.35
Good (G)	8	0.65	0.7	0.2	0.25
Very Good (VG)	9	0.75	0.8	0.1	0.15
Very Very Good (VVG)	10	0.85	0.9	0.05	0.1
Extremely Good (EG)	11	0.9	0.95	0.01	0.05

Proposed Method

In this paper, we propose an approach for MCDM problems with an interval-valued intuitionistic AHP and IVIF-WASPAS method. IVIF-AHP was used to weight the sub-sub criteria. Following that, the results were used as the input of the IVIF-WASPAS for the ranking procedure. The methodology is composed of two phases. The first phase consists of nine steps and ends by obtaining the level-3 criteria weights. The second phase consists of ten steps and ends by ranking the online transportation service providers. Figure 2 illustrates the flowchart of the proposed method.

Phase 1: Calculation of Criteria Weight using IVIF-AHP

The steps in phase 1 of the proposed method refer to the IVIF-AHP procedure developed by [10], [20], [22] dan [39].

Step 1. Create the linguistic pairwise comparison matrix for each respondent.

Step 2. Convert the linguistic pairwise matrix to their IVIF values using Table 2 to obtain intuitionistic pairwise comparison matrix. Afterwards, perform aggregation of the IVIF value for the i and j criteria pairs by using Equations 2-5 to obtain the aggregated intuitionistic pairwise comparison matrix ($\tilde{R}_g$) [39]. The aggregated intuitionistic pairwise comparison matrix is represented by Equation 6.

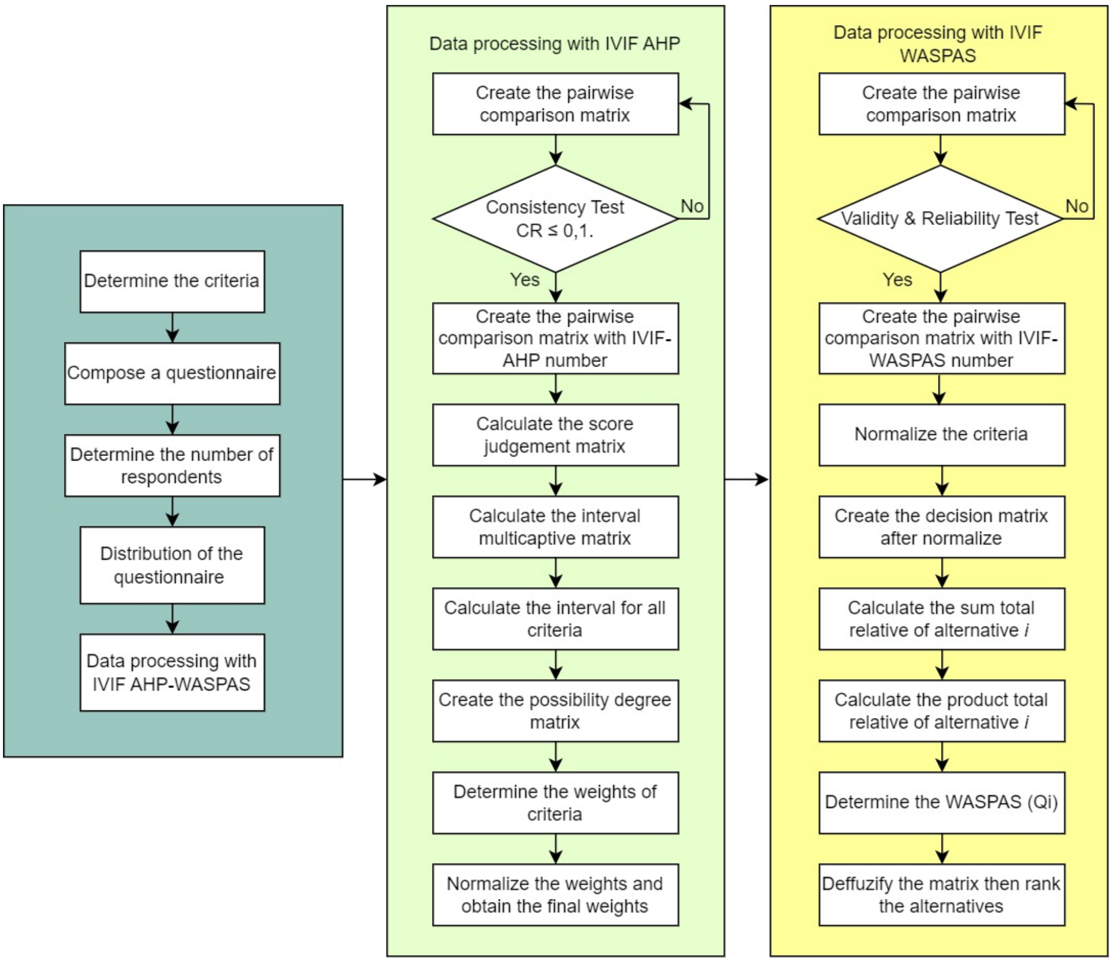

Figure 2. Flowchart of the Proposed Method

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$$\mu_{g1n}^{L} = 1 - (\sqrt[k]{(1-\mu_{11n}^{L})\ x\ (1-\mu_{21n}^{L})\ x\ (\dots\dots\dots)\ x\ (1-\mu_{k1n}^{L})} \quad (2)$$

$$\mu_{g1n}^{U} = 1 - (\sqrt[k]{(1-\mu_{11n}^{U})\ x\ (1-\mu_{21n}^{U})\ x\ (\dots\dots\dots)\ x\ (1-\mu_{k1n}^{U})} \quad (3)$$

$$v_{g1n}^{L} = (\sqrt[k]{v_{11n}^{L}\ x\ v_{21n}^{L}\ x \dots\dots x\ v_{k1n}^{L}} \quad (4)$$

$$v_{g1n}^{U} = (\sqrt[k]{v_{11n}^{U}\ x\ v_{21n}^{U}\ x \dots\dots x\ v_{k1n}^{U}} \quad (5)$$

$$\tilde{R}_g = \begin{bmatrix} [\mu_{g11}^{L}, \mu_{g11}^{U}], [v_{g11}^{L}, v_{g11}^{U}] & \cdots & [\mu_{g1n}^{L}, \mu_{g1n}^{U}], [v_{g1n}^{L}, v_{g1n}^{U}] \\ \vdots & \ddots & \vdots \\ [\mu_{gn1}^{L}, \mu_{gn1}^{U}], [v_{gn1}^{L}, v_{gn1}^{U}] & \cdots & [\mu_{gnn}^{L}, \mu_{gnn}^{U}], [v_{gnn}^{L}, v_{gnn}^{U}] \end{bmatrix} \quad (6)$$

μ_{kij} denote the membership function interval for the pair of i-th criterion and the j-th criterion (i, j = 1,2,3,…, n) by respondent k (k = 1, 2, …., m). Their starting and ending points are denoted by $[\mu_{kij}^{L}, \mu_{kij}^{U}]$. v_{kij} denote the non-membership function interval for the pair of i-th criterion and the j-th criterion (i, j = 1,2,3,… n) by respondent k (k = 1, 2,…, m). Their starting and ending points are denoted by $[v_{kij}^{L}, v_{kij}^{U}]$. Whereas μ_{gij} and v_{gij} denote the membership function interval and non-membership function interval for aggregated value from the i and j criteria pairs.

Step 3. Conduct a consistency test to examine whether the assessment of the importance level of the sub-sub criteria by the respondents is consistent. The crisp values proposed by Saaty is used to find the consistency ratio (CR) [10]. Because the assessment in this study was carried out by one group of respondents, it is necessary to aggregate the assessment data. Aggregation is obtained by calculating the geometric average of the assessment of the importance level between criteria by all respondents. Furthermore, the aggregated pairwise comparison matrix expressed in crisp values is used to calculate the matrix consistency index (CI). The matrix consistency index (CI) is calculated using Equation 7 and the Consistency Ratio (CR) is calculated by Equation 8. If the CR value ≤ 0.1, the assessment of the importance level of the criteria is said to be consistent [40].

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (7)$$

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

Step 4. Calculate the score judgment matrix using Equation 9 [20, 22].

$$\tilde{S} = \begin{bmatrix} [\mu_{g11}^{L} - v_{g11}^{U}], [\mu_{g11}^{U} - v_{g11}^{L}] & \cdots & [\mu_{g1n}^{L} - v_{g1n}^{U}], [\mu_{g1n}^{U} - v_{g1n}^{L}] \\ \vdots & \ddots & \vdots \\ [\mu_{gn1}^{L} - v_{gn1}^{U}], [\mu_{gn1}^{U} - v_{gn1}^{L}] & \cdots & [\mu_{gnn}^{L} - v_{gnn}^{U}] \cdot [\mu_{gnn}^{U} - v_{gnn}^{L}] \end{bmatrix} \quad (9)$$

Step 5. Calculate the interval multiplicative matrix using Equation 10.

$$\tilde{A} = \begin{bmatrix} 10^{[\mu_{g11}^{L} - v_{g11}^{U}], [\mu_{g11}^{U} - v_{g11}^{L}]} & \cdots & 10^{[\mu_{g11}^{L} - v_{g11}^{U}], [\mu_{g11}^{U} - v_{g11}^{L}]} \\ \vdots & \ddots & \vdots \\ 10^{[\mu_{gn1}^{L} - v_{gn1}^{U}], [\mu_{gn1}^{U} - v_{gn1}^{L}]} & \cdots & 10^{[\mu_{gnm}^{L} - v_{gnm}^{U}], [\mu_{gnm}^{U} - v_{gnm}^{L}]} \end{bmatrix} \quad 10)$$

Step 6. Calculate the weight vector for all criteria using Equation 11.

$$\widetilde{W}_i = \left[\frac{\sum_{j=1}^{n} \tilde{a}_{ij}^{L}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij}^{U}}, \frac{\sum_{j=1}^{n} \tilde{a}_{ij}^{U}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij}^{L}}\right] \quad (11)$$

Step 7. Create the probability degree matrix using Equation 12.

$$P(W_i \geq W_j) = \frac{\min\left\{L_{W_i} + L_{W_j} \cdot \max\left(w_i^{U} - w_j^{L}.0\right)\right\}}{L_{W_i} + L_{W_j}} \quad (12)$$

Dimana $L_{W_i} = w_i^{U} - w_i^{L}$ dan $L_{W_j} = w_j^{U} - w_j^{L}$ dan $P_{ij} \geq 0, P_{ij} + P_{ji} = 1, P_{ii} = 0.5$

Step 8. Calculate criteria weights using Equation 13.

$$W_i = \frac{1}{n}\left[\sum_{j=1}^{n} P_{ij} + \frac{n}{2} - 1\right] \quad (13)$$

Step 9. Normalize the weights (W_i) and obtain the final weights using Equation 14.

$$W_i^{T} = \frac{W_i}{\sum_{i=1}^{n} W_i} \quad (14)$$

Phase 2: Ranking Procedure with IVIF-WASPAS

The steps in phase 2 of the proposed method refer to the IVIF-WASPAS procedure developed by [21, 22].

Step 1. Construct the alternative assesment matrix for each respondent using the linguistic terms in Table 3.

$$X^{k} = \begin{bmatrix} x_{11}^{k} & x_{12}^{k} & \cdots & x_{1n}^{k} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \quad (15)$$

Where x_{ij}^{k} defines the evaluation value of alternative i according to criterion j by respondent k. Variables n and m define the number of criteria and alternatives, respectively.

Step 2. Convert the linguistic terms in the alternative assesment matrix into their crisp values based on Table 3. Convert the matrices of the 1st to k-th respondent.

Step 3. Perform validity test and reliability test to examine whether part 2 of the questionnaire is valid and reliable, so that the results of the questionnaire can be processed to the next step. The input of these tests is the converted matrix produced in step 2. The data is said to be valid if the value of $R_{test} > R_{table}$. Moreover, according to [41], the data is said to be reliable if the Cronbach's alpha value > 0.6.

Step 4. Convert the linguistic terms in the alternative assesment matrix to their IVIF values using Table 3. Next, aggregate the IVIF values using Equations 2-5 to obtain the aggregated intuitionistic alternative assessment matrix $(\tilde{X}_g)$. $(\tilde{X}_g)$ is represented by Equation 16.

$$\tilde{X}_g = \begin{bmatrix} \tilde{X}_{11} & \dots & \tilde{X}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{X}_{m1} & \dots & \tilde{X}_{mn} \end{bmatrix} = \begin{bmatrix} [\mu_{11}^L, \mu_{11}^U], [v_{11}^L, v_{11}^U] & \dots & [\mu_{1n}^L, \mu_{1n}^U], [v_{1n}^L, v_{1n}^U] \\ \vdots & \ddots & \vdots \\ [\mu_{m1}^L, \mu_{m1}^U], [v_{m1}^L, v_{m1}^U] & \dots & [\mu_{mn}^L, \mu_{mn}^U], [v_{mn}^L, v_{mn}^U] \end{bmatrix} \quad (16)$$

Step 5. In this step, the criteria are divided into two subsets: the subset containing the benefit criteria (B) and the subset containing the cost criteria (C). Then, the normalization of the alternative scoring matrix is calculated using Equations 17-20 and the normalized matrix $\tilde{\bar{X}}$ is demonstrated by Equation 21.

$$\tilde{\bar{X}}_{ij} = \frac{\tilde{x}_{ij}}{max_i\, \tilde{x}_{ij}}, j \epsilon \mathrm{B} \quad (17)$$

$$\max_i \tilde{x}_{ij} = \left(\left[\max_i \mu_{ij}^L, \max_i \mu_{ij}^U\right], \left[\min_i v_{ij}^L, \min_i v_{ij}^U\right]\right) \quad (18)$$

$$\tilde{\bar{X}}_{ij} = \frac{min_i\, \tilde{x}_{ij}}{\tilde{x}_{ij}}, j \epsilon \mathrm{C} \quad (19)$$

$$\min_i \tilde{x}_{ij} = \left(\left[\min_i \mu_{ij}^L, \min_i \mu_{ij}^U\right], \left[\max_i v_{ij}^L, \max_i v_{ij}^U\right]\right) \quad (20)$$

$$\tilde{\bar{X}} = \begin{bmatrix} \tilde{\bar{x}}_{11} & \tilde{\bar{x}}_{12} & \cdots & \tilde{\bar{x}}_{1n} \\ \tilde{\bar{x}}_{21} & \tilde{\bar{x}}_{22} & \cdots & \tilde{\bar{x}}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\bar{x}}_{m1} & \tilde{\bar{x}}_{m2} & \cdots & \tilde{\bar{x}}_{mn} \end{bmatrix} \quad (21)$$

Step 6. Calculate the sum total relative importance of the alternative i $\left(\tilde{Q}_i^{(1)}\right)$ using Equation 22.

$$\tilde{Q}_i^{(1)} = \sum_{j=1}^{n} \tilde{\bar{x}}_{ij} \,.\, \tilde{W}_j \quad (22)$$

Where $\tilde{W}_j$ is the weight vector for the j-th sub-sub criteria. This vector is obtained from step 6 of Phase 1.

Step 7. Calculate the product total relative importance of the alternative i $(\tilde{Q}_i^{(2)})$ dengan using Equation 23.

$$\tilde{Q}_i^{(2)} = \prod_{j=1}^{n} \left(\tilde{\bar{x}}_{ij}\right)^{\tilde{W}_j} \quad (23)$$

Step 8. Determine the threshold value (λ). Calculate $\tilde{Q}_i$ using Equation 24, where λ takes values between 0 and 1 and it usually takes the value of 0.5 [21].

$$\tilde{Q}_i = \lambda \tilde{Q}_i^{(1)} + (1-\lambda)\tilde{Q}_i^{(2)} \quad (24)$$

Step 9. Defuzzify IVIF number of $\tilde{Q}_i$ to determine the final scores of each alternative. Let $\alpha = [\mu_\alpha^L, \mu_\alpha^U], [v_\alpha^L, v_\alpha^U]$ be an IVIF number. α is defuzzified using Equation 25 [10].

$$\vartheta(\alpha) = \frac{\mu_\alpha^L + \mu_\alpha^U + (1 - v_\alpha^L) + (1 - v_\alpha^U) + \mu_\alpha^L \mu_\alpha^U - \sqrt{(1 - v_\alpha^L)(1 - v_\alpha^U)}}{4} \quad (25)$$

Step 10. Rank the alternatives in descending order of their scores.

RESULTS AND DISCUSSION

Gojek, Grab, and Maxim are 3 of the numerous online transportation service providers. They provide many features, including transportation services using cars or what are commonly called Go-car, Grab-car, and Maxim-car. This research is focused on assessing the quality of online transportation services, specifically cars. The minimum number of respondents has been calculated using the Bernoulli formula as in Equation 1, which gave a threshold of 50 respondents. The respondents that qualify are consumers who have used the car service by Gojek, Grab, and Maxim during the pandemic. The questionnaires were distributed in Malang City area in June to July 2022.

Calculation of Criteria Weight using IVIF-AHP

Step 1. From the results of part 1 of the questionnaire, a linguistic and intuitionistic pairwise comparison matrix was then performed for criteria at levels 1, 2, and 3 for each respondent. Furthermore, by following step 2 to step 9 of Phase 1 of the proposed method, the calculation of criteria weight with IVIF AHP is obtained as follows:

Step 2. Aggregation is obtained from the geometric averages based on the IVIF values in the intuitionistic pairwise comparison matrix of respondents 1 to 50. For example, the aggregated IVIF values for the criteria pair 6.2.1. and 6.2.2 are calculated using Equations 2-5.

$$\mu_{g621622}^L = 1 - (\sqrt[50]{(1-0.2)\; x\; (1-0.5)\; x\; (1-\cdots)\; x\; (1-0.15)} = 0.26$$

$$\mu_{g621622}^U = 1 - (\sqrt[50]{(1-0.35)\; x\; (1-0.50)\; x\; (1-\cdots)\; x\; (1-0.30)} = 0.39$$

$$v_{g621622}^L = (\sqrt[50]{0.55\; x\; 0.50\; x \ldots x\; 0.6} = 0.54$$

$$v_{g621622}^U = (\sqrt[50]{0.65\; x\; 0.5\; x \ldots\; x\; 0.7} = 0.62$$

Using the same procedure, the aggregated IVIF values for level-3 criteria pairs within the Transportation Technologies sub criterion are obtained. The resulting aggregated pairwise comparison matrix $(\tilde{R}_g)$ are as shown in Figure 3.

$$\tilde{R}_g = \begin{bmatrix} [0.5,0.5], [0.5,0.5] & [0.26,0.39], [0.54,0.62] & [0.31,0.41], [0.53,0.6] \\ [0.54,0.62], [0.26,0.39] & [0.5,0.5], [0.5,0.5] & [0.45,0.56], [0.31,0.45] \\ [0.53,0.6], [0.31,0.41] & [0.31,0.45], [0.45,0.56] & [0.5,0.5], [0.5,0.5] \end{bmatrix}$$

Figure 3. Aggregated Intuitionistic Pairwise Comparison Matrix between Sub-sub Criteria Within Transportation Technologies Sub Criterion

Step 3. In this step, the conversion of linguistic terms to crisp values is done using Table 2 based on the linguistic pairwise comparison matrix of each respondent. Afterwards, aggregation is obtained by calculating the geometric average of the importance level crisp values between criteria at levels 1, 2, and

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3 for all respondents. After obtaining the aggregated pairwise comparison matrix, which are expressed in crisp values, consistency test is performed using Equations 7 and 8. For instance, the calculation results of CI and CR for criteria at level 3 are shown as follows.

$$CI = \frac{\lambda_{max} - n}{n-1}$$

$$CI = \frac{22.697 - 20}{20-1}$$

$$CI = 0.1419$$

$$CR = \frac{\mathrm{CI}}{RI}$$

$$CR = \frac{0.1419}{1.63}$$

$$CR = 0.086$$

It can be seen that CR = 0.086 and with CR ≤ 0.1, the criteria are said to be consistent.

Step 4. The calculation of the score judgment matrix is based on the aggregated intuitionistic pairwise comparison matrix that was obtained in step 2 using Equation 9. For example, the calculation of the judgment score for the criteria pair 6.2.1. and 6.2.2 as well as the pair 6.2.3 and 6.2.1 are as follows:

a. Criterion 6.2.1 with Criterion 6.2.2
$\tilde{S}$ $=[\mu^L_{g621622} - v^U_{g621622}],[\mu^U_{g621622} - v^L_{g621622}]$
= [0.26 – 0.62] , [0.39-0.54]
= [-0.36], [-0.15]

b. Criterion 6.2.3 with Criterion 6.2.1
$\tilde{S}$ $= [\mu^L_{g623621} - v^U_{g623621}],[\mu^U_{g623621} - v^L_{g623621}]$
= [0.53 – 0.41], [0.60 – 0.31]
= [0.12], [0.29]

A score judgment matrix ($\widetilde{S}$) is thus obtained for the pairs of level-3 criteria (i.e., sub-sub criteria) within the Transportation Technologies sub criterion, as shown in Figure 4.

$$\tilde{S} = \begin{bmatrix} [0],[0] & [-0.36],[-0.15] & [-0.29],[-0.12] \\ [0.15],[0.36] & [0],[0] & [0],[0.25] \\ [0.12],[0.29] & [-0.25],[0] & [0],[0] \end{bmatrix}$$

Figure 4. Score Judgment Matrix between Sub-sub Criteria within Transportation Technologies Sub Criterion

Step 5. The calculation of the interval multiplicative matrix is based on Equation 10. For example, the interval multiplicative calculation for the criteria pair 6.2.1. and 6.2.2 as well as the pair 6.2.3 and 6.2.1 are as follows:

a. Criteria 6.2.1 with Criteria 6.2.2
$\tilde{A}$ $= 10^{[\mu^L_{621622}-v^U_{g621622}],[\mu^U_{g621622}-v^L_{g621622}]}$
= [10^[-0,36]], [10^[-0,15]]
= [0.437] , [0.708]

b. Criteria 6.2.3 with Criteria 6.2.1
$\tilde{A}$ $= 10^{[\mu^L_{g623621}-v^U_{g623621}],[\mu^U_{g623621}-v^L_{g623621}]}$
= [10^[0.12]] [10^[0.29]]
= [1.318] [1.950]

An interval multiplicative matrix ($\widetilde{A}$) is obtained for pairs of sub-sub criteria within the Transportation Technologies sub criterion, as shown in Figure 5.

$$\tilde{A} = \begin{bmatrix} [1],[1] & [0.437],[0.708] & [0.513],[0.759] \\ [1.413],[2.291] & [1],[1] & [1],[1.778] \\ [1.318],[1.950] & [0.562],[1] & [1],[1] \end{bmatrix}$$

Figure 5. Interval Multiplicative Matrix between Sub-Sub Criteria within Transportation Technologies Sub Criterion

Step 6. The weight vector of each criterion at level 1, 2, and 3 are calculated in this step. According to the criteria's hierarchical structure in Figure 1, the calculation of the weight vector starts from level 1 to obtain the local weights of the criteria. Then, it proceeds to level 2 to calculate thes local weights of the sub-criteria. Finally, calculation is done at level 3 to obtain the local weights of the onsub-sub criteria. The calculation of the weight vector is based on Equation 11 and uses the interval multiplicative matrix obtained from step 5 as its input. For example, the calculation for level-3 criteria of Transportation Technologies refers to the results presented in Figure 5.

$$\sum_{j=1}^{n} \tilde{a}^L_{1j} = 1.949 \sum_{j=1}^{n} \tilde{a}^L_{2j} = 3.413 \sum_{j=1}^{n} \tilde{a}^L_{3j} = 2.881 \sum_{j=1}^{n} \tilde{a}^U_{1j} = 2.467 \sum_{j=1}^{n} \tilde{a}^U_{2j} = 5.069 \sum_{j=1}^{n} \tilde{a}^U_{3j} = 3.950$$

$$\sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{a}^L_{ij} = 8.243 \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{a}^U_{ij} = 11.486$$

Weight of Criteria 6.2.1

$$\widetilde{W}_1 = \left[\frac{\sum_{j=1}^{n} \tilde{a}^L_{1j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^U_{ij}}, \frac{\sum_{j=1}^{n} \tilde{a}^U_{1j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^L_{ij}}\right] = \left[\frac{1.949}{11.486}, \frac{2.467}{8.243}\right] = [0.169, 0.299]$$

Weight of Criteria 6.2.2

$$\widetilde{W}_2 = \left[\frac{\sum_{j=1}^{n} \tilde{a}^L_{2j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^U_{ij}}, \frac{\sum_{j=1}^{n} \tilde{a}^U_{2j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^L_{ij}}\right] = \left[\frac{3.413}{11.486}, \frac{5.069}{8.243}\right] = [0.297, 0.615]$$

Weight of Criteria 6.2.3

$$\widetilde{W}_3 = \left[\frac{\sum_{j=1}^{n} \tilde{a}^L_{3j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^U_{ij}}, \frac{\sum_{j=1}^{n} \tilde{a}^U_{3j}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}^L_{ij}}\right] = \left[\frac{2.881}{11.486}, \frac{3.950}{8.243}\right] = [0.251, 0.479]$$

Step 7. Create a probability degree matrix. Before calculating the probability degree between the 2 criteria, calculate $L_{W_i} = w^U_i - w^L_i$ .For instance, the calculation for the sub-sub criteria in the Transportation Technologies sub criterion are as follows:

$L_{W_1} = w^U_1 - w^L_1 = 0.299 - 0.169 = 0.130$
$L_{W_2} = w^U_2 - w^L_2 = 0.615 - 0.297 = 0.318$
$L_{W_3} = w^U_3 - w^L_3 = 0.479 - 0.251 = 0.228$

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The next step is to calculate the probability degree between the two criteria using Equation 12.

a. Criteria 6.2.1 with Criteria 6.2.2

$$P(W_1 \geq W_2) = \frac{\min\{L_{W_1} + L_{W_2}, \max(w_1^U - w_1^L, 0)\}}{L_{W_1} + L_{W_2}} = \frac{\min\{0.130 + 0.318, \max(0.130, 0)\}}{0.130 + 0.318} = \frac{\min\{0.448, 0.130\}}{0.130 + 0.318} = 0.289$$

b. Criteria 6.2.1 with Criteria 6.2.3

$$P(W_1 \geq W_3) = \frac{\min\{L_{W_1} + L_{W_3}, \max(w_1^U - w_1^L, 0)\}}{L_{W_1} + L_{W_2}} = \frac{\min\{0.130 + 0.228, \max(0.130, 0)\}}{0.130 + 0.228} = \frac{\min\{0.358, 0.130\}}{0.130 + 0.228} = 0.362$$

With $P_{ij} \geq 0, P_{ij} + P_{ji} = 1$, then $P(W_2 \geq W_1) = 1 - 0.289 = 0.711$ and $P_{11} = P_{22} = P_{33} = 0.5$. The probability degree matrix is shown in Figure 6.

$$P = \begin{bmatrix} 0.5 & 0.289 & 0.362 \\ 0.711 & 0.5 & 0.582 \\ 0.638 & 0.418 & 0.5 \end{bmatrix}$$

Figure 6. *P*robability Degree Matrix between Sub-sub Criteria within Transportation Technologies Sub Criterion

Step 8. After creating the probability degree matrix, the weight of each criterion (W_i) is calculated with Equation 13. Using the probability degree matrix in Figure 5, the weight calculation for criteria 6.2.1, 6.2.2, and 6.2.3 are as follows:

a. Weight of criterion 6.2.1

$$W_1 = \frac{1}{n}\left[\sum_{j=1}^{n} P_{1j} + \frac{n}{2} - 1\right] = \frac{1}{3}\left[\sum_{j=1}^{n} P_{1j} + \frac{3}{2} - 1\right] = \frac{1}{3}\left[1.151 + \frac{3}{2} - 1\right] = 0.550$$

b. Weight of criterion 6.2.2

$$W_2 = \frac{1}{n}\left[\sum_{j=1}^{n} P_{2j} + \frac{n}{2} - 1\right] = \frac{1}{3}\left[\sum_{j=1}^{n} P_{2j} + \frac{3}{2} - 1\right] = \frac{1}{3}\left[1.793 + \frac{3}{2} - 1\right] = 0.764$$

c. Weight of criterion 6.2.3

$$W_3 = \frac{1}{n}\left[\sum_{j=1}^{n} P_{3j} + \frac{n}{2} - 1\right] = \frac{1}{3}\left[\sum_{j=1}^{n} P_{3j} + \frac{3}{2} - 1\right] = \frac{1}{3}\left[1.556 + \frac{3}{2} - 1\right] = 0.685$$

Step 9. Normalize the criteria weights from step 8 to obtain the final weights, using Equation 14.

$$W_1^T = \frac{W_1}{\sum_{i=1}^{n} W_i} = \frac{0.550}{1.999} = 0.275$$

$$W_2^T = \frac{W_2}{\sum_{i=1}^{n} W_i} = \frac{0.764}{1.999} = 0.382$$

$$W_3^T = \frac{W_3}{\sum_{i=1}^{n} W_i} = \frac{0.685}{1.999} = 0.343$$

After calculating the weight of the criteria at levels 1 to 3, following steps 1-9 produce the following results as shown in Table 4.

The global weights are obtained by multiplying all local weights at each level. Calculation examples for the global weights of criteria 6.2.1 and 6.3.1 are as follows:

a. Global Weight of Criterion 6.2.1 = Local Weight of Criterion 6 x Local Weight of Criterion 6.2 x Local Weight of Criterion 6.2.1
= 0.1370 x 0.332 x 0.275
= 0.013
b. Global Weight of Criterion 6.3.1 = Local Weight of Criterion 6 x Local Weight of Criterion 6.3 x Local Weight of Criterion 6.3.1
= 0.1370 x 0.274 x 1.000
= 0.038

Determination of Ranking Online Transportation Service Provider with IVIF-WASPAS

Step 1 and 2. Based on the results of part 2 of the questionnaire, steps 1 and 2 are constructing an alternative assessment matrix using the linguistic terms and crisp values of each respondent.

Step 3. Based on the alternative assessment matrix for the three online transportation service providers, the correlation coefficient is calculated. Using SPSS software, this coefficient (r_{test}) is shown in Table 5. Because the value of $r_{test} > r_{table}$ for all level-3 criteria for each service provider, it can be concluded that the questionnaire is valid. The next step is to test the reliability using SPSS software. The Cronbach's alpha value for each service provider is 0.875 for Go-car; 0.836 for Grab-car and 0.824 for Maxim-car. Because the Cronbach's alpha values for all providers are > 0.6, it can be said that the questionnaire is reliable.

Step 4. After converting the linguistic terms of the alternative assessment matrix to their IVIF, the IVIF values are then aggregated using Equations 2-5 to obtain the aggregated intuitionistic alternative assessment matrix, as shown in Figure 7.

$$\tilde{X}_g = \begin{bmatrix} [0.87, 0.92], [0.98, 0.93] & [0.77,0.83], [0.92,0.86] \ldots\ldots & [0.82, 0.88], [0.95, 0.89] \\ [0.85, 0.91], [0.97, 0.92] & [0.82,0.87], [0.94,0.88] \ldots\ldots & [0.84,0.90], [0.96, 0.91] \\ [0.65,0.71], [0.82,0.75] & [0.74,0.79], [0.89,0.83] \ldots\ldots & [0.79,0.85], [0.93, 0.87] \end{bmatrix}$$

Figure 7. Aggregated Intuitionistic Alternative Assessment Matrix

Step 5. Of the criteria at level 3, only criterion 1.3.1 is included in the cost criteria subset (C). Meanwhile, the other 19 sub-sub criteria are classified into the benefit criteria subset (B). Furthermore, the normalization of the alternative scoring matrix is calculated using Equations 17-20 and the normalized $\tilde{\tilde{X}}$ matrix is shown in Figure 8.

$$\tilde{\tilde{X}} = \begin{bmatrix} [0.89, 0.94], [1.00, 0.95] & [0.84,0.90], [1.00,0.93] \ldots\ldots & [0.86, 0.93], [1.00, 0.94] \\ [0.88, 0.94], [1.00, 0.95] & [0.87,0.93], [1.00,0.94] \ldots\ldots & [0.88,0.94], [1.00,0.95] \\ [0.79,0.87], [1.00,0.91] & [0.83,0.89], [1.00,0.93] \ldots\ldots & [0.85,0.91], [1.00,0.94] \end{bmatrix}$$

Figure 8. Normalized $\tilde{\tilde{X}}$ matrix

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Table 4. Result of Level 1, 2, and 3 Criteria Weights using IVIF-AHP

Level 1 Criteria	Local Weight	Level 2 Criteria/ Sub Criteria	Local Weight	Level 3 Criteria/Sub-Sub Criteria	Local Weight	Global Weight	Rank
1.Tangi-ble	0.1467	1.1. Comfortable Vehicle	0.363	1.1.1. Number of vehicles	1.000	0.053	8
		1.2. Personnel (drivers)	0.288	1.2.1. Politeness of transportation personnel	1.000	0.042	12
		1.3. Transportation Fee	0.349	1.3.1. Price	1.000	0.051	10
2. Responsi-venes	0.1505	2.1. Service Ability	0.547	2.1.1. Safety service	0.644	0.053	9
				2.1.2. Prompt handling of request	0.356	0.029	17
		2.2. Easily Accessed Information	0.453	2.2.1. Call center service	1.000	0.068	3
3. Empathy	0.1176	3.1. Customer Interests	0.579	3.1.1. Caring about interest	1.000	0.068	4
		3.2. Customer Needs	0.421	3.2.1. Understanding needs	1.000	0.050	11
4. Assu-rance	0.1476	4.1 The Knowledge of Driver	0.555	4.1.1. The driving ability of drivers	1.000	0.082	2
		4.2. Travel Safety	0.445	4.2.1. Passengers' belonging security	1.000	0.066	5
5. Relia-bility	0.1389	5.1. On Time Performance	1.000	5.1.1. Arriving to the destination punctually	1.000	0.139	1
6. Digital Techno-logy	0.1370	6.1. Information	0.394	6.1.1. Website and mobile applications	1.000	0.054	6
		6.2. Transportation Technologies	0.332	6.2.1. Free internet	0.275	0.013	20
				6.2.2. Camera usage	0.382	0.017	18
				6.2.3. GPS systems (vehicle tracking)	0.343	0.016	19
		6.3. Smart Transportation	0.274	6.3.1. Payment systems	1.000	0.038	16
7. Pandemic	0.1616	7.1. Hygiene	0.579	7.1.1. Vehicle hygiene	0.569	0.053	7
				7.1.2. Sanitary facilities in the vehicle	0.431	0.040	13
		7.2. In Vehicle	0.421	7.2.1. In vehicle regulations	0.555	0.038	14
				7.2.2. Social distancing in vehicle	0.555	0.038	14

Table 5. Result of Validity Test for Part 2 of the Questionnaire

Level-3 Criteria	r_{table} Value	r_{test} Value of Go-car	r_{test} Value of Grab-car	r_{test} Value of Maxim-car
1.1.1	0.279	0.288	0.412	0.503
1.2.1	0.279	0.330	0.656	0.527
1.31	0.279	0.599	0.690	0.540
2.1.1	0.279	0.761	0.644	0.387
2.1.2	0.279	0.649	0.455	0.507
2.2.1	0.279	0.794	0.552	0.497
3.1.1	0.279	0.711	0.665	0.591
3.2.1	0.279	0.609	0.449	0.431
4.1.1	0.279	0.378	0.344	0.512
4.2.1	0.279	0.651	0.562	0.493
5.1.1	0.279	0.453	0.439	0.704
6.1.1	0.279	0.348	0.498	0.519
6.2.1	0.279	0.434	0.297	0.283
6.2.2	0.279	0.297	0.310	0.316
6.2.3	0.279	0.544	0.498	0.540
6.3.1	0.279	0.691	0.507	0.323
7.1.1	0.279	0.723	0.580	0.616
7.1.2	0.279	0.726	0.528	0.401
7.2.1	0.279	0.833	0.612	0.556
7.2.2	0.279	0.347	0.430	0.573

For instance, the calculation for alternative A2 for criterion 1.1.1 (type max) is as follows:

$$\tilde{X}_{A2C111} = [0.85, 0.91] , [0.97, 0.92]$$

$$\max_i \tilde{x}_{ij} = \left(\left[\max_i \mu_{ij}^L, \max_i \mu_{ij}^U\right], \left[\min_i v_{ij}^L, \min_i v_{ij}^U\right]\right) = (0.97)$$

$$\tilde{\tilde{X}}_{A2C111} = \frac{\tilde{x}_{ij}}{\max_i \tilde{x}_{ij}} = [\frac{0.85}{0.97}, \frac{0.91}{0.97}] , [\frac{0.97}{0.97}, \frac{0.92}{0.97}] = [0.88 , 0.94] , [1.00, 0.95]$$

Meanwhile, the calculation for alternative A1 for criterion 1.3.1 (type min) is as follows:

$$\tilde{X}_{A1C131} = [0.82\ 0.87] , [0.94\ 0.88]$$

$$\min_i \tilde{x}_{ij} = \left(\left[\min_i \mu_{ij}^L, \min_i \mu_{ij}^U\right], \left[\max_i v_{ij}^L, \max_i v_{ij}^U\right]\right) = (0.82)$$

$$\tilde{\tilde{X}}_{A1C131} = \frac{\min_i \tilde{x}_{ij}}{\tilde{x}_{ij}} = [\frac{0.82}{0.82}, \frac{0.82}{0.87}] , [\frac{0.82}{0.94}, \frac{0.82}{0.88}] = [0.10\ 0.92] , [0.80 , 0.87]$$

Step 6. The calculation of the sum total relative importance of alternative *i* is based on Equation 22. For example, the calculation for alternative A1 is as follows:

$\tilde{Q}_1^{(1)} = \sum_{j=1}^{n} [0.89, 0.94], [1.00, 0.95] * [1, 1] + [0.84, 0.90], [1.00, 0.93] * [1, 1] + \cdots + [0.86, 0.93], [1.00, 0.94] * [0.321, 0.563]$ = [0.842, 0.902], [0.998, 0.929]

$\tilde{Q}_2^{(1)}$ = [0.888, 0.916], [0.999, 0.939]
$\tilde{Q}_3^{(1)}$ = [0.828, 0.890], [1.000, 0.934]

Step 7. Calculate the product total relative importance of alternative *i* using Equation 23, with some examples as shown below:

$$\tilde{Q}_1^{(2)} = \prod_{j=1}^{n} [0.89, 0.94], [1.00, 0.95]^{[1,1]} + [0.84, 0.90], [1.00, 0.93]^{[1,1]} + \cdots + [0.86, 0.93], [1.00, 0.94]^{[[0.321, 0.563]]} = [0.833, 0.894], [0.988, 0.921]$$

$\tilde{Q}_2^{(2)}$ = [0.849, 0.908], [0.991, 0.932]
$\tilde{Q}_3^{(2)}$ = [0.819, 0.883], [0.993, 0.927]

Step 8. Determine the threshold value (λ= 0.5). Calculate $\tilde{Q}_i$ using Equation 24.

$\tilde{Q}_1 = 0.5\tilde{Q}_1^{(1)} + 0.5\tilde{Q}_1^{(2)}$
= (0.5 x [0.842, 0.902], [0.998, 0.929]) + (0.5 x [0.833, 0.894], [0.988, 0.921])
= [0.838, 0.898], [0.993, 0.926]

$\tilde{Q}_2$ = (0.5 x [0.888, 0.916], [0.999, 0.939]) + (0.5 x [0.849, 0.908], [0.991, 0.932])
= [0.854, 0.912], [0.996, 0.936]

$\tilde{Q}_3$ = (0.5 x [0.828, 0.890], [1.000, 0.934]) + (0.5 x [0.819, 0.883], [0.993, 0.927])
= [0.823, 0.886], [0.997, 0.930]

Step 9. Perform defuzzification using Equation 25.

$$\vartheta(\tilde{Q}_1) = \frac{0.838+0.898+(1-0.993)+(1-0.926)+0.838*0.898-\sqrt{(1-0.993)(1-0.926)}}{4} = 0.641$$

$$\vartheta(\tilde{Q}_2) = \frac{0.854+0.912+(1-0.996)+(1-0.936)+0.854*0.912-\sqrt{(1-0.996)(1-0.936)}}{4} = 0.652$$

$$\vartheta(\tilde{Q}_3) = \frac{0.823+0.886+(1-0.997)+(1-0.930)+0.823*0.886-\sqrt{(1-0.997)(1-0.930)}}{4} = 0.627$$

Step 10. Perform ranking based on the result of defuzzification in step 9. The results are shown in Table 6.

Table 4. Result of Weight Calculation and Ranking of Service Provider

Online Transportation Service Provider	Code	Score	Rank
Grab-car	A2	0.652	1
Go-car	A1	0.641	2
Maxim-car	A3	0.627	3

DISCUSSION

From Interval Valued Intuitionistic Fuzzy Analytic Hierarchy Process (IVIF-AHP), the weights of criteria at level 1— Tangibles, Responsiveness, Empathy, Assurance, Reliability, Digital Technology, and Pandemic— are obtained at 0.1467, 0.1505, 0.1176, 0.1476, 0.1389, 0.1370, and 0.1616 respectively. The highest weight is assigned to the pandemic criterion. The pandemic situation is indeed the main reason for everyone to increase their alertness to the spread of the virus, considering the high number of victims who have contracted the virus. This situation will influence customer decisions in using online transportation service providers. Online transportation service providers are expected to improve their service security for their customers. Furthermore, the responsiveness criterion has the second highest weight, making it one of the most main considerations for customers in choosing online transportation service providers. A company's responsiveness in handling complaints, criticisms, and suggestions will greatly affect customer satisfaction. Of the seven criteria, empathy has the smallest weight, which is 0.1176.

In the Pandemic criterion, there are 2 sub criteria that are considered in the assessment of online transportation service providers, namely "hygiene" and "in vehicle". From the calculation results, the weight of the "hygiene" sub criterion is 0.579 whereas "in vehicle" is assigned a weight of 0.421. This shows that customers are slightly more concerned with "hygiene" than "in vehicle", meaning that they value clean and sterile vehicles more than the implementation of social distancing and the use of masks. On the other hand, the Digital Technology criterion consists of 3 sub criteria: "information", "transportation technologies", and "smart transportation". From the calculation, the weights of these sub criteria are 0.394, 0.332, and 0.274. It can be concluded that "information" is the most important aspect of the Digital Technology criterion. Information regarding the services provided by online transportation service providers is highly dependent on the availability of websites and mobile applications. It is from websites and mobile applications that customers access information about how they can order the desired service.

From the calculation of the global weights of level-3 criteria, it was revealed that arriving to the destination punctually was ranked first. Although the pandemic criterion has the highest weight, the sub-sub criterion with the highest weight is arriving to the destination punctually. This shows that customers have high expectations regarding the timeliness provided by online transportation service providers during the pandemic and new normal condition. Customers dislike having to wait too long for a vehicle so that they can arrive at their destination on time. Furthermore, the sub criterion that is ranked second is "The driving ability of drivers". The drivers' ability is necessary and customer safety depends on the driver's ability to avoid unwanted things such as accidents and traffic violations. Research done by Alqeed [42] shows the quality of transportation drivers has an influence on customer satisfaction. The third highest weight is assigned to the sub-sub criteria "Call center service", since the call center facilitates customers to give their criticism and suggestions regarding the provided services. Moreover, under the

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"Pandemic" criterion, the sub-sub criterion "vehicle hygiene" is ranked 7th and "Sanitary facilities in the vehicle" is ranked 13th. Based on the results of this research, customers of online transportation services, especially in Malang City, most consider the following service quality criteria relevant with the SERVQUAL dimension: "Arriving to the destination punctually", "Call center service", and "The driving ability of drivers".

Based on the service quality assessment of 3 online transportation service providers using IVIF-WASPAS, Grab-car (A2) was ranked first, followed by Go-car (A1) and finally Maxim-car (A3). This study was conducted in the new normal era. The condition of the new normal era is that residents are able to conduct activities outside the house while still adhering to specified health standards. As a result, the P-SERVQUAL 4.0 dimension is used in this study, which is still relevant to the pandemic and the new normal. From Table 6, it can be seen that the scores of the three online transportation service providers only differ slightly. Research conducted by [43] in 2018 states that Go-Car has significantly fulfilled its customers' satisfaction, whereas Uber Car and Grab Car have not significantly done so. This is different from the results of the research in this study, which is possibly caused by a difference in the data collection time. Meanwhile, another study conducted by [44] in 2022 states that the level of customer satisfaction for Gojek services was "very satisfied", higher than Grab's rating of "satisfied". It can be concluded that the service quality of Gojek and Grab during the pandemic did not have a significant difference. The results of this research concur with the previous statement, proven by the score difference between the two providers only being 0.011. In addition, another study by [45] stated that Gojek and Grab are the 2 most recommended online transportation service providers based on aspects of application quality and driver-customer interactions.

Based on the results of a survey conducted by authors, Grab and Gojek are the top 2 applications according to two application provider platforms, namely Play Store and App Store. In the Play Store, Grab received a rating of 4.8 out of 5 while Gojek received 4.6 out of 5. The two apps have been downloaded more than 100 million times. On the other hand, Maxim was rated 4.8 but was only downloaded just over 10 million times. This is a tenfold difference compared to Gojek and Grab. Gojek and Grab applications was launched earlier than Maxim, explaining why Maxim is somewhat less "popular" among people. Furthermore, in the App Store, Grab received a rating of 4.9 out of 5 while Gojek received 4.5 and Maxim received 4.9. However, according to same survey, customers choose Maxim because it provides cheaper rates than Gojek and Grab. Quoted from user reviews on the Quora website, the competitive advantage that Grab has over Gojek and Maxim is the "Grab Now" feature which allows customers to choose the nearest vehicle without waiting for recommendations from the application. This is a very beneficial feature for its users. Sometimes users need to wait quite a long time because the recommended vehicle is far from the customer's position, even though in reality there are many vehicles that are closer to the customer.

CONCLUSION

This study has used the P-SERVQUAL 4.0 model to evaluate the service quality of online transportation service providers. IVIF-AHP is used to determine the weights of the sub-sub criteria. Then, IVIF-WASPAS is used to rank the alternatives of online transportation service providers, namely Gojek, Grab, and Maxim. Based on the results of data processing, Grab occupies the 1st position as an online transportation service provider during the pandemic whereas Maxim occupies the last position. For future research, the size of the respondents could be expanded by distributing questionnaires throughout Java or throughout Indonesia. Moreover, the criteria at level 3 could be made more comprehensive so that there are at least 2 sub-sub criteria for each sub criterion so as to avoid the local weight value being equal to one, which affects the accuracy of the global weight.

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NOMENCLATURE

n	minimum sample size
α	1- confidence level
e	margin of error (5%)
$Z\alpha/_2$	critical value of the normal distribution at α/2 (α is 0.05 and the critical value is 1.96)
p	proportion of questionnaire filled in correctly
q	proportion of questionnaire considered filled out incorrectly
RI	Random Index
λ_{max}	largest Eigen value
n	number of elements compared
$\widetilde{W}_j$	the weight vector for the j-th sub-sub criteria

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