

## **HFLTS-DEA Model for Benchmarking Qualitative Data**

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International Journal of Advances in Soft Computing and Its Application Vol. 11 No. 2, Juli 2019

1. Submit pada Conference ICSITECH 2018 : 27 Juni 2018
2. Accepted with Major Revision: 31 Juli 2018
3. Submit hasil revisi : 16 Agustus 2018
4. Conference di UTEM Malaka: 30-31 Oktober 2016
5. Accepted to be published in IJASCA Journal: 16 April 2019
6. Submit hasil revisi ke IJASCA: 29 April 2019
7. Pertanyaan seputar status artikel ke IJASCA: 24 Juni 2019
8. Terbit: Juli 2019

## **Bukti Korespondensi Pengajuan Guru Besar Hartono**

Judul Karya Ilmiah : HFLTS-DEA Model for Benchmarking Qualitative Data  
Jurnal : International Journal of Advances in Soft Computing and Its  
Application  
Penulis : Hartono, Erianto Ongko, Dahlan Abdullah  
Edisi : 2019  
Volume : Vol. 11 No. 2  
Penerbit : Al-Zaytoonah University of Jordan

*Int. J. Advance Soft Compu. Appl, Vol. 11, No. 2, July 2019*  
*ISSN 2074-8523*

### **HFLTS-DEA Model for Benchmarking Qualitative Data**

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# Bukti Keikutsertaan pada ICSITECH 2018 dimana semua paper yang diterima dan dipresentasikan akan dipublikasikan pada jurnal IJASCA dan jurnal lainnya sesuai dengan Scope

## CFP

	<b>ICSITech 2018: 2018 4th International Conference on Science in Information Technology (ICSITech)</b> Melaka, Malaysia Melaka, Malaysia, October 30-31, 2018
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Conference website	<a href="http://icsitech.org/">http://icsitech.org/</a>
Submission deadline	June 30, 2018
Final notification of paper acceptance	July 31, 2018
Deadline for camera ready paper	August 15, 2018
Deadline for Registration and payment	September 1, 2018

Topics: [computer science](#) [computer engineering](#) [information technology](#)

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Pattern Recognition	Robotics	Smart City
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- International Journal of Advances in Intelligent Informatics (ISSN:2442-6571, EBSCOHost Indexed, Accredited with "A" Grade (The highest grade) by the Ministry of Research, Technology and Higher Education (RistekDikti) of The Republic of Indonesia)\*
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## Venue

Melaka, Malaysia

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Hartono Ibbi <hartonoibbi@gmail.com>

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### [ICSITech 2018] Paper 1570470912 has been registered

1 pesan

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27 Juni 2018 pukul 10.15

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Cc: Andri Pranolo <andri.pranolo@tif.uad.ac.id>, Ummi Rabaah Hashim <ummi@utem.edu.my>, "Intan Ermahani A. Jalil" <ermahani@utem.edu.my>, Hazli Rafis Abdul Rahim <hazli.rafis@utem.edu.my>, Zahriladha Zakaria <zahriladha@utem.edu.my>, Anas Abdul Latiff <anasabdullatiff@utem.edu.my>

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⋮	Erianto Ongko	Akademi Teknologi Industri Immanuel, Indonesia	eriantoongko@gmail.com	✉	✕
⋮	Dahlan Abdullah	Universitas Malikussaleh, Indonesia	dahlan.unimal@gmail.com	✉	✕

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**Paper title** *HFLTS-DEA Model for Benchmarking Qualitative Data*

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**Abstract** [✉](#) In Data Coverage Analysis (DEA), performance evaluation is generally assumed to be based on a set...

**Keywords** Hesitant Fuzzy Linguistic Term Sets; Data Envelopment Analysis; Benchmarking; Qualitative Data; Computational Trust Only the chairs can edit

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Kepada: Hartono Hartono &lt;hartonoibbi@gmail.com&gt;, Erianto Ongko &lt;eriantoongko@gmail.com&gt;, Dahlan Abdullah &lt;dahlan.unimal@gmail.com&gt;

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Congratulations! We are pleased to inform you that your paper #1570470912 ('HFLTS-DEA Model for Benchmarking Qualitative Data') has been accepted, but requires major revisions and will be presented in the ICSITech 2018.

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> \*\*\* Standard of English: Standard of English

Fair (2)

> \*\*\* Appropriateness of abstract as a description of the paper: Appropriateness of abstract as a description of the paper

Fair (2)

> \*\*\* Use and number of keywords/key phrases: Use and number of keywords/key phrases

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> \*\*\* Relevance and clarity of drawings, graphs and tables: Relevance and clarity of drawings, graphs and tables

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> \*\*\* Appropriateness of the research/study method: Appropriateness of the research/study method

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> \*\*\* Discussion and conclusions: Discussion and conclusions

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> \*\*\* Reference list, adequate and correctly cited: Reference list, adequate and correctly cited

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> \*\*\* Appropriateness of abstract as a description of the paper: Appropriateness of abstract as a description of the paper

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> \*\*\* Relevance and clarity of drawings, graphs and tables: Relevance and clarity of drawings, graphs and tables

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> \*\*\* Appropriateness of the research/study method: Appropriateness of the research/study method

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> \*\*\* Discussion and conclusions: Discussion and conclusions

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Good (3)

> \*\*\* Comments: Explanations for the above ratings and other general comments to the authors

Overall organization is fine however authors must pay attention on the grammars (please use any grammar software to check the sentences - such as the free Grammarly).

Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

Abstract -

1st line - Data Coverage Analysis (DEA) ==> DEA or DCA?

What is DMU? - not explained or spell out.

1. Introduction - 'A wide' not 'a wide'

2. Proposed method - Please describe Figure 1. Numbering the methods in Figure 2 would help in understanding the steps/processes in Section 3 and 4.

3. Please relate the method to the proposed study. Highlight the enhancement/new processes added as mentioned in Figure 2.

4. Experimental process has been described in detail however it must be paralleled with the steps in the proposed method in Section 2.2.

Please revise the sentences in the paragraph. There are some grammatical errors.

Results and Discussion:

- Too little discussion on the results in Section 5.

- First line - The results can be seen in Table 2? (Wrong table reference).

- DMU numbers are not included in Table 13 but have been mentioned in the paragraph.

=====  
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Good (3)

> \*\*\* Standard of English: Standard of English

Poor (1)

> \*\*\* Appropriateness of abstract as a description of the paper: Appropriateness of abstract as a description of the paper

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> \*\*\* Use and number of keywords/key phrases: Use and number of keywords/key phrases

Fair (2)

> \*\*\* Relevance and clarity of drawings, graphs and tables: Relevance and clarity of drawings, graphs and tables

Fair (2)

> \*\*\* Appropriateness of the research/study method: Appropriateness of the research/study method

Fair (2)

> \*\*\* Discussion and conclusions: Discussion and conclusions

Fair (2)

> \*\*\* Reference list, adequate and correctly cited: Reference list, adequate and correctly cited

Fair (2)

> \*\*\* Significance: - How important is the work reported? Does it attack an important/difficult problem (as opposed to a peripheral/simple one)? - Does the approach offered advance the state of the art? - Does it involve or synthesize ideas, methods, approaches from multiple disciplines? - Does it have interesting implications for multiple disciplines?\*

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Fair (2)

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The overall technical quality is acceptable. However, this paper requires serious proofreading as the English language is poor.

-The structure needs to be revised. (Both Section 2 & 3 discussed method)

-No section on literature review / related works.

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**Hartono Ibbi** <hartonoibbi@gmail.com>

1 Agustus 2018 pukul 12.49

Kepada: info2018@icsitech.org

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1 Agustus 2018 pukul 12.50

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Best Regards,

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Pada tanggal Sel, 31 Jul 2018 pukul 18.13 <[info2018@icsitech.org](mailto:info2018@icsitech.org)> menulis:  
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**Tidak ada Komentar, hanya pernyataan Accepted**

**PERBAIKAN YANG DILAKUKAN SESUAI KOMENTAR DARI REVIEWER 2**

## HFLTS-DEA Model for Benchmarking Qualitative Data

Hartono<sup>1</sup>, Erianto Ongko<sup>2</sup>, and Dahlan Abdullah<sup>3</sup>

<sup>1</sup>Department of Computer Science, STMIK IBBI, Medan, Indonesia  
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### Abstract

*In Data Envelopment Analysis (DEA), performance evaluation is generally assumed to be based on a set of quantitative data. In many real-world environments, however, it is necessary to take into account the presence of qualitative factors in assessing the performance of decision-making units. The easiest thing to do is to give an assessment to the input and output values of each Decision-Making Unit (DMU) in the form of scale eg 1 is the best and 5 is the worst. The benchmarking process in qualitative data often creates problems when at the same time some people are giving judgments. Some people who provide an assessment may be able to provide different assessments, perhaps also hesitancy when assessing. The advantage of the Hesitant Fuzzy Linguistic Term Sets (HFLTS) model is that it can provide value for each Input and Output of DMU based on a qualitative and sometimes hesitancy-based assessment. The value provided by HFLTS will be used for the benchmarking process with Data Envelopment Analysis (DEA). Some qualitative data measurements involving Likert scale and Ordinal Data approaches have disadvantages when there are some assessors that provide judgment and can not model the computational trust considering hesitancy, vagueness, and uncertainty. The results of this study indicate that in HFLTS-DEA, the assessor can perform a good assessment in the form of qualitative data on the input and output of each DMU and then there will be available HFLTS evaluation results for use in the benchmarking process with DEA.*

**Keywords:** Computational Trust, Benchmarking, Data Envelopment Analysis, Hesitant Fuzzy Linguistic Term Sets, Qualitative Data

Comment [Office1]: 1st line - Data Coverage Analysis (DEA) ==> DEA or DCA?

Comment [Office2]: What is DMU? - not explained or spell out.

## 1 Introduction

A wide range of problem-setting issues that can be used by DEA, especially in non-profit cases, qualitative factors are often present[1]. In many DEA applications, qualitative or ordinal inputs and outputs have been quantified as convenience for adapting the DEA structure, this quantification may be difficult[2]. Recent studies have begun to address qualitative measures such as outcomes such as education levels [3], actual deaths from expected deaths in health care [4] in the aerospace industry [5]. To solve this problem, there were several approaches to arranging a series of data such as the imprecise model [6] and the project model [7]. Lee and Kim proposed DEA-SERVQUAL to measurement and benchmarking of service quality[8]. SERVQUAL is a multi-dimensional scale of five dimensions and 22 items to measure customer service quality perceptions[9]. The current practice of benchmarking services with SERVQUAL has the limitation that there is no clear guideline to determine who will be comparing and what quality of service to improve[8]. Cronin and Taylor suggested SERVPERF[10], which directly evaluates perceptions of customer performance. The SERVPERF level is more effective than the SERVQUAL weight, because it reduces the number of measured items in the SERVQUAL system by half.

Comment [Office3]: Introduction - 'A wide' not 'a wide'

Traditionally, DEA assumes that input and output variables are known in advance, ignoring critical data uncertainty[11]. Thus, many researchers have tried to model DEA with various uncertain theories. Probability theory is the earliest theory that has been used to determine stochastic DEA models. Sengupta [12] generalized the stochastic DEA model using the expected value. Fuzzy theory is another theory that has been used to address uncertainty in DEA. As one of the DEA initiators, Cooper et al. [6] presented how to deal with inaccurate data such as bound data, serial data, and data delimited by DEA. Kao and Liu have developed a method for finding member functions of fuzzy efficiency values when some inputs or inputs are fuzzy numbers[13]. Puri and Yadav designed the Fuzzy DEA with fuzzy input and output data to overcome the limitations of the existing DEA[14]. Cheng et al. using the Hybrid DEA-AdaBoost in selecting suppliers for fuzzy variables and multiple targets[15]. Hesitant Fuzzy Sets (HFS) was first introduced by Torra. Using HFS provides a more natural model infrastructure for the unique characteristics of trusted decision-making[16]. Ashtiani and Azgomi proposed Hesitant Fuzzy Linguistic Term Sets (HFLTS) with a computational trust model capable of taking into account the hesitancy, vagueness, taste and uncertainty of entities in calculating trust-worth values[17].

In this study we propose the HFLTS-DEA model, in which HFLTS can combine assessment of some assessors for qualitative input and output by considering

computational trusts. The value of the HFLTS will be used by DEA to measure the efficiency of a Decision-Making Unit (DMU). The rest of the paper is organized as follows. In Section 2, The Related Work, In Section 3, Problem Formulations or Methodology. In Section 4, the proposed method. In Section 5, Result, Analysis and Discussions. Finally, the paper reaches a conclusion in Section 6.

## 2 Related Work

The benchmarking process for quantitative data is easier because it can be measured. Measurement of qualitative data will be more difficult, especially if it contains elements of uncertainty and hesitant. The benchmarking process carried out on qualitative data has been carried out by a number of researchers. Lee and Worthington have used the DEA Network Model to conduct a benchmarking process against the quality of university research publications in relation to the benchmarking process of higher education[18]. The use of the DEA Network Model has been carried out by a number of other researchers in the benchmarking process against the university library[19] and also research and development[20]. Use of the DEA Network This model is actually to overcome the limitations of the Standard DEA Model in handling measurements on qualitative data, where each input and output is denoted by a node. Where the weight at each input and output node will be distinguished based on the type of data. The existence of the DEA Model Network can do the benchmarking process on qualitative data, but still cannot overcome the conditions that contain fuzzy, uncertainty, and hesitancy. Research conducted by Jafarzadeh et al. have used Fuzzy Quality Function Development and DEA in the process of benchmarking against qualitative data in uncertainty[21].

The use of Fuzzy in the benchmarking process has been carried out by a number of researchers such as: Ghapanchi et al.[22] proposed the FUZZY DEA method, Huang et al. explained about the Fuzzy AHP method[23], and Tavana et al. put forward the Fuzzy DEA TOPSIS method[24]. Research conducted by a number of researchers although it can overcome the element of uncertainty but has not been able to overcome hesitancy from assessors in providing an assessment. The research conducted by Kao and Lin gave results that in giving assessment is easier to do by using linguistic variables provided by fuzzy[25]. In research involving fuzzy efficiency there are several values that can be given to a qualitative data in a linguistic variable and therefore it is necessary to pay attention to the hesitancy aspects of decision making in the provision of qualitative data[26]. Fuzzy Hesitant can be used for assessment due to the presence of doubt in giving an assessment among several values [27].

**Comment [Office4]:** Please relate the method to the proposed study. Highlight the enhancement/new processes added as mentioned in Figure 2.

### 3 Problem Formulations or Methodology

#### 3.1 HFLTS-DEA Correspondence

Taking the two advantage of HFLTS, A benchmarking process that involves many assessors and computational trusts in providing an assessment, this study proposes a HFLTS-DEA to measuring and benchmarking of qualitative data. Qualitative data measurements cannot be done as easily as quantitative data that directly have a measurable value. Quality measurement is usually expressed in linguistic variables such as: Good and excellent or in the form of linguistic value ranges such as lower than moderate which can mean low and very low. This is coupled with hesitations in decision making related to computational trust. The existence of this can be more easily done by obtaining the exact value to be used in the benchmarking process with DEA, using HFLTS. The HFLTS-DEA correspondence can be seen in Figure 1.

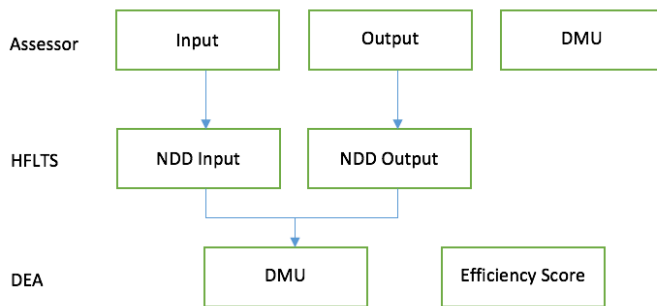


Fig. 1: HFLTS-DEA Correspondence

In Figure 1 it can be seen that in the evaluation of efficiency with DEA, the assessor conducts an assessment process for each DMU based on the inputs and outputs produced by each DMU. The problem that arises is if there are inputs and outputs that contain qualitative data so that the HFLTS method is needed to carry out the assessment process with the DEA. Where each input and output containing qualitative data will be assessed based on Non-Dominance Choice Degree (NDD) values generated by HFLTS. NDD values generated in qualitative data will be assessed together with quantitative data from each DMU by using DEA to obtain efficiency scores from each DMU.

Comment [Office5]: Proposed method - Please describe Figure 1

### 3.2 HFLTS-DEA Model

In general HFLTS-DEA begins with a number of assessors providing an assessment of linguistic terms to the inputs and outputs of each DMU. HFLTS will process collecting the linguistic expressions and then collecting linguistic terms for HFLTS will be conducted. After that, calculating the envelope for hesitant terms will be done and then aggregation process can be done to calculate linguistic interval vector. The next step will be established preference relation degrees and followed by calculating NDD to generate exact values for input and output of each DMU. Once generated the input and output values of each DMU will proceed with the benchmarking process with the bound output of DEA. The benchmarking results will determine whether a DMU is efficient or not. General Scheme of the proposed approach can be seen in Figure 2.

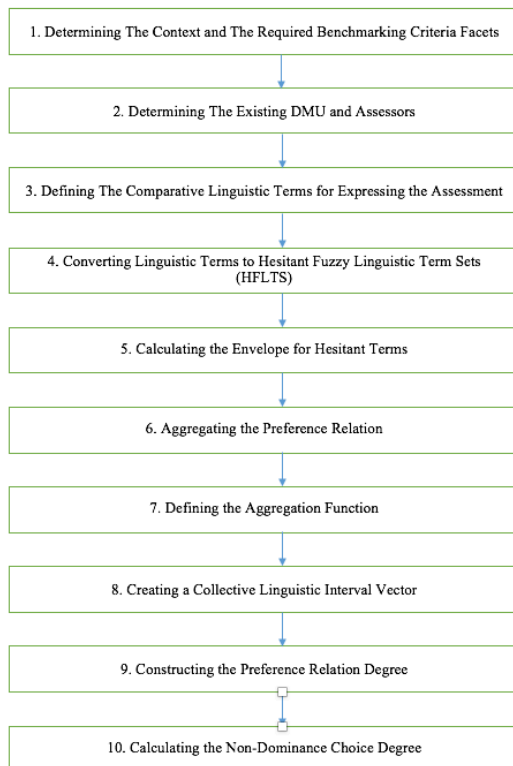


Fig. 2: The General Scheme of The Proposed Method

**Comment [Office6]:** Numbering the methods in Figure 2 would help in understanding the steps/processes in Section 3 and 4.

In Figure 2, it can be seen that the HFLTS-DEA Model consists of 10 (ten) stages, and a more detailed discussion of the stages of the HFLTS-DEA Model can be seen in Sections 4 and 5.

## 4 The Proposed Method

### 4.1 Hesitant Fuzzy Linguistic Term Sets (HFLTS)

As for the steps in Hesitant Fuzzy Linguistic Term Sets (HFLTS) are as follows[17].

#### 1. Determining The Context and The Required Benchmarking Criteria Facets

The first step is to determine the Context and benchmarking criteria for each input and output. Once obtained, then the next step is to define the priority of each criteria in the following set.

$$P_{r \text{ Criteria}}^{\text{Context}} = \{pr_1, \dots, pr_N\} \quad (1)$$

#### 2. Determining The Existing DMU and Assessors

We assume that a set of assessors  $R = \{r_1, \dots, r_M\}$  ( $M \geq 2$ ) express their opinions about a set of existing DMU represented as  $Tr = \{tr_1, \dots, tr_T\}$  ( $T \geq 2$ ). The Assessors provide their assessment about the DMU by using a preference relation matrix as below:

$$P_f^i = \begin{bmatrix} p_{f11}^i & \dots & p_{f1T}^i \\ \vdots & \ddots & \vdots \\ p_{fT1}^i & \dots & p_{fTT}^i \end{bmatrix} \quad (2)$$

Where  $p_f^i$  denotes the preference relation matrix of  $r_i$  toward the benchmarking criteria facet  $f$  and  $p_{f_{lk}}^i$  ( $1 \leq l \leq n$ ,  $1 \leq k \leq n$ ) represents the preference degree of  $t_l$  over  $t_k$  corresponding of the benchmarking facet  $f$  and from the subjective viewpoint of  $r_i$ .

Exthe

#### 3. Defining The Comparative Linguistic Terms for Expressing the Assessment.

For defining the evaluations in qualitative manner, similar to other fuzzy method to trust modeling. The following basic linguistic terms sets is defined.

$$S = \{\text{neither, very low, low, medium, high, very high, absolute}\} \quad (3)$$

There for an assessors  $r_i$  can express his/her opinion through a preference matrix as below:

$$P_f^i = \begin{bmatrix} - & \text{Very High} & \text{Low} \\ \text{Medium} & - & \text{Absolute} \\ \text{Very Low} & \text{Neither} & - \end{bmatrix} \quad (4)$$

In order to provide more complex linguistic expressions, we use the Context-Free Grammar introduced by Rodriguez et al[28].

$$V_N = \{ \langle \text{Primary Term} \rangle, \langle \text{Composite Term} \rangle, \langle \text{Unary Relation} \rangle, \langle \text{Binary Relation} \rangle, \langle \text{Conjunction} \rangle \}$$

$$V_T = \{ \text{Lower than, Greater than, At Least, At Most, Between, and, } s_0, \dots, s_g \}$$

$$i \in V_N$$

$$P =$$

$$\{ I ::= \langle \text{Primary Term} \rangle; \langle \text{Composite Term} \rangle$$

$$\langle \text{Composite Term} \rangle ::= =$$

$$\langle \text{Unary Relation} \rangle \langle \text{Primary Term} \rangle \langle \text{Binary Relation} \rangle$$

$$\langle \text{Primary Term} \rangle \langle \text{Conjunction} \rangle \langle \text{Primary Term} \rangle$$

$$\langle \text{Primary Term} \rangle ::= s_0 | s_1 | \dots | s_g$$

$$\langle \text{Unary Relation} \rangle ::= \text{Lower Than} | \text{Greater Than} | \text{At Least} | \text{At Most}$$

$$\langle \text{Binary Relation} \rangle ::= \text{Between}$$

$$\langle \text{Conjunction} \rangle ::= \text{And} \} \quad (5)$$

An Assessor may express his/her opinion in the following manner:

$$P_f^i = \begin{bmatrix} - & \text{Lower than High} & \text{Low} \\ \text{Greater than Medium} & - & \text{At most Medium} \\ \text{At least High} & \text{Between Very Low and Medium} & - \end{bmatrix} \quad (6)$$

#### 4. Converting Linguistic Terms to Hesitant Fuzzy Linguistic Term Sets (HFLTS)

The conversion function should be performed by using a transformation function as  $E_{G_H}$ .

Assume that  $E_{G_H}$  to be transformation function that converts the linguistic expressions  $l \in S_l$  obtained by using the grammar  $G_H$  to HFLTS. Therefore, this transformation function is formally defined as:

$$E_{G_H}: S_l \rightarrow H_s \quad (7)$$

Where  $S_l$  is the expression domain generated by  $G_H$  and  $H_s$  denotes the HFLTS.

#### 5. Calculating The Envelope for Hesitant Terms

The envelope of HFLTS denoted as  $env(H_s)$  is a linguistic interval which is defined as below:

$$env(H_s) = [H_{s-}, H_{s+}], H_{s-} \leq H_{s+} \quad (8)$$

Where  $H_{s-}$  and  $H_{s+}$  are defined as follows:

$$\begin{aligned} H_{s+} &= \max(s_i) = s_j \in H_s \text{ and } s_i \leq s_j \forall i \\ H_{s-} &= \min(s_i) = s_j \in H_s \text{ and } s_i \geq s_j \forall i \end{aligned} \quad (9)$$

#### 6. Aggregating the Preference Relation

In order to obtain a collective preference for DMUs, language intervals should be aggregated. Aggregation is performed using a linguistic aggregation operator  $\varphi$ . This operator will be applied to lower bound and upper bound of linguistic intervals. This will result in pessimistic (for lower bound aggregation) and optimistic (for upper bound aggregation). The optimistic and pessimistic collective preference matrices are defined as follows:

$$P_C^+ = \begin{bmatrix} (S_r, \alpha)_{11}^+ & \dots & (S_r, \alpha)_{1+}^+ \\ \vdots & \ddots & \vdots \\ (S_r, \alpha)_{T1}^+ & \dots & (S_r, \alpha)_{TT}^+ \end{bmatrix} \quad (10)$$

#### 7. Defining The Aggregation Function

We define the weight parameter for benchmarking criteria aggregation as follows:

$$\omega_i = \text{Vagueness} \times \text{Certainty} \times \text{Trustworthiness} \quad (11)$$

Therefore, we need a parameter to quantify the vagueness of the provided opinion. If we assume that the envelope of HFLTS is defined as  $[s_i, s_j]$   $\{0 \leq i \leq g, 0 \leq j \leq g\}$ , then, the vagueness parameter is defined as follows:

$$\text{Vagueness} = \frac{g - |i - j|}{g} \quad (12)$$

Assume that the basic linguistic terms as below:

$$S = \{\text{Very Doubtful}, \text{Doubtful}, \text{Neutral}, \text{Sure}, \text{Very Sure}, \text{Absolutely Sure}\} \quad (13)$$

By using the following equation, we can convert these certainty expressions to concrete values:

$$\text{Certainty}_i = \Delta^{-1}(S_i, \alpha) \quad (14)$$

Trustworthiness refers to the amount of trust that the benchmarking criteria of DMU has toward the assessors. The distance between the DMU's direct evaluation and the assessors evaluation will updated based on the hesitant normalized Hamming Distance as below:

$$d(\text{DMU}, \text{Assessors}) = \frac{1}{l} \sum_{j=1}^l |h^{\text{Direct}}(x_j) - h^{\text{Evaluation}}(x_j)| \quad (15)$$

#### 8. Creating a Collective Linguistic Interval Vector

The collective linguistic interval vector are calculated as follows:

$$\begin{aligned} p_i^+ &= \Delta(\delta(\Delta^{-1}(s_t, \alpha)_{ij}^+)) \quad \forall j \in \{1, \dots, T\} \\ p_i^- &= \Delta(\delta(\Delta^{-1}(s_t, \alpha)_{ij}^-)) \quad \forall j \in \{1, \dots, T\} \end{aligned} \quad (16)$$

A Collective linguistic interval vector for each DMU as follows:

$$V^t = (p_1^t, p_2^t, \dots, p_T^t) \quad (17)$$

#### 9. Constructing the Preference Relation Degree

By using the following equation we can calculate the preference degree of each DMU:

$$P(A > B) = \frac{\max(0, a_2 - b_1) - \max(0, a_1 - b_2)}{(a_2 - a_1) + (b_2 - b_1)} \quad (18)$$

$$P(B > A) = \frac{\max(0, b_2 - a_1) - \max(0, b_1 - a_2)}{(a_2 - a_1) + (b_2 - b_1)}$$

#### 10. Calculating the Non-Dominance Choice Degree

The NDD of the each DMU is defined as follows:

$$NDD_f = \min \{1 - p_{fji}^s, j = 1 \dots n, j \neq i\} \quad (19)$$

### 4.2 Data Envelopment Analysis with Upper Bound on Output

Fractional Programming with CCR Method can be modeled by the following equation[29].

$$\text{Maximize } \alpha = \frac{\sum_{r=1}^k u_r y_{r0}}{\sum_{s=1}^l v_s x_{s0}} \quad (20)$$

Limit or constraint function:

$$u_r, v_s \geq 0; r = 1, \dots, k; s = 1, \dots, l$$

Where:

$\alpha$  = Efficiency object s

$k$  = output object s observed

$y_{is}$  = the number of outputs i produced by object s

$x_{js}$  = number of inputs i used by object s

$u_i$  = the output weight i produced by object s

$v_j$  = the input weight i given by object s

The linear programming model for generating bounded intervals is as follows:

$$\begin{aligned}
& \text{Maximize } \beta = \sum_{r=1}^k u_r y_{rj} \\
& \sum_{i=1}^m w_{id} x_{id}^l - \sum_{r=1}^s u_{rd} y_{rd}^u \geq 0, j = 1, 2, \dots, n \\
& \sum_{i=1}^m w_{id} x_{id}^l = 1 \\
& w_{id}, u_{rd} \geq \epsilon, \forall id, rd
\end{aligned} \tag{21}$$

In Eq. (21), it can be seen that the DMU is in an under evaluation state in the sense that the issued input is still greater than the maximum output produced. This equation can be refined to produce an output bounder by using linear programming as can be seen in Eq. (22).

$$\begin{aligned}
& \text{Maximize } \beta = \sum_{r=1}^k u_r y_{rj} \\
& \sum_{i=1}^m w_{id} x_{id}^l - \\
& \sum_{r=1}^s u_{rd} y_{rd}^u \geq 0, j = 1, 2, \dots, n \\
& \theta_d^l * \sum_{r=1}^s u_{rd} y_{rd}^l - \sum_{i=1}^m w_{id} x_{id}^u = 0 \\
& \sum_{i=1}^m w_{id} x_{id}^u = 1 \\
& w_{id}, u_{rd} \geq \epsilon, \forall id, rd
\end{aligned} \tag{22}$$

Where  $\theta$  is the upper bound interval.  $\theta$  itself can be obtained by using Eq. (23).

$$\begin{aligned}
& \sum_{i=1}^m w_{id} x_{id}^u = 1 \\
& w_{id}, u_{rd} \geq \epsilon, \forall id, rd
\end{aligned} \tag{23}$$

Where  $\theta$  is essentially the result of a linear equation for the sum of the input values of each DMU.

## 5 Results, Analysis and Discussions

### 5.1 HFLTS Process

To facilitate us in understanding how the HFLTS method works in benchmarking inputs and inputs that are qualitative data, in this study will be given a

benchmarking example of a study program at the Universitas Malikussaleh. In general the inputs are: Number of Students, Number of Lecturers, academic service quality, and academic atmosphere. While the output is: Number of Research, Number of Graduates, and Student Satisfaction. Where there are 2 inputs that is qualitative data, namely: academic service quality and academic atmosphere and 1 output that is qualitative data, that is: student satisfaction. In the study it is assumed that 3 criteria will be assessed by 3 assessors using HFLTS for 3 DMU. The steps are as follows.

1. Determining the results of the assessment in linguistic form

Assessment in linguistic form can be expressed as follows.

- a. Neither
- b. Very Poor
- c. Poor
- d. Medium
- e. Good
- f. Very Good
- g. Absolut

2. Determining the assessment results in linguistic form

Suppose the results of the assessment of the first assessor in the preference matrix is as follows.

$$\begin{aligned}
 P_{Service}^1 &= \begin{bmatrix} - & \text{Between very poor and poor} & \text{Lower than medium} \\ \text{High} & - & \text{At least medium} \\ \text{At most Good} & \text{Between poor and Medium} & - \end{bmatrix} \\
 P_{Atmosphere}^1 &= \begin{bmatrix} - & \text{Greater than medium} & \text{Poor} \\ \text{Very Poor} & - & \text{At least Good} \\ \text{At least medium} & \text{Between high and very high} & - \end{bmatrix} \\
 P_{Satisfaction}^1 &= \begin{bmatrix} - & \text{Good} & \text{Poor} \\ \text{Very Good} & - & \text{At most poor} \\ \text{Between medium and very good} & \text{Greater than medium} & - \end{bmatrix}
 \end{aligned} \quad (24)$$

Suppose the results of the assessment of the second assessor in the preference matrix is as follows.

$$\begin{aligned}
 P_{Service}^2 &= \begin{bmatrix} - & \text{Very poor} & \text{Lower than poor} \\ \text{Between good and very good} & - & \text{very good} \\ \text{Greater than medium} & \text{At most poor} & - \end{bmatrix} \\
 P_{Atmosphere}^2 &= \begin{bmatrix} - & \text{Greater than medium} & \text{Very good} \\ \text{Greater than good} & - & \text{At least medium} \\ \text{Between very poor and medium} & \text{Between medium and very good} & - \end{bmatrix} \quad (25) \\
 P_{Satisfaction}^2 &= \begin{bmatrix} - & \text{Between good and very good} & \text{Medium} \\ \text{Very poor} & - & \text{At least medium} \\ \text{Lower than medium} & \text{Between very poor and poor} & - \end{bmatrix}
 \end{aligned}$$

Suppose the results of the assessment of the third assessor in the preference matrix is as follows.

$$\begin{aligned}
 P_{Service}^3 &= \begin{bmatrix} - & \text{Very poor} & \text{Very good lower than poor} \\ \text{Very poor} & - & \text{Very good} \\ \text{Greater than medium} & \text{medium} & - \end{bmatrix} \\
 P_{Atmosphere}^3 &= \begin{bmatrix} - & \text{Poor} & \text{Very good} \\ \text{Greater than good} & - & \text{Greater than medium} \\ \text{Between very poor and medium} & \text{Very good} & - \end{bmatrix} \quad (26) \\
 P_{Satisfaction}^3 &= \begin{bmatrix} - & \text{High} & \text{Poor} \\ \text{Poor} & - & \text{Medium} \\ \text{Lower than medium} & \text{Between very poor and poor} & - \end{bmatrix}
 \end{aligned}$$

3. Presents the results of the assessment in the form of envelopes linguistic

The next step after obtaining the results of the assessment of the assessors 1, 2, and 3. Then the next step is to combine the results of the assessment and presents it in the form of envelopes linguistic as can be seen in Table 1.

Table 1: Envelopes Linguistic

	Service			Atmosphere			Satisfaction		
$R_1$	-	[vp, p]	[n, m]	-	[g, a]	[p, p]	-	[g, g]	[p, p]
	[g, g]	-	[m, a]	[vp, vp]	-	[g, a]	[vg, vg]	-	[n, p]
	[n, g]	[p, m]	-	[m, a]	[g, vg]	-	[m, vg]	[g, a]	-
$R_2$	-	[vp, vp]	[vp, vp]	-	[g, a]	[vg, vg]	-	[g, vg]	[m, m]
	[g, vg]	-	[vg, vg]	[vg, vg]	-	[m, a]	[vp, vp]	-	[m, a]
	[g, a]	[n, p]	-	[vp, m]	[m, vg]	-	[n, p]	[vp, p]	-
$R_3$	-	[vg, vg]	[n, n]	-	[p, p]	[vg, vg]	-	[g, g]	[p, p]
	[vp, vp]	-	[vg, vg]	[m, m]	-	[g, a]	[p, p]	-	[m, m]
	[g, a]	[m, m]	-	[vp, m]	[vg, vg]	-	[n, p]	[vp, p]	-

Comment [Office7]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

4. Express the degree of certainty of the assessment

The assessor may also state the degree of certainty in providing an assessment in the previous stage (if not granted, the assumed value is 2). The degree of certainty of the assessment if given then it is done in the form of linguistic value.

- a. Very Doubtful = 0
- b. Doubtful = 1
- c. Neutral = 2
- d. Sure = 3
- e. Very Sure = 4
- f. Absolutely = 5

For example, suppose the level of assurance that is filled can be seen in Table 2.

**Comment [Office8]:** Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

Table 2: Degree of Certainty

	Service			Atmosphere			Satisfaction		
$R_1$	-	[d, s]	[s, as]	-	[n, s]	[vd, as]	-	[s, s]	[d, d]
	[vd, d]	-	[d, n]	[vd, vd]	-	[d, n]	[vd, n]	-	[vd, d]
	[vs, vs]	[vs, as]	-	[vs, as]	[d, as]	-	[n, as]	[s, s]	-
$R_2$	-	[n, s]	[d, as]	-	[d, n]	[n, vs]	-	[n, vs]	[d, n]
	[vd, vd]	-	[d, s]	[d, d]	-	[vd, n]	[d, vd]	-	[d, d]
	[s, vs]	[vs, vs]	-	[n, vs]	[s, as]	-	[d, n]	[vd, vs]	-
$R_3$	-	[vd, n]	[s, vs]	-	[sd, vd]	[s, s]	-	[d, n]	[s, as]
	[d, d]	-	[vd, vd]	[d, d]	-	[vd, vd]	[s, s]	-	[as, as]
	[n, n]	[s, s]	-	[as, as]	[s, s]	-	[n, n]	[d, d]	-

5. Determining the Value of Optimistic and Pessimistic Assessment

5.1. Determining the Value of Optimistic Assessment

To perform an optimistic assessment it can be done using equations (10), (11), and (13). Suppose we will determine the optimistic value of DMU 1 to DMU 2 derived from the assessors 1, 2, and 3. Then we can see Table 1 and Table 2. The optimistic assessment results for DMU 1 to 2 for Service, Atmosphere, and Satisfaction are as follows.

- a. Assessment of the 1st Assessor (DMU 1 to 2 for service)

[VP,P], this mean Optimistic is P, and Pessimistic is VP

- b. Assessment of the 2nd Assessor (DMU 1 to 2 for service)

[VP,P], this mean Optimistic is VP, and Pessimistic is VP

c. Assessment of the 3rd Assessor (DMU 1 to 2 for service)

[VG, VG], this mean Optimistic is VG, and Pessimistic is VG

The degree of certainty results for DMU 1 to 2 for Service, Atmosphere, and Satisfaction are as follows.

a. Degree of certainty of the 1st Assessor (DMU 1 to 2 for service)

[D, S], this mean Optimistic is S, and Pessimistic is D

b. Degree of certainty of the 2nd Assessor (DMU 1 to 2 for service)

[N, S], this mean Optimistic is S, and Pessimistic is N

c. Degree of certainty of the 3rd Assessor (DMU 1 to 2 for service)

[VD, N], this mean Optimistic is N, and Pessimistic is VD

So to calculate the optimistic value of DMU 1 to 2 for services derived from the assessors 1, 2, and 3 are as follows:

$$P_{C_{Service_{12}}}^+ = \Delta \left( \frac{1}{\sum_{i=1}^3 w_i} (w_1 \Delta^{-1}(p, 0) + w_2 \Delta^{-1}(vp, 0) + w_3 \Delta^{-1}(vg, 0)) \right) \quad (27)$$

The values of  $W_1$ ,  $W_2$ , and  $W_3$  are calculated as follows.

$$W_1 = Vagueness_1 \chi Certainty_1 \chi Trustworthiness_1$$

$$W_1 = \frac{6-1}{6} \times \Delta^{-1}(s, 0) \times 0.5 = 1.25$$

$$W_2 = \frac{6-(1-1)}{6} \times \Delta^{-1}(s, 0) \times 0.5 = 1.5 \quad (28)$$

$$W_3 = \frac{6-(5-5)}{6} \times \Delta^{-1}(s, 0) \times 0.5 = 1$$

Having obtained values  $W_1$ ,  $W_2$ , and  $W_3$  then we can calculate the optimistic value of DMU 1 to 2 for service criteria.

$$P_{C_{Service_{12}}}^+ = \Delta \left( \frac{1}{3.75} (1.25 \times 2 + 1.5 \times 1 + 1 \times 5) \right) = \Delta(2.39) \quad (29)$$

$$P_{C_{Service_{12}}}^+ = (p, 0.39)$$

The same way can be used to calculate the optimistic values of various DMU combinations for each input and output. So the final result of optimistic value calculation is shown in Table 3.

**Comment [Office9]:** Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

Table 3: Optimistic Value

	Service			Atmosphere			Satisfaction		
$P_c^+$	-	[p, 0.39]	[vp, 0]	-	[a, 0]	[g, -0]	-	[g, 0.4]	[p, 0]
	[p, 0.5]	-	[vg, 0]	[g, 0]	-	[a, -0]	[m, 0.2]	-	[m, 0]
	[vg, 0.42]	[m, -0.29]	-	[g, -0.08]	[a, -0.01]	-	[g, -0.34]	[m, 0.33]	-

5.2. Determining the Value of Pessimistic Assessment

The equation for calculating pessimistic value is the same as calculating the optimistic value. We must calculate the values of  $W_1$ ,  $W_2$ , and  $W_3$  as follows:

$$P_{C_{Service12}}^- = \Delta \left( \frac{1}{\sum_{i=1}^3 w_i} (w_1 \Delta^{-1}(vp, 0) + w_2 \Delta^{-1}(vp, 0) + w_3 \Delta^{-1}(vg, 0)) \right) \quad (30)$$

How to calculate the value of  $W_1$ ,  $W_2$ , and  $W_3$  is the same as in Optimistic calculation. Vagueness and trustworthiness values for  $W_1$ ,  $W_2$ , and  $W_3$  are the same as in Optimistic. The only difference in the calculation of certainty, the Pessimistic calculation used is the Pessimistic scale value.

In the Optimistic Calculation, Vagueness value for  $W_1$  is 5/6, for  $W_2$  is 1, and for  $W_3$  is 1. The Trustworthiness value is 0.5. The Certainty value for  $W_1$  is to take the pessimistic value is d (scale value = 1), the certainty value for  $W_2$  is n (scale value = 2), and the certainty value for  $W_3$  is vd (scale value = 0). Then the values  $W_1$ ,  $W_2$ , and  $W_3$  are as follows.

$$\begin{aligned}
 W_1 &= \frac{5}{6} \times 1 \times 0.5 = 0.41 \\
 W_2 &= 1 \times 2 \times 0.5 = 1 \\
 W_3 &= 1 \times 0 \times 0.5 = 0
 \end{aligned} \quad (31)$$

Pessimistic value for DMU 1 to 2 for Service is as follows:

$$\begin{aligned}
 &= 1 / 1.41 * (0.41 * 1 + 1 * 1 + 0 * 5) \\
 &= 1 / 1.41 * (1.41) = 1.41 \\
 &= [VP, 0]
 \end{aligned}$$

The same calculation can be done to calculate the pessimistic value of alternative combinations for each criterion. So the final result of calculation of pessimistic value is can be seen in Table 4.

Table 4: Pessimistic Value

	Service			Atmosphere			Satisfaction		
$P_c^+$	-	$[vp, 0]$	$[n, 0.17]$	-	$[g, 0]$	$[vg, 0]$	-	$[g, 0]$	$[p, 0.2]$
	$[vp, 0]$	-	$[g, 0.27]$	$[vp, 0]$	-	$[g, 0]$	$[p, -0.25]$	-	$[m, 0]$
	$[m, -0.3]$	$[p, -0.3]$	-	$[p, -0.38]$	$[g, 0.14]$	-	$[vp, 0.19]$	$[m, 0.14]$	-

Comment [Office10]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

6. Establish a Vector Interval Linguistic for Each Criterion

Before building a vector interval linguistic for each criterion, we must construct vector optimistic and pessimistic for each criterion. In this process, the optimistic and pessimistic data values on the same row in the matrix will be combined. Vector optimistic and pessimistic for each criterion can be seen in Table 5.

Table 5: Vector Optimistic and Pessimistic for Each Criterion

	$P_1^+$	$P_2^+$	$P_3^+$	$P_1^-$	$P_2^-$	$P_3^-$
<b>Service</b>	$(p, -0.235)$	$(g, -0.125)$	$(g, 0.065)$	$(vp, -0.415)$	$(m, -0.365)$	$(p, 0.2)$
<b>Atmosphere</b>	$(vg, -0.125)$	$(vg, -0.005)$	$(g, 0.455)$	$(g, 0.5)$	$(p, 0.5)$	$(m, -0.12)$
<b>Satisfaction</b>	$(m, 0.1)$	$(m, 0.175)$	$(m, 0.495)$	$(m, 0.1)$	$(p, 0.375)$	$(p, 0.165)$

Comment [Office11]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

Having obtained an optimistic and pessimistic merging matrix for each criterion we can construct vector interval linguistic for each criterion as can be seen in Table 6.

Table 6: Vector Interval Linguistic for Each Criterion

	$V^r$
<b>Service</b>	$([(vp, -0.415), (p, -0.235)], [(vp, -0.415), (p, -0.235)], [(p, 0.2), (g, 0.065)])$
<b>Atmosphere</b>	$([(g, 0.5), (vg, -0.125)], [(p, 0.5), (vg, -0.005)], [(m, -0.12), (g, 0.455)])$
<b>Satisfaction</b>	$([(m, 0.1), (m, 0.1)], [(p, 0.375), (m, 0.175)], [(p, 0.165), (m, 0.495)])$

Comment [Office12]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

7. Determining the Preference Relation Degree for Each Criteria of the Alternative

To be able to determine the preference relation degree value for each criterion on the alternative it can be done by using equation (18). For example, we will combine the 2nd and 3rd DMUs on the service.

A represents  $([m, -0.365], [g, -0.125])$  and B represents  $([p, 0.2], [g, 0.065])$

The merging process can be seen in Table 7.

Comment [Office13]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

Table 7: Merging Process

A (2nd DMU)	B (3rd DMU)
m,-0.35 = 2.635	p,0.2 = 2.2
g,-0.125 = 3.875	g,0.065

$$p_{13}^{Service} = \frac{\max(0, 3.875-2.2) - \max(0, 2.635-4.065)}{(3.875-2.635) + (4.065-2.2)}$$

$$p_{13}^{Service} = \frac{1.675}{3.0465} = 0.549$$

The result of the merger becomes the 2nd column row element to 3 in the preference relation degree matrix. The same way can be used for other elements to obtain a preference relation degree matrix as can be seen in Table 8.

Table 8: Preference Relation Degree Matrix

	Service	Atmosphere	Satisfaction
$P_D$	$\begin{bmatrix} - & 0 & 0 \\ 1 & - & 0.549 \\ 1 & 0.451 & - \end{bmatrix}$	$\begin{bmatrix} - & 0.82 & 1 \\ 0.18 & - & 0.519 \\ 0 & 0.481 & - \end{bmatrix}$	$\begin{bmatrix} - & 0.9 & 0.7 \\ 0.1 & - & 0.474 \\ 0.3 & 0.526 & - \end{bmatrix}$

Comment [Office14]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

### 8. Determining the Non-Dominance Choice Degree (NDD)

To be able to determine the value of NDD then we must calculate PNDD with equation (32).

$$\text{Max}(P_{f_{ji}} - P_{f_{ij}}, 0) \tag{32}$$

For example we want to obtain the 1st row element of the 2nd column in service, then the data used is the 1st column row element data and the 2nd column row element data in the preference relation degree matrix.

The 1st row element of column 2 = 0  
 The 2nd row element of column 1 = 1  
 Then Max (0-1, 0) = Max (-1, 0) = 0

So the PNDD matrix formed can be seen in Table 9.

Table 9: PNDD Matrix

	Service	Atmosphere	Satisfaction
$P_{NDD}$	$\begin{bmatrix} - & 0 & 0 \\ 1 & - & 0.098 \\ 1 & 0 & - \end{bmatrix}$	$\begin{bmatrix} - & 0.64 & 1 \\ 0 & - & 0.038 \\ 0 & 0 & - \end{bmatrix}$	$\begin{bmatrix} - & 0.8 & 0.4 \\ 0 & - & 0 \\ 0 & 0.052 & - \end{bmatrix}$

Comment [Office15]: Every table/figure should be referenced in text (for example, as seen in Table 12 - not just 'as follows').

Having obtained the value of PNDD, then we can get the value of NDD by using the following equation.

$$NDD_f = \min \{1 - P_{f_j}^S, j = 1 \dots n, j \neq 1\} \quad (33)$$

For example, we want to calculate NDD service for the 1st DMU, then we can use the data element on the 1st row of column 1, row 2nd column 1

The 1st row element of column 1 = is not taken into account

The 2nd row element of column 1 = 1

The 3rd row element of the 1st column = 1

The NDD element in the service for the 1st DMU is

$$\min (1-1, 1-1) = \min (0,0) = 0$$

NDD calculation results can be seen in the following matrix.

Table 10: NDD Matrix

	<b>DMU 1</b>	<b>DMU 2</b>	<b>DMU 3</b>
<i>NDD<sub>Service</sub></i>	0	1	0.902
<i>NDD<sub>Atmosphere</sub></i>	1	0.36	0
<i>NDD<sub>Satisfaction</sub></i>	1	0.2	0.6

## 5.2 Result of HFLTS-DEA Process

The DMU used in this study is 19 courses at the University of Malikussaleh. The data of each DMU is as follows.

Table 11: DMU Universitas Malikussaleh

DMU	Input		Output	
	Number of Lecturers	Number of Students	Number of Research	Number of Graduates
Information Technology	17	588	5	610
Civil Engineering	26	747	5	533
Architectural Engineering	15	396	5	195
Industrial Engineering	17	467	5	300
Chemical Engineering	25	348	5	252
Mechanical Engineering	23	499	5	224
Electrical Engineering	19	420	5	326
Agribusiness	17	689	5	273
Agro-Technology	34	822	5	284
Aquaculture	10	501	5	204
Communication Science	11	719	5	273
Political Science	11	262	5	183
Sociology	13	487	5	204
Anthropology	9	173	5	116
Jurisprudence	50	1096	10	467
Medicine	30	278	4	257
Management	48	1265	5	1302
Economic Development	11	853	5	290
Accounting	23	1127	5	417

The above DMU data was obtained from Malikussaleh University. The data of each DMU will be coupled with 2 inputs sourced from HFLTS namely: Academic Service Quality and Academic Atmosphere and 1 output sourced from HFLTS are: Student Satisfaction. So the result of DMU HFLTS-DEA is as follows.

Table 12: The Result of HFLTS-DEA

DMU	Input				Output		
	Number of Lecturers	Number of Students	Academic Service Quality	Academic Atmosphere	Number of Research	Number of Graduates	Student Satisfaction
Information Technology	17	588	0.75	0.8	5	610	0.87
Civil Engineering	26	747	0.32	0.67	5	533	0.43
Architectural Engineering	15	396	0.59	0.65	5	195	0.64
Industrial Engineering	17	467	0.81	0.56	5	300	0.76
Chemical Engineering	25	348	0.73	0.75	5	252	0.81
Mechanical Engineering	23	499	0.56	0.32	5	224	0.57
Electrical Engineering	19	420	0.66	0.68	5	326	0.68
Agribusiness	17	689	0.75	0.52	5	273	0.65
Agro-Technology	34	822	0.73	0.65	5	284	0.72
Aquaculture	10	501	0.59	0.57	5	204	0.61
Communication Science	11	719	0.67	0.87	5	273	0.9
Political Science	11	262	0.65	0.77	5	183	0.73
Sociology	13	487	0.66	0.69	5	204	0.71
Anthropology	9	173	0.65	0.45	5	116	0.67
Jurisprudence	50	1096	0.54	0.56	10	467	0.58
Medicine	30	278	0.67	0.71	4	257	0.73
Management	48	1265	0.68	0.78	5	1302	0.81
Economic Development	11	853	0.59	0.73	5	290	0.87
Accounting	23	1127	0.81	0.77	5	417	0.81

### 5.3 Discussion

Using (22), we can calculate the efficiency score of each DMU. The result can be seen in Table 13. For example for DMU1 (Department of Information Technology), the linear programming model can be written as follows.

Maximize  $610 U_1 + 5 U_2 + 0.87 U_3$

Subject to

$$17 V_1 + 588 V_2 + 0.75 V_3 + 0.8 V_4 = 1$$

$$610 U_1 + 5 U_2 + 0.87 U_3 - 17 V_1 - 588 V_2 - 0.75 V_3 - 0.8 V_4 \leq 0$$

$$533 U_1 + 5 U_2 + 0.43 U_3 - 26 V_1 - 747 V_2 - 0.32 V_3 - 0.67 V_4 \leq 0$$

$$195 U_1 + 5 U_2 + 0.64 U_3 - 15 V_1 - 396 V_2 - 0.59 V_3 - 0.65 V_4 \leq 0$$

Comment [Office16]: Too little discussion on the results in Section 5.

$$\begin{aligned}
 &300 U_1 + 5 U_2 + 0.76 U_3 - 17 V_1 - 467 V_2 - 0.81 V_3 - 0.56 V_4 \leq 0 \\
 &252 U_1 + 5 U_2 + 0.81 U_3 - 25 V_1 - 348 V_2 - 0.73 V_3 - 0.75 V_4 \leq 0 \\
 &224 U_1 + 5 U_2 + 0.57 U_3 - 23 V_1 - 499 V_2 - 0.56 V_3 - 0.32 V_4 \leq 0 \\
 &326 U_1 + 5 U_2 + 0.68 U_3 - 19 V_1 - 420 V_2 - 0.66 V_3 - 0.68 V_4 \leq 0 \\
 &273 U_1 + 5 U_2 + 0.65 U_3 - 17 V_1 - 689 V_2 - 0.75 V_3 - 0.52 V_4 \leq 0 \\
 &284 U_1 + 5 U_2 + 0.72 U_3 - 34 V_1 - 822 V_2 - 0.73 V_3 - 0.65 V_4 \leq 0 \\
 &204 U_1 + 5 U_2 + 0.61 U_3 - 10 V_1 - 501 V_2 - 0.59 V_3 - 0.57 V_4 \leq 0 \\
 &273 U_1 + 5 U_2 + 0.9 U_3 - 11 V_1 - 719 V_2 - 0.67 V_3 - 0.87 V_4 \leq 0 \\
 &183 U_1 + 5 U_2 + 0.73 U_3 - 11 V_1 - 262 V_2 - 0.65 V_3 - 0.77 V_4 \leq 0 \\
 &204 U_1 + 5 U_2 + 0.71 U_3 - 13 V_1 - 487 V_2 - 0.66 V_3 - 0.69 V_4 \leq 0 \\
 &116 U_1 + 5 U_2 + 0.67 U_3 - 9 V_1 - 173 V_2 - 0.65 V_3 - 0.45 V_4 \leq 0 \\
 &467 U_1 + 5 U_2 + 0.58 U_3 - 50 V_1 - 1096 V_2 - 0.54 V_3 - 0.56 V_4 \leq 0 \\
 &257 U_1 + 5 U_2 + 0.73 U_3 - 30 V_1 - 278 V_2 - 0.67 V_3 - 0.71 V_4 \leq 0 \\
 &1302 U_1 + 5 U_2 + 0.81 U_3 - 48 V_1 - 1265 V_2 - 0.68 V_3 - 0.78 V_4 \leq 0 \\
 &290 U_1 + 5 U_2 + 0.87 U_3 - 11 V_1 - 853 V_2 - 0.59 V_3 - 0.73 V_4 \leq 0 \\
 &417 U_1 + 5 U_2 + 0.81 U_3 - 23 V_1 - 1127 V_2 - 0.81 V_3 - 0.77 V_4 \leq 0 \\
 &U_1, U_2, U_3, V_1, V_2, V_3, V_4 \geq 0
 \end{aligned}$$

END

Based on the measurements with HFLTS-DEA, the efficiency of each as follows.

Table 13: Efficiency Score

Number	DMU	DEA Score
1	Information Technology	1
2	Civil Engineering	1
3	Architectural Engineering	0.95
4	Industrial Engineering	0.96
5	Chemical Engineering	0.99
6	Mechanical Engineering	1
7	Electrical Engineering	0.93
8	Agribusiness	0.91
9	Agrotechnology	0.81
10	Aquaculture	1
11	Communication Science	1
12	Political Science	1
13	Sociology	0.9
14	Anthropology	1
15	Jurisprudence	1
16	Medical	1
17	Management	1
18	Economic Development	1
19	Accounting	0.83

Comment [Office17]: DMU numbers are not included in Table 13 but have been mentioned in the paragraph.

Based on Table 13 it can be seen that DMU 3, 4, 5, 7, 8, 9, 13, and 19 are inefficient marked with DEA Score which is not worth 1. It can be seen that HFLTS can give good measurement result on Qualitative Data so the HFLTS-DEA model can be used in the benchmarking process for qualitative data.

## 5 Conclusion

Based on the results of the research, there are several things obtained. First, the qualitative data assessment process can be used HFLTS. Second, HFLTS can be used in the assessment process that contains uncertainty and can take into account the computational trust. Third, HFLTS-DEA can perform benchmarking process in qualitative data well. Future research should be able to provide suggestions for efficiency improvement processes by considering the use of input and output resources generated.

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**Hartono Ibbi** <[hartonoibbi@gmail.com](mailto:hartonoibbi@gmail.com)>  
Kepada: "DR. INTAN ERMAHANI BINTI A. JALIL" <[ermahani@utem.edu.my](mailto:ermahani@utem.edu.my)>

24 Juni 2019 pukul 10.57

Dear Dr. Intan Ermahani A. Jalil,

Hopefully Dr. Intan is always in good health. On this occasion, allow us to ask for information about the publication of our research paper at IJASCA. Please Dr. Intan doesn't hesitate to tell us, if there are other things we need to complete. Thank you for your attention.

Best Regards,

Hartono

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**DR. INTAN ERMAHANI BINTI A. JALIL** <[ermahani@utem.edu.my](mailto:ermahani@utem.edu.my)>  
Kepada: Hartono Ibbi <[hartonoibbi@gmail.com](mailto:hartonoibbi@gmail.com)>

24 Juni 2019 pukul 12.42

Dear Authors,

Please be informed that your paper has been submitted to the Chief Editor of IJASCA for further process of publication. The paper is aimed to be published in this year of 2019.

We hope that you could give some time to IJASCA team to process and publish your paper.

Please inform us should you have any inquiries and we are sorry for any inconvenience.

Thank you.

Regards,

Dr. Intan Ermahani A. Jalil  
TPC of ICSITech2018

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**From:** Hartono Ibbi <[hartonoibbi@gmail.com](mailto:hartonoibbi@gmail.com)>  
**Sent:** Monday, June 24, 2019 12:57:20 PM  
**To:** DR. INTAN ERMAHANI BINTI A. JALIL  
**Subject:** Re: Urgent: Amendment on Final Manuscript of Paper accepted to ICSITech2018 to be published in IJASCA Journal.

Dear Dr. Intan Ermahani A. Jalil,

[Kutipan teks disembunyikan]

Kepada: "DR. INTAN ERMAHANI BINTI A. JALIL" <ermahani@utem.edu.my>

Dear Dr. Intan,

Thank you for your help. I will wait and ask to be informed if there are things that need to be completed.

Best Regards,

Hartono

[Kutipan teks disembunyikan]