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Review Paper

Excel solver as the software to construct MUSA model

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Abstract

The study discusses steps to construct MUSA Model using Excel Solver software. This software applies the linear programming approach as needed, in the ordinal regression MUSA Model, with ordinal scaled data set It was found that the Excel Solver could construct the MUSA Model well. Even though the data set need to be re-coded again in Excel Solver, the cheaper cost and availability of this software makes it's as a good option too.

Keywords: *Multi-Criteria Satisfaction Analysis (MUSA), Excel Solver, Linear Programming Approach.*

1. Introduction

The study discusses steps to construct a MUSA Model using Excel Solver software. Previous studies used mainly some specific software like TELOS to construct the MUSA Model [4]. However, this specific software is costly compared to the Excel Solver software. Therefore, this study aimed to explain step by step construction of MUSA Model using Excel Solver software.

2. Literature review

Construction of a MUSA Model is discussed based on the previous research by Grigoroudis & Siskos (2002) entitled: Preference Disaggregation For Measuring and Analyzing Customer Satisfaction [2]. The study used a data set of 20 respondents, where they are asked on their satisfaction towards the quality of service at an organization. The satisfaction consists of global and partial satisfaction (consists of three criteria namely Product, Purchasing Process, and Additional service). Table 1 shows the data set.
MUSA method aims to obtain the global satisfaction value and partial satisfaction value that is as consistent as possible. Therefore, satisfaction for both sides should be calculated to conclude if there is a need for error estimation. If it was found that global satisfaction value exceeds partial satisfaction value, an overestimated error should be added to the system, while if it was found that global satisfaction value is less than partial satisfaction value, an underestimated error should be added to the system[1,2,3,4,5,6,7].
Function value (Y*) and (Xi*) are at the range of [0, 100], and the increase is consistent for each level, along the interval. Therefore, increment for each level is $\frac{100}{\alpha-1}$ for global satisfaction and $\frac{100}{\alpha_i-1}$ for partial satisfaction. Symbol of α and α_i represent number of levels in the ordinal scale for the global satisfaction and partial satisfaction, respectively. Therefore, function value for each level will obtain an increment of 50%, that is $\frac{100}{3-1}$.
Value function for global satisfaction is as follow:
$Y^{*1} = 0, \quad Y^{*2} = 50, \quad Y^{*3} = 100$
As all the three criteria have three levels for each ordinal scale, therefore function value for each criterion is the same as the global satisfaction, that is:
$x_1^{*1} = 0, \quad x_1^{*2} = 50, \quad x_1^{*3} = 100$
$x_2^{*1} = 0, \quad x_2^{*2} = 50, \quad x_2^{*3} = 100$
$x_3^{*1} = 0, \quad x_3^{*2} = 50, \quad x_3^{*3} = 100$

As there are three criteria, therefore the weight for each criteria is $\frac{1}{3}$.
Therefore, based on the ordinal regression equation is as:

$$\widetilde{Y^*} = \sum_{i=1}^{n} b_i X_i^* - \sigma^+ + \sigma^- \quad (1)$$

The function value (FV) for global satisfaction is estimated to be consistent with the summation of function value (FV) for partial satisfaction. Any differences should be solved with the error estimation. Table 2 shows the function value for global satisfaction and partial satisfaction, and the need for error estimation.

Table 1: Data for the Numerical Example

Customer	Global Satisfaction	Product	Purchasing Process	Additional Service
1	Satisfied	Very Satisfied	Satisfied	Not Satisfied
2	Not Satisfied	Not Satisfied	Not Satisfied	Not Satisfied
3	Very Satisfied	Very Satisfied	Very Satisfied	Very Satisfied
4	Satisfied	Very Satisfied	Not Satisfied	Satisfied
5	Not Satisfied	Not Satisfied	Not Satisfied i	Not Satisfied
6	Very Satisfied	Very Satisfied	Very Satisfied	Very Satisfied
7	Satisfied	Very Satisfied	Not Satisfied	Very Satisfied
8	Satisfied	Very Satisfied	Not Satisfied	Very Satisfied
9	Satisfied	Satisfied	Satisfied	Satisfied
10	Not Satisfied	Not Satisfied	Not Satisfied	Not Satisfied
11	Satisfied	Satisfied	Very Satisfied	Not Satisfied
12	Not Satisfied	Not Satisfied	Not Satisfied	Not Satisfied
13	Very Satisfied	Very Satisfied	Very Satisfied	Very Satisfied
14	Satisfied	Satisfied	Very Satisfied	Not Satisfied
15	Not Satisfied	Not Satisfied	Not Satisfied	Not Satisfied
16	Very Satisfied	Very Satisfied	Very Satisfied	Satisfied
17	Very Satisfied	Very Satisfied	Very Satisfied	Very Satisfied
18	Very Satisfied	Very Satisfied	Very Satisfied	Satisfied
19	Satisfied	Satisfied	Satisfied	Satisfied
20	Not Satisfied	Satisfied	Not Satisfied	Not Satisfied

Table 2: Function Value for Global and Partial Satisfaction

Customer	FV for Global Satisfaction	FV for Partial Satisfaction	Differences of FV	Need for Error Estimation
1	50	$\frac{1}{3}\times 100+\frac{1}{3}\times 50+\frac{1}{3}\times 0 = 50$	0	No
2	0	$\frac{1}{3}\times 0+\frac{1}{3}\times 0+\frac{1}{3}\times 0 = 0$	0	No
3	100	$\frac{1}{3}\times 100+\frac{1}{3}\times 100+\frac{1}{3}\times 100 = 100$	0	No
4	50	$\frac{1}{3}\times 100+\frac{1}{3}\times 0+\frac{1}{3}\times 50 = 50$	0	No
5	0	$\frac{1}{3}\times 0+\frac{1}{3}\times 0+\frac{1}{3}\times 0 = 0$	0	No
6	100	$\frac{1}{3}\times 100+\frac{1}{3}\times 100+\frac{1}{3}\times 100 = 100$	0	No
7	50	$\frac{1}{3}\times 100+\frac{1}{3}\times 0+\frac{1}{3}\times 100 = 66.67$	16.67	Under Estimated Error (σ^-)
8	50	$\frac{1}{3}\times 100+\frac{1}{3}\times 0+\frac{1}{3}\times 100 = 66.67$	16.67	Under Estimated Error (σ^-)
9	50	$\frac{1}{3}\times 50+\frac{1}{3}\times 50+\frac{1}{3}\times 50 = 50$	0	No
10	0	$\frac{1}{3}\times 0+\frac{1}{3}\times 0+\frac{1}{3}\times 0 = 0$	0	No
11	50	$\frac{1}{3}\times 50+\frac{1}{3}\times 100+\frac{1}{3}\times 0 = 50$	0	No
12	0	$\frac{1}{3}\times 0+\frac{1}{3}\times 0+\frac{1}{3}\times 0 = 0$	0	No

13	100	$\frac{1}{3}\times 100+\frac{1}{3}\times 100+\frac{1}{3}\times 100 = 100$	0	No
14	50	$\frac{1}{3}\times 50+\frac{1}{3}\times 100+\frac{1}{3}\times 0 = 50$	0	No
15	0	$\frac{1}{3}\times 0+\frac{1}{3}\times 0+\frac{1}{3}\times 0 = 0$	0	No
16	100	$\frac{1}{3}\times 100+\frac{1}{3}\times 100+\frac{1}{3}\times 50 = 83.33$	16.67	Over Estimated Error (σ^+)
17	100	$\frac{1}{3}\times 100+\frac{1}{3}\times 100+\frac{1}{3}\times 100 = 100$	0	No
18	100	$\frac{1}{3}\times 100+\frac{1}{3}\times 100+\frac{1}{3}\times 50 = 83.33$	16.67	Over Estimated Error (σ^+)
19	50	$\frac{1}{3}\times 50+\frac{1}{3}\times 50+\frac{1}{3}\times 50 = 50$	0	No
20	0	$\frac{1}{3}\times 50+\frac{1}{3}\times 0+\frac{1}{3}\times 0 = 16.67$	16.67	Under Estimated Error (σ^-)

Next, the monotonic characteristics of variables Y^* and x_i^* are represented by transformation variables z_m and w_{ik}, and they are represented in a matrix form, with a new coding system, based on their respective function value. Figure 1 show the linear programming approach which is formed based on equation 1. Explanation for the first constraint, that is the first customer, constraint-21, 22 are discussed as examples below.

Satisfaction level of first customer for the first criteria (product) is `Very Satisfied' that is the third level of the ordinal scale. Therefore, the transformation variable w_{11} and w_{12} are valued one. Value 1 is given for variable w_{11} when there is an increment from level one into level two. Whereas, Value 1 is given for variable w_{12} when there is an increment from level two into level three. Both these value are for the first criteria where the transformation variable uses symbol w_{ik}, with $_i$ represents ith criteria, and k represents k- interval. Satisfaction level of second criteria (Purchasing Process) for this customer is `Satisfied', that is the second level in the ordinal scale. Therefore, the transformation variable w21 values one and transformation variable $w_{22}$ values zero. Satisfaction level of third criteria (Additional Service) for this customer is `Not Satisfied', that is the first level in the ordinal scale. Therefore, both the transformation variable w31 and w32 value zero. For the overall satisfaction, customer stated `Satisfied', therefore the value of transformation variable of z_1 is one and z_2 is zero.

21st Constraint explains that summation of all the transformation variable w_{ik} valued 100. Therefore, all the transformation variable w_{ik} should value one, whereas transformation variable zm should value zero. 22nd Constraint explains that summation of all the transformation variable zm valued 100. Therefore, all the transformation variable zm should value one, whereas transformation variable w_{ik} should value zero.

$$
\begin{pmatrix}
1&1&1&0&0&0\\
0&0&0&0&0&0\\
1&1&1&1&1&1\\
1&1&0&0&1&0\\
0&0&0&0&0&0\\
1&1&1&1&1&1\\
1&1&0&0&1&1\\
1&1&0&0&1&1\\
1&0&1&0&1&0\\
0&0&0&0&0&0\\
1&0&1&1&0&0\\
0&0&0&0&0&0\\
1&1&1&1&1&1\\
1&0&1&1&0&0\\
0&0&0&0&0&0\\
1&1&1&1&1&0\\
1&1&1&1&1&1\\
1&1&1&1&1&0\\
1&0&1&0&1&0\\
1&0&0&0&0&0\\
1&1&1&1&1&1\\
0&0&0&0&0&0
\end{pmatrix} w -
\begin{pmatrix}
1&0\\
0&0\\
1&1\\
1&0\\
0&0\\
1&1\\
1&0\\
1&0\\
1&0\\
0&0\\
1&0\\
0&0\\
1&1\\
1&0\\
0&0\\
1&1\\
1&1\\
1&1\\
1&0\\
0&0\\
0&0\\
1&1
\end{pmatrix} z +
\begin{pmatrix}
0&0\\
0&0\\
0&0\\
0&0\\
0&0\\
0&0\\
0&1\\
0&1\\
0&0\\
0&0\\
0&0\\
0&0\\
0&0\\
0&0\\
0&0\\
-1&0\\
0&0\\
-1&0\\
0&0\\
0&1\\
0&0\\
0&0
\end{pmatrix} \sigma =
\begin{pmatrix}
0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\0\\100\\100
\end{pmatrix}
$$

Fig. 1: Linear Programming Approach in the Matrix Form

With variables $w_{ik}, z_m, \sigma^+, \sigma^- \geq 0$

To solve this Matrix, a linear programming method with Simplex approach is used. Excel Solver software was used to solve the linear programming. Figure 2 and 3 explains the solving steps and the optimum value gained.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2			Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
3			w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma [-]			
4															
5		Pelanggan 1	1	1	1	0	0	0	1	0	0	0	(C5*C4+D5*D4+E5*E4+F5*F4+G5*G4+H5*H4)-(I5*I4+J5*J4)+(-K5*K4+L5*L4)	=	0
6		Pelanggan 2	0	0	0	0	0	0	0	0	0	0	(C6*C4+D6*D4+E6*E4+F6*F4+G6*G4+H6*H4)-(I6*I4+J6*J4)+(-K6*K4+L6*L4)	=	0
7		Pelanggan 3	1	1	1	1	1	1	1	1	0	0	(C7*C4+D7*D4+E7*E4+F7*F4+G7*G4+H7*H4)-(I7*I4+J7*J4)+(-K7*K4+L7*L4)	=	0
8		Pelanggan 4	1	1	0	0	1	0	1	0	0	0	(C8*C4+D8*D4+E8*E4+F8*F4+G8*G4+H8*H4)-(I8*I4+J8*J4)+(-K8*K4+L8*L4)	=	0
9		Pelanggan 5	0	0	0	0	0	0	0	0	0	0	(C9*C4+D9*D4+E9*E4+F9*F4+G9*G4+H9*H4)-(I9*I4+J9*J4)+(-K9*K4+L9*L4)	=	0
10		Pelanggan 6	1	1	1	1	1	1	1	1	0	0	(C10*C4+D10*D4+E10*E4+F10*F4+G10*G4+H10*H4)-(I10*I4+J10*J4)+(-K10*K4+L10*L4)	=	0
11		Pelanggan 7	1	1	0	0	1	1	1	0	0	1	(C11*C4+D11*D4+E11*E4+F11*F4+G11*G4+H11*H4)-(I11*I4+J11*J4)+(-K11*K4+L11*L4)	=	0
12		Pelanggan 8	1	1	0	0	1	1	1	0	0	1	(C12*C4+D12*D4+E12*E4+F12*F4+G12*G4+H12*H4)-(I12*I4+J12*J4)+(-K12*K4+L12*L4)	=	0
13		Pelanggan 9	1	0	1	0	1	0	1	0	0	0	(C13*C4+D13*D4+E13*E4+F13*F4+G13*G4+H13*H4)-(I13*I4+J13*J4)+(-K13*K4+L13*L4)	=	0
14		Pelanggan 10	0	0	0	0	0	0	0	0	0	0	(C14*C4+D14*D4+E14*E4+F14*F4+G14*G4+H14*H4)-(I14*I4+J14*J4)+(-K14*K4+L14*L4)	=	0
15		Pelanggan 11	1	0	1	1	0	0	1	0	0	0	(C15*C4+D15*D4+E15*E4+F15*F4+G15*G4+H15*H4)-(I15*I4+J15*J4)+(-K15*K4+L15*L4)	=	0
16		Pelanggan 12	0	0	0	0	0	0	0	0	0	0	(C16*C4+D16*D4+E16*E4+F16*F4+G16*G4+H16*H4)-(I16*I4+J16*J4)+(-K16*K4+L16*L4)	=	0
17		Pelanggan 13	1	1	1	1	1	1	1	1	0	0	(C17*C4+D17*D4+E17*E4+F17*F4+G17*G4+H17*H4)-(I17*I4+J17*J4)+(-K17*K4+L17*L4)	=	0
18		Pelanggan 14	1	0	1	1	0	0	1	0	0	0	(C18*C4+D18*D4+E18*E4+F18*F4+G18*G4+H18*H4)-(I18*I4+J18*J4)+(-K18*K4+L18*L4)	=	0
19		Pelanggan 15	0	0	0	0	0	0	0	0	0	0	(C19*C4+D19*D4+E19*E4+F19*F4+G19*G4+H19*H4)-(I19*I4+J19*J4)+(-K19*K4+L19*L4)	=	0
20		Pelanggan 16	1	1	1	1	1	0	1	1	1	0	(C20*C4+D20*D4+E20*E4+F20*F4+G20*G4+H20*H4)-(I20*I4+J20*J4)+(-K20*K4+L20*L4)	=	0
21		Pelanggan 17	1	1	1	1	1	1	1	1	0	0	(C21*C4+D21*D4+E21*E4+F21*F4+G21*G4+H21*H4)-(I21*I4+J21*J4)+(-K21*K4+L21*L4)	=	0
22		Pelanggan 18	1	1	1	1	1	0	1	1	1	0	(C22*C4+D22*D4+E22*E4+F22*F4+G22*G4+H22*H4)-(I22*I4+J22*J4)+(-K22*K4+L22*L4)	=	0
23		Pelanggan 19	1	0	1	0	1	0	1	0	0	0	(C23*C4+D23*D4+E23*E4+F23*F4+G23*G4+H23*H4)-(I23*I4+J23*J4)+(-K23*K4+L23*L4)	=	0
24		Pelanggan 20	1	0	0	0	0	0	0	0	0	1	(C24*C4+D24*D4+E24*E4+F24*F4+G24*G4+H24*H4)-(I24*I4+J24*J4)+(-K24*K4+L24*L4)	=	0
25		Pemberat w[ik]	1	1	1	1	1	1	0	0	0	0	C25*C4+D25*D4+E25*E4+F25*F4+G25*G4+H25*H4	=	100
26		Pemberat z[m]	0	0	0	0	0	0	1	1	0	0	I26*I4+J26*J4	=	100
27		Pekali Objektif	0	0	1	1	0	0	0	0	1	1	K27*K4+L27*L4		

Fig. 2: Formula of MUSA Method with Optimum Solution

	Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
	w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
	0	25	25	25	25	0	50	50	0	0			
Pelanggan 1	1	1	1	0	0	0	1	0	0	0	0	=	0
Pelanggan 2	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 3	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 4	1	1	0	0	1	0	1	0	0	0	0	=	0
Pelanggan 5	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 6	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 7	1	1	0	0	1	1	1	0	0	1	0	=	0
Pelanggan 8	1	1	0	0	1	1	1	0	0	1	0	=	0
Pelanggan 9	1	0	1	0	1	0	1	0	0	0	0	=	0
Pelanggan 10	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 11	1	0	1	1	0	0	1	0	0	0	0	=	0
Pelanggan 12	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 13	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 14	1	0	1	1	0	0	1	0	0	0	0	=	0
Pelanggan 15	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 16	1	1	1	1	1	0	1	1	1	0	0	=	0
Pelanggan 17	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 18	1	1	1	1	1	0	1	1	1	0	0	=	0
Pelanggan 19	1	0	1	0	1	0	1	0	0	0	0	=	0
Pelanggan 20	1	0	0	0	0	0	0	0	0	1	0	=	0
Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	100	=	100
Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	100	=	100
Pekali Ralat	0	0	0	0	0	0	0	0	1	1	0		

Fig. 3: Result of Linear Programming

Therefore, based on the linear programming approach used, it is found that the value of underestimated and overestimated error is zero. That is the consistency between global satisfaction and summation of partial satisfaction is achieved without any addition of error. Optimum values for the transformation variable obtained are summarized in Table 3.

Table 3: Optimum Solution

Variable	Optimum Value
w_{11}	0
w_{12}	25
w_{21}	25
w_{22}	25
w_{31}	25
w_{32}	0
z_1	50
z_2	50
σ^+	0
σ^-	0

Next, stability analysis is done on the optimum solution obtained. In this study, there will be three solutions after optimum, so that all the three criteria could be maximized. In this analysis, summation of error is allowed to be increased till a fixed value ε, as in the Figure 4 below.

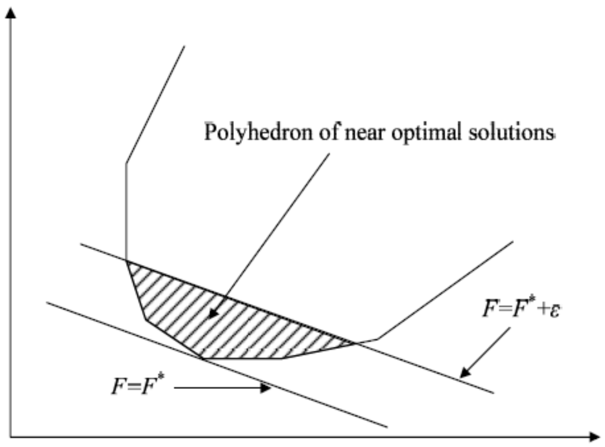

Fig. 4: Post-Optimality Analysis

This value is to be chosen by own, and this study used a value $\varepsilon = 10$. Figure 5, 6, 7 and 8 is used to explain the stability analysis for the first criteria. Figure 5 shows the formula of MUSA method to maximize the first criteria, and Figure 6 shows the optimum value obtained. Figure 7 shows the Sensitivity Report obtained. This report is used to identify customer that is the constraint which allows an increment at the error value. This increment of error occurs through two ways. First through the constraint which has the positive shadow price and has a value at the Allowable Increase. This will cause an increment for the tested criteria, and this increment is because of the underestimated error σ^-. Second, is through the constraint that has negative value for the shadow price and has a value at the Allowable Decrease. This will cause an increment for the tested criteria, and this increment is because of the overestimated error,σ^+

		Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
1														
2		Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
3		w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
4														
5	Pelanggan 1	1	1	1	0	0	0	1	0	0	0	(C5*C4+D5*D4+E5*E4+F5*F4+G5*G4+H5*H4)-(I5*I4+J5*J4)+(-K5*K4+L5*L4)	=	0
6	Pelanggan 2	0	0	0	0	0	0	0	0	0	0	(C6*C4+D6*D4+E6*E4+F6*F4+G6*G4+H6*H4)-(I6*I4+J6*J4)+(-K6*K4+L6*L4)	=	0
7	Pelanggan 3	1	1	1	1	1	1	1	1	0	0	(C7*C4+D7*D4+E7*E4+F7*F4+G7*G4+H7*H4)-(I7*I4+J7*J4)+(-K7*K4+L7*L4)	=	0
8	Pelanggan 4	1	1	0	0	1	0	1	0	0	0	(C8*C4+D8*D4+E8*E4+F8*F4+G8*G4+H8*H4)-(I8*I4+J8*J4)+(-K8*K4+L8*L4)	=	0
9	Pelanggan 5	0	0	0	0	0	0	0	0	0	0	(C9*C4+D9*D4+E9*E4+F9*F4+G9*G4+H9*H4)-(I9*I4+J9*J4)+(-K9*K4+L9*L4)	=	0
10	Pelanggan 6	1	1	1	1	1	1	1	1	0	0	(C10*C4+D10*D4+E10*E4+F10*F4+G10*G4+H10*H4)-(I10*I4+J10*J4)+(-K10*K4+L10*L4)	=	0
11	Pelanggan 7	1	1	0	0	1	1	1	0	0	1	(C11*C4+D11*D4+E11*E4+F11*F4+G11*G4+H11*H4)-(I11*I4+J11*J4)+(-K11*K4+L11*L4)	=	0
12	Pelanggan 8	1	1	0	0	1	1	1	0	0	1	(C12*C4+D12*D4+E12*E4+F12*F4+G12*G4+H12*H4)-(I12*I4+J12*J4)+(-K12*K4+L12*L4)	=	0
13	Pelanggan 9	1	0	1	0	1	0	1	0	0	0	(C13*C4+D13*D4+E13*E4+F13*F4+G13*G4+H13*H4)-(I13*I4+J13*J4)+(-K13*K4+L13*L4)	=	0
14	Pelanggan 10	0	0	0	0	0	0	0	0	0	0	(C14*C4+D14*D4+E14*E4+F14*F4+G14*G4+H14*H4)-(I14*I4+J14*J4)+(-K14*K4+L14*L4)	=	0
15	Pelanggan 11	1	0	1	1	0	0	1	0	0	0	(C15*C4+D15*D4+E15*E4+F15*F4+G15*G4+H15*H4)-(I15*I4+J15*J4)+(-K15*K4+L15*L4)	=	0
16	Pelanggan 12	0	0	0	0	0	0	0	0	0	0	(C16*C4+D16*D4+E16*E4+F16*F4+G16*G4+H16*H4)-(I16*I4+J16*J4)+(-K16*K4+L16*L4)	=	0
17	Pelanggan 13	1	1	1	1	1	1	1	1	0	0	(C17*C4+D17*D4+E17*E4+F17*F4+G17*G4+H17*H4)-(I17*I4+J17*J4)+(-K17*K4+L17*L4)	=	0
18	Pelanggan 14	1	0	1	1	0	0	1	0	0	0	(C18*C4+D18*D4+E18*E4+F18*F4+G18*G4+H18*H4)-(I18*I4+J18*J4)+(-K18*K4+L18*L4)	=	0
19	Pelanggan 15	0	0	0	0	0	0	0	0	0	0	(C19*C4+D19*D4+E19*E4+F19*F4+G19*G4+H19*H4)-(I19*I4+J19*J4)+(-K19*K4+L19*L4)	=	0
20	Pelanggan 16	1	1	1	1	1	0	1	1	1	0	(C20*C4+D20*D4+E20*E4+F20*F4+G20*G4+H20*H4)-(I20*I4+J20*J4)+(-K20*K4+L20*L4)	=	0
21	Pelanggan 17	1	1	1	1	1	1	1	1	0	0	(C21*C4+D21*D4+E21*E4+F21*F4+G21*G4+H21*H4)-(I21*I4+J21*J4)+(-K21*K4+L21*L4)	=	0
22	Pelanggan 18	1	1	1	1	1	0	1	1	1	0	(C22*C4+D22*D4+E22*E4+F22*F4+G22*G4+H22*H4)-(I22*I4+J22*J4)+(-K22*K4+L22*L4)	=	0
23	Pelanggan 19	1	0	1	0	1	0	1	0	0	0	(C23*C4+D23*D4+E23*E4+F23*F4+G23*G4+H23*H4)-(I23*I4+J23*J4)+(-K23*K4+L23*L4)	=	0
24	Pelanggan 20	1	0	0	0	0	0	0	0	0	1	(C24*C4+D24*D4+E24*E4+F24*F4+G24*G4+H24*H4)-(I24*I4+J24*J4)+(-K24*K4+L24*L4)	=	0
25	Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	C25*C4+D25*D4+E25*E4+F25*F4+G25*G4+H25*H4	=	100
26	Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	I26*I4+J26*J4	=	100
27	Pekali Ralat	0	0	0	0	0	0	0	0	1	1	K27*K4+L27*L4	<=	10
28	Pekali Objektif	1	1	0	0	0	0	0	0	0	0	C28*C4+D28*D4		

Fig. 5: Formula of MUSA Method for First Criteria with Value of Ɛ=10

	Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
	w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
	0	25	25	25	25	0	50	50	0	0			
Pelanggan 1	1	1	1	0	0	0	1	0	0	0	0	=	0
Pelanggan 2	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 3	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 4	1	1	0	0	1	0	1	0	0	0	0	=	0
Pelanggan 5	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 6	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 7	1	1	0	0	1	1	1	0	0	1	0	=	0
Pelanggan 8	1	1	0	0	1	1	1	0	0	1	0	=	0
Pelanggan 9	1	0	1	0	1	0	1	0	0	0	0	=	0
Pelanggan 10	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 11	1	0	1	1	0	0	1	0	0	0	0	=	0
Pelanggan 12	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 13	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 14	1	0	1	1	0	0	1	0	0	0	0	=	0
Pelanggan 15	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 16	1	1	1	1	1	0	1	1	1	0	0	=	0
Pelanggan 17	1	1	1	1	1	1	1	1	0	0	0	=	0
Pelanggan 18	1	1	1	1	1	0	1	1	1	0	0	=	0
Pelanggan 19	1	0	1	0	1	0	1	0	0	0	0	=	0
Pelanggan 20	1	0	0	0	0	0	0	0	0	1	0	=	0
Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	100	=	100
Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	100	=	100
Pekali Ralat	0	0	0	0	0	0	0	0	1	1	0	<=	10
Pekali Objektif	1	1	0	0	0	0	0	0	0	0	25		

Fig. 6: Optimum Solution for First Criteria with Value Ɛ=10

This stability analysis only allows one changes at a time. Based on Figure 7, 20th customer has Allowable Increase valued 100, and allowing an increase of error valued 10 as wished by the researcher. This customer has the highest shadow price value that is 0.75. Therefore, this customer is chosen to be done the addition of error. Through the modification at this customer, increment for the first criteria is (10 x 0.75 = 7.5), and this makes the weight for the first criteria ($w_{11} + w_{12}$) is (25+7.5=32.5). The result for the linear programming with this constraint modification is as in Figure 8.

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
M27		0	0	10	1E+30	10
M5	Pelanggan 1	0	0.5	0	50	50
M6	Pelanggan 2	0	0	0	0	1E+30
M7	Pelanggan 3	0	0	0	0	1E+30
M8	Pelanggan 4	0	0.5	0	0	0
M9	Pelanggan 5	0	0	0	0	1E+30
M10	Pelanggan 6	0	0	0	0	1E+30
M11	Pelanggan 7	0	0	0	0	1E+30
M12	Pelanggan 8	0	-0.25	0	0	0
M13	Pelanggan 9	0	0	0	0	1E+30
M14	Pelanggan 10	0	0	0	0	1E+30
M15	Pelanggan 11	0	0	0	0	1E+30
M16	Pelanggan 12	0	0	0	0	1E+30
M17	Pelanggan 13	0	0	0	0	1E+30
M18	Pelanggan 14	0	-0.25	0	0	33.33333333
M19	Pelanggan 15	0	0	0	0	1E+30
M20	Pelanggan 16	0	0	0	0	1E+30
M21	Pelanggan 17	0	0.25	0	0	0
M22	Pelanggan 18	0	0	0	0	10
M23	Pelanggan 19	0	-0.5	0	0	50
M24	Pelanggan 20	0	0.75	0	100	0
M25	Penjumlahan w[ik]	100	0	100	0	1E+30
M26	Penjumlahan z[m]	100	0.25	100	0	100

Fig. 7: Sensitivity Report of First Criteria

	Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
	w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
	10	22.5	22.5	22.5	22.5	0	55	45	0	0			
Pelanggan 1	1	1	1	0	0	0	1	0	0	0	-3.2E-09	=	0
Pelanggan 2	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 3	1	1	1	1	1	1	1	1	0	0	-3.2E-09	=	0
Pelanggan 4	1	1	0	0	1	0	1	0	0	0	-3.2E-09	=	0
Pelanggan 5	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 6	1	1	1	1	1	1	1	1	0	0	-3.2E-09	=	0
Pelanggan 7	1	1	0	0	1	1	1	0	0	1	-3.2E-09	=	0
Pelanggan 8	1	1	0	0	1	1	1	0	0	1	-3.2E-09	=	0
Pelanggan 9	1	0	1	0	1	0	1	0	0	0	-3.2E-09	=	0
Pelanggan 10	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 11	1	0	1	1	0	0	1	0	0	0	-3.2E-09	=	0
Pelanggan 12	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 13	1	1	1	1	1	1	1	1	0	0	-3.2E-09	=	0
Pelanggan 14	1	0	1	1	0	0	1	0	0	0	-3.2E-09	=	0
Pelanggan 15	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 16	1	1	1	1	1	0	1	1	1	0	-3.2E-09	=	0
Pelanggan 17	1	1	1	1	1	1	1	1	0	0	-3.2E-09	=	0
Pelanggan 18	1	1	1	1	1	0	1	1	1	0	-3.2E-09	=	0
Pelanggan 19	1	0	1	0	1	0	1	0	0	0	-3.2E-09	=	0
Pelanggan 20	1	0	0	0	0	0	0	0	0	1	10	=	10
Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	100	=	100
Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	100	=	100
Pekali Ralat	0	0	0	0	0	0	0	0	1	1	0	<=	10
Pekali Objektif	1	1	0	0	0	0	0	0	0	0	32.5		

Fig. 8: Stability Analysis of First Criteria

The same steps used to determine the maximum value for second and third criteria. Next, average value of all the three criteria are calculated and used as the final value. Table 4 shows the summary of transformation variables for each criteria and the averages obtained.

Table 4: Summary of Transformation Variable and Average Value for Each Criteria

Max. Value	w_{11}	w_{12}	w_{21}	w_{22}	w_{31}	w_{32}	z_1	z_2
Criteria 1	10.0	22.50	22.50	22.50	22.50	0.00	55.00	45.00
Criteria 2	0.00	23.75	23.75	28.75	23.75	0.00	47.50	52.50
Criteria 3	0.00	20.00	20.00	30.00	30.00	0.00	50.00	50.00
Average	3.33	22.08	22.08	27.08	25.42	0	50.83	49.17

Based on the results of Table 4, few important results could be obtained. They were Weight of each Criteria, Average Satisfaction Index, Average Demanding Index, and Average Improvement Index for each criteria. Table 5 explains the numerical result.

Table 5 shows there are criteria having the same function value for consecutive levels. That is the third criteria (Additional Service) have function value of 100 at the second and third level. This explains the instability of the model and this value should be replaced. Therefore, Analysis of Solution after Optimization should be repeated, introducing a new positive value, known as γ or $\boldsymbol{\gamma_i}$ (for each criteria).

Table 5: Numerical Results with γ=0 and γ_i=0

Criteria	Function Value	Weight	Average Satisfaction Index $S_i=\sum_{k=1}^{\alpha_i} p_i^k x_i^{*k}$ $S=\frac{1}{100}\sum_{m=1}^{\alpha} p^m y^{*m}$	Average Demanding Index $D_i=\frac{\sum_{k=1}^{\alpha-1}(\frac{100(k-1)}{\alpha_i-1}-x_i^{*k})}{100\sum_{k=1}^{m-1}\frac{k-1}{\alpha_i-1}}$ $D=\frac{\sum_{m=1}^{\alpha-1}(\frac{100(m-1)}{\alpha-1}-y^{*m})}{100\sum_{m=1}^{\alpha-1}\frac{m-1}{\alpha-1}}$	Average Improvement Index $I_i=b_i(1-S_i)$
First	$x_1^{*1}=0$ $x_1^{*2}=\frac{100(w_{11})}{w_{11}+w_{12}}=\frac{100\times 3.33}{3.33+22.08}=13.11\%$ $x_1^{*3}=\frac{100(w_{11}+w_{12})}{w_{11}+w_{12}}=\frac{100\times(3.33+22.08)}{3.33+22.08}=100.00\%$	$=\frac{w_{11}+w_{12}}{100}=\frac{0+25}{100}=\frac{1}{4}$	$=\frac{1}{100}(\frac{5}{20}\times 0+\frac{5}{20}\times 13.11+\frac{10}{20}\times 100)=53.28\%$	$=\frac{(\frac{100(1-1)}{3-1}-0)+\frac{100(2-1)}{3-1}-13.11)}{100(\frac{1-1}{3-1}+\frac{2-1}{3-1})}=0.74$	$I_1=0.25(1-0.5328)=0.12$
Second	$x_2^{*1}=0$ $x_2^{*2}=\frac{100(w_{21})}{w_{21}+w_{22}}=\frac{100\times 22.08}{22.08+27.08}=44.91\%$ $x_2^{*3}=\frac{100(w_{21}+w_{22})}{w_{21}+w_{22}}=\frac{100\times(22.08+27.08)}{22.08+27.08}=100.00\%$	$=\frac{w_{21}+w_{22}}{100}=\frac{25+25}{100}=\frac{1}{2}$	$=\frac{1}{100}(\frac{9}{20}\times 0+\frac{3}{20}\times 44.91+\frac{8}{20}\times 100)=46.74\%$	$=\frac{(\frac{100(1-1)}{3-1}-0)+\frac{100(2-1)}{3-1}-44.91)}{100(\frac{1-1}{3-1}+\frac{2-1}{3-1})}=0.10$	$I_2=0.50(1-0.4674)=0.26$
Third	$x_3^{*1}=0$ $x_3^{*2}=\frac{100w_{31}}{w_{31}+w_{32}}=\frac{100\times 25.42}{25.42+0}=100\%$ $x_3^{*3}=\frac{100(w_{31}+w_{32})}{w_{31}+w_{32}}=\frac{100\times(25.42+0)}{25.42+0}=100\%$	$=\frac{w_{31}+w_{32}}{100}=\frac{25+0}{100}=\frac{1}{4}$	$=\frac{1}{100}(\frac{9}{20}\times 0+\frac{5}{20}\times 100+\frac{6}{20}\times 100)=55.00\%$	$=\frac{(\frac{100(1-1)}{3-1}-0)+\frac{100(2-1)}{3-1}-50.83)}{100(\frac{1-1}{3-1}+\frac{2-1}{3-1})}=-1.00$	$I_3=0.25(1-0.55)=0.11$
Global	$y^{*1}=0$ $y^{*2}=\frac{100\times z_1}{z_1+z_2}=\frac{100\times 50.83}{50.83+49.17}=50.83\%$ $y^{*3}=\frac{100\times(z_1+z_2)}{z_1+z_2}=\frac{100\times(50.83+49.17)}{50.83+49.17}=100\%$	-	$=\frac{1}{100}(\frac{6}{20}\times 0+\frac{8}{20}\times 50.83+\frac{6}{20}\times 100)=50.33\%$	$=\frac{(\frac{100(1-1)}{3-1}-0)+\frac{100(2-1)}{3-1}-50.83)}{100(\frac{1-1}{3-1}+\frac{2-1}{3-1})}=-0.02$	-

In this study, researcher have used value of γ=2 and γ_i=2. This γ and γ_i can be any positive number, but should be as small as possible. When this value is being used, the value of ε in the Analysis of Solution after Optimization should be the same with the value of γ and γ_i. This analysis is based on the equation 2 below and it forms a matrix as in Figure 9.

$$z_m = z'_m + \gamma \quad \text{for } m = 1,2, \ldots \alpha$$

$$w_{ik} = w'_{ik} + \gamma_i \quad \text{for } k = 1,2, \ldots, \alpha_i - 1, \text{ and } i = 1,2, \ldots, n \qquad (2)$$

With variables $w_{ik}, z_m, \sigma^+, \sigma^- \geq 0$

Steps to obtain the right side of matrix are discussed. For the first criteria, satisfaction level of `Not Satisfied' is zero. Satisfaction level `Satisfied' also given value zero as the transformation variable at this stage is also zero. Value for the Very Satisfied' level is given two.

For the second criteria, scale value for the first level `Not Satisfied' is zero. Scale value for the second level `Satisfied' is one and scale value for third level `Very Satisfied' is two.

For the third criteria, scale value for the first level `Not Satisfied' is zero. Scale value for the second level `Satisfied' is two, as the maximum value of the weight has been achieved in this level itself. Scale value for third level `Very Satisfied' is two.

For the global satisfaction, scale value for the `Not Satisfied' level is zero. Scale value for the `satisfied' level is one, and scale value for third level `Very Satisfied' is two.

As an example, for the first customer, value of four is achieved through the equation (2x1)-(2x2+2x1)=-4, and for the 9th customer is (2x1)-(2x1+2x1+2x1)=-4. The same calculation is done for the other customers; accept for the 11th and 14th customer. Value of γ_i is doubled as the ε value for this criteria is only half compared to the ε value of the other criteria. As an example, for the 11th customer, value of $\gamma_i$is -4 and not 2 as this constraint have double increment.

Figure 10 till 12 show the steps of solving for the first criteria. The same steps followed for the other two criteria. The results obtained are been summarized as the Table 6.

$$
\begin{pmatrix}
 & 1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 1 & 1 \\
1 & 1 & 0 & 0 & 1 & 1 \\
1 & 0 & 1 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 \\
1 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 & 1 & 0 \\
1 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 \\
0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix} w -
\begin{pmatrix}
1 & 0 \\ 0 & 0 \\ 1 & 1 \\ 1 & 0 \\ 0 & 0 \\ 1 & 1 \\ 1 & 0 \\ 1 & 0 \\ 1 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 1 & 1 \\ 1 & 0 \\ 0 & 0 \\ 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 1 & 1
\end{pmatrix} z +
\begin{pmatrix}
0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ -1 & 0 \\ 0 & 0 \\ -1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0
\end{pmatrix} \sigma =
\begin{pmatrix}
-4 \\ 0 \\ -8 \\ -6 \\ 0 \\ -8 \\ -6 \\ -6 \\ -4 \\ 0 \\ -4 \\ 0 \\ -8 \\ -4 \\ 0 \\ -8 \\ -8 \\ -8 \\ -4 \\ 0 \\ 88 \\ 96
\end{pmatrix}
$$

$$
\begin{pmatrix} 1 & 1 \end{pmatrix} \sigma \leq \begin{pmatrix} 10 \end{pmatrix}
$$

Fig. 9: Matrix Equation to Identify Transformation Variable Values

	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2		Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
3		w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
4														
5	Pelanggan 1	1	1	1	0	0	0	1	0	0	0	(C5*C4+D5*D4+E5*E4+F5*F4+G5*G4+H5*H4)-(I5*I4+J5*J4)+(-K5*K4+L5*L4)	=	2*(1)-2*(2+1+0)
6	Pelanggan 2	0	0	0	0	0	0	0	0	0	0	(C6*C4+D6*D4+E6*E4+F6*F4+G6*G4+H6*H4)-(I6*I4+J6*J4)+(-K6*K4+L6*L4)	=	2*(0)-2*(0+0+0)
7	Pelanggan 3	1	1	1	1	1	1	1	1	0	0	(C7*C4+D7*D4+E7*E4+F7*F4+G7*G4+H7*H4)-(I7*I4+J7*J4)+(-K7*K4+L7*L4)	=	2*(2)-2*(2+2+2)
8	Pelanggan 4	1	1	0	0	1	0	1	0	0	0	(C8*C4+D8*D4+E8*E4+F8*F4+G8*G4+H8*H4)-(I8*I4+J8*J4)+(-K8*K4+L8*L4)	=	2*(1)-2*(2+0+2)
9	Pelanggan 5	0	0	0	0	0	0	0	0	0	0	(C9*C4+D9*D4+E9*E4+F9*F4+G9*G4+H9*H4)-(I9*I4+J9*J4)+(-K9*K4+L9*L4)	=	2*(0)-2*(0+0+0)
10	Pelanggan 6	1	1	1	1	1	1	1	1	0	0	(C10*C4+D10*D4+E10*E4+F10*F4+G10*G4+H10*H4)-(I10*I4+J10*J4)+(-K10*K4+L10*L4)	=	2*(2)-2*(2+2+2)
11	Pelanggan 7	1	1	0	0	1	1	1	0	0	1	(C11*C4+D11*D4+E11*E4+F11*F4+G11*G4+H11*H4)-(I11*I4+J11*J4)+(-K11*K4+L11*L4)	=	2*(1)-2*(2+0+2)
12	Pelanggan 8	1	1	0	0	1	1	1	0	0	1	(C12*C4+D12*D4+E12*E4+F12*F4+G12*G4+H12*H4)-(I12*I4+J12*J4)+(-K12*K4+L12*L4)	=	2*(1)-2*(2+0+2)
13	Pelanggan 9	1	0	1	0	1	0	1	0	0	0	(C13*C4+D13*D4+E13*E4+F13*F4+G13*G4+H13*H4)-(I13*I4+J13*J4)+(-K13*K4+L13*L4)	=	2*(1)-2*(0+1+2)
14	Pelanggan 10	0	0	0	0	0	0	0	0	0	0	(C14*C4+D14*D4+E14*E4+F14*F4+G14*G4+H14*H4)-(I14*I4+J14*J4)+(-K14*K4+L14*L4)	=	2*(0)-2*(0+0+0)
15	Pelanggan 11	1	0	1	1	0	0	1	0	0	0	(C15*C4+D15*D4+E15*E4+F15*F4+G15*G4+H15*H4)-(I15*I4+J15*J4)+(-K15*K4+L15*L4)	=	2*(1)-2*(0+2+0)-2
16	Pelanggan 12	0	0	0	0	0	0	0	0	0	0	(C16*C4+D16*D4+E16*E4+F16*F4+G16*G4+H16*H4)-(I16*I4+J16*J4)+(-K16*K4+L16*L4)	=	2*(0)-2*(0+0+0)
17	Pelanggan 13	1	1	1	1	1	1	1	1	0	0	(C17*C4+D17*D4+E17*E4+F17*F4+G17*G4+H17*H4)-(I17*I4+J17*J4)+(-K17*K4+L17*L4)	=	2*(2)-2*(2+2+2)
18	Pelanggan 14	1	0	1	1	0	0	1	0	0	0	(C18*C4+D18*D4+E18*E4+F18*F4+G18*G4+H18*H4)-(I18*I4+J18*J4)+(-K18*K4+L18*L4)	=	2*(1)-2*(0+2+0)-2
19	Pelanggan 15	0	0	0	0	0	0	0	0	0	0	(C19*C4+D19*D4+E19*E4+F19*F4+G19*G4+H19*H4)-(I19*I4+J19*J4)+(-K19*K4+L19*L4)	=	2*(0)-2*(0+0+0)
20	Pelanggan 16	1	1	1	1	1	0	1	1	1	0	(C20*C4+D20*D4+E20*E4+F20*F4+G20*G4+H20*H4)-(I20*I4+J20*J4)+(-K20*K4+L20*L4)	=	2*(2)-2*(2+2+2)
21	Pelanggan 17	1	1	1	1	1	1	1	1	0	0	(C21*C4+D21*D4+E21*E4+F21*F4+G21*G4+H21*H4)-(I21*I4+J21*J4)+(-K21*K4+L21*L4)	=	2*(2)-2*(2+2+2)
22	Pelanggan 18	1	1	1	1	1	0	1	1	1	0	(C22*C4+D22*D4+E22*E4+F22*F4+G22*G4+H22*H4)-(I22*I4+J22*J4)+(-K22*K4+L22*L4)	=	2*(2)-2*(2+2+2)
23	Pelanggan 19	1	0	1	0	1	0	1	0	0	0	(C23*C4+D23*D4+E23*E4+F23*F4+G23*G4+H23*H4)-(I23*I4+J23*J4)+(-K23*K4+L23*L4)	=	2*(1)-2*(0+1+2)
24	Pelanggan 20	1	0	0	0	0	0	0	0	0	1	(C24*C4+D24*D4+E24*E4+F24*F4+G24*G4+H24*H4)-(I24*I4+J24*J4)+(-K24*K4+L24*L4)	=	2*(0)-2*(0+0+0)+2
25	Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	C25*C4+D25*D4+E25*E4+F25*F4+G25*G4+H25*H4	=	100-2*(2+2+2)
26	Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	I26*I4+J26*J4	=	100-(2*2)
27	Pekali Ralat	0	0	0	0	0	0	0	0	1	1	K27*K4+L27*L4	<=	2
28	Pekali Objektif	1	1	0	0	0	0	0	0	0	0	C28*C4+D28*D4		

Fig. 10: Formula of MUSA Method for First Criteria with Value of γ_1=2

	Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
	w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
	0	21.5	23.5	21.5	21.5	0	49	47	2.387E-15	0			
Pelanggan 1	1	1	1	0	0	0	1	0	0	0	-4	=	-4
Pelanggan 2	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 3	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 4	1	1	0	0	1	0	1	0	0	0	-6	=	-6
Pelanggan 5	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 6	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 7	1	1	0	0	1	1	1	0	0	1	-6	=	-6
Pelanggan 8	1	1	0	0	1	1	1	0	0	1	-6	=	-6
Pelanggan 9	1	0	1	0	1	0	1	0	0	0	-4	=	-4
Pelanggan 10	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 11	1	0	1	1	0	0	1	0	0	0	-4	=	-4
Pelanggan 12	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 13	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 14	1	0	1	1	0	0	1	0	0	0	-4	=	-4
Pelanggan 15	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 16	1	1	1	1	1	0	1	1	1	0	-8	=	-8
Pelanggan 17	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 18	1	1	1	1	1	0	1	1	1	0	-8	=	-8
Pelanggan 19	1	0	1	0	1	0	1	0	0	0	-4	=	-4
Pelanggan 20	1	0	0	0	0	0	0	0	0	1	0	=	0
Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	88	=	88
Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	96	=	96
Pekali Ralat	0	0	0	0	0	0	0	0	1	1	2.39E-15	<=	2
Pekali Objektif	1	1	0	0	0	0	0	0	0	0	21.5		

Fig. 11: Optimum Solution for First Criteria with Value of E And $\gamma_1 = 2$

	Produk		Proses Pembelian		Servis Tambahan		Keseluruhan		Ralat Anggaran				
	w[11]	w[12]	w[21]	w[22]	w[31]	w[32]	z[1]	z[2]	Sigma[+]	Sigma[-]			
	2	21	23	21	21	0	50	46	0	0			
Pelanggan 1	1	1	1	0	0	0	1	0	0	0	-4	=	-4
Pelanggan 2	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 3	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 4	1	1	0	0	1	0	1	0	0	0	-6	=	-6
Pelanggan 5	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 6	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 7	1	1	0	0	1	1	1	0	0	1	-6	=	-6
Pelanggan 8	1	1	0	0	1	1	1	0	0	1	-6	=	-6
Pelanggan 9	1	0	1	0	1	0	1	0	0	0	-4	=	-4
Pelanggan 10	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 11	1	0	1	1	0	0	1	0	0	0	-4	=	-4
Pelanggan 12	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 13	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 14	1	0	1	1	0	0	1	0	0	0	-4	=	-4
Pelanggan 15	0	0	0	0	0	0	0	0	0	0	0	=	0
Pelanggan 16	1	1	1	1	1	0	1	1	1	0	-8	=	-8
Pelanggan 17	1	1	1	1	1	1	1	1	0	0	-8	=	-8
Pelanggan 18	1	1	1	1	1	0	1	1	1	0	-8	=	-8
Pelanggan 19	1	0	1	0	1	0	1	0	0	0	-4	=	-4
Pelanggan 20	1	0	0	0	0	0	0	0	0	1	2	=	2
Penjumlahan w[ik]	1	1	1	1	1	1	0	0	0	0	88	=	88
Penjumlahan z[m]	0	0	0	0	0	0	1	1	0	0	96	=	96
Pekali Ralat	0	0	0	0	0	0	0	0	1	1	0	<=	2
Pekali Objektif	1	1	0	0	0	0	0	0	0	0	23		

Fig .12: Stability Analysis for First Criteria with Value Of E and $\gamma_1 = 2$

Table 6: Transformation Variable Values & Average for Each Criteria with Value of Γ and Γ_I=2

Max. Value	w_{11}	w_{12}	w_{21}	w_{22}	w_{31}	w_{32}	z_1	z_2
Criteria 1	4.0	23.00	25.00	23.00	23.00	2.00	52.00	48.00
Criteria 2	2.00	23.25	25.25	24.25	23.25	2.00	50.50	49.50
Criteria 3	2.00	22.50	24.50	24.50	24.50	2.00	51.00	49.00
Average	2.67	22.92	24.92	23.92	23.58	2.00	51.17	48.83

Comparison of result accuracy is done between Table 4 and Table 6. Comparison explains that Solution After Optimum with values of $\gamma = 2$ and $\gamma_i = 2$ give a more accurate value of transformation variable, that is the standardized error is smaller compared to standardized error of the three criteria with$\gamma = 0$ dan $\gamma_i = 0$. This comparison is explained in Table 7 and equation (3) below:

Table 7: Results Comparison of Table 4 and Table 6

Max. Value	Solution After Optimum with Value of $\gamma = 0$ and $\gamma_i = 0$			Solution After Optimum with Value of $\gamma = 2$ and $\gamma_i = 2$		
Criteria 1	32.50	45.00	22.50	27.00	48.00	25.00
Criteria 2	23.75	52.50	23.75	25.25	49.50	25.25
Criteria 3	20.00	50.00	30.00	24.50	49.00	26.50
Standardized Error, σ	5.24	3.12	3.28	1.05	0.62	0.66

Where values of σ is obtained from the following equation:

$$\sqrt{\frac{\sum_{i=1}^{4}(x_i-\bar{x})^2}{N-1}}$$

With x1 = maximum value of first criteria, x2 = maximum value of second criteria,
x3 = maximum value of third criteria

$$= \sqrt{\frac{((32.5-25.31)^2+(23.75-25.31)^2+(20-25.31)^2+(25-25.31)^2)}{3}} = 5.24$$

$$= \sqrt{\frac{((45-49.38)^2+(52.5-49.38)^2+(50-49.38)^2+(50-49.38)^2)}{3}} = 3.12$$

$$= \sqrt{\frac{((22.5-25.31)^2+(23.75-25.31)^2+(30-25.31)^2+(25-25.31)^2)}{3}} = 3.28$$

$$= \sqrt{\frac{((27-25.59)^2+(25.25-25.59)^2+(24.5-25.59)^2+(25.59-25.59)^2)}{3}} = 1.05$$

$$= \sqrt{\frac{((48-48.84)^2+(49.5-48.84)^2+(49-48.84)^2+(48.84-48.84)^2)}{3}} = 0.62$$

$$= \sqrt{\frac{((25-25.59)^2+(25.25-25.59)^2+(26.5-25.59)^2+(25.59-25.59)^2)}{3}} = 0.66 \quad (3)$$

Based on the results of Table 6, important results of the MUSA Model could be built, which are the Weight Values, Average Satisfaction Index, Average Demanding Index, and Average Improvement Index for each criteria. Steps to obtain all these results are explained in Table 8.

Results from Table 8 could be used to build the Added Value Curve, Action Diagram and Improvement Diagram. All these diagrams are explained through the Figure 13 till 18.

Table 8: Numerical Result with γ=2 and γ_i=2

Criteria	Function Value	Weigth	Average Satisfaction Index $S_i = \sum_{k=1}^{\alpha_i} p_i^k x_i^{*k}$ $S = \frac{1}{100}\sum_{m=1}^{\alpha} p^m y^{*m}$	Average Demanding Index $D_i = \frac{\sum_{k=1}^{\alpha_i-1}(\frac{100(k-1)}{\alpha_i-1} - x_i^{*k})}{100\sum_{k=1}^{\alpha_i-1}\frac{k-1}{\alpha_i-1}}$ $D = \frac{\sum_{m=1}^{\alpha-1}(\frac{100(m-1)}{\alpha-1} - y^{*m})}{100\sum_{m=1}^{\alpha-1}\frac{m-1}{\alpha-1}}$	Average Improvement Index $I_i = b_i(1-S_i)$
First	$x_1^{*1} = 0$ $x_1^{*2} = \frac{100(w_{11})}{w_{11}+w_{12}} = \frac{100 \times 2.67}{2.67+22.92} = 10.43\%$ $x_1^{*3} = \frac{100(w_{11}+w_{12})}{w_{11}+w_{12}} = \frac{100 \times (2.67+22.92)}{2.67+22.92} = 100.00\%$	$= \frac{w_{11}+w_{12}}{100}$ $= \frac{2.67+22.92}{100}$ $= 0.25$	$= \frac{1}{100}(\frac{5}{20} \times 0 + \frac{5}{20} \times 10.43 + \frac{10}{20} \times 100)$ $= 52.61\%$	$= \frac{(\frac{100(1-1)}{3-1} - 0) + \frac{100(2-1)}{3-1} - 10.43)}{100(\frac{1-1}{3-1} + \frac{2-1}{3-1})}$ $= 0.79$	$I_1 = 0.25(1-0.5261) = 0.12$
Second	$x_2^{*1} = 0$ $x_2^{*2} = \frac{100(w_{21})}{w_{21}+w_{22}} = \frac{100 \times 24.92}{24.92+23.92} = 51.02\%$ $x_2^{*3} = \frac{100(w_{21}+w_{22})}{w_{21}+w_{22}} = \frac{100 \times (24.92+23.92)}{24.92+23.92} = 100.00\%$	$= \frac{w_{21}+w_{22}}{100}$ $= \frac{24.92+23.92}{100}$ $= 0.49$	$= \frac{1}{100}(\frac{9}{20} \times 0 + \frac{3}{20} \times 51.02 + \frac{8}{20} \times 100)$ $= 47.65\%$	$= \frac{(\frac{100(1-1)}{3-1} - 0) + \frac{100(2-1)}{3-1} - 51.02)}{100(\frac{1-1}{3-1} + \frac{2-1}{3-1})}$ $= -0.02$	$I_2 = 0.49(1-0.4765) = 0.26$
Third	$x_3^{*1} = 0$ $x_3^{*2} = \frac{100w_{31}}{w_{31}+w_{32}} = \frac{100 \times 23.58}{23.58+2.00} = 92.18\%$ $x_3^{*3} = \frac{100(w_{31}+w_{32})}{w_{31}+w_{32}} = \frac{100 \times (23.58+2.00)}{23.58+2.00} = 100\%$	$= \frac{w_{31}+w_{32}}{100}$ $= \frac{23.58+2}{100}$ $= 0.26$	$= \frac{1}{100}(\frac{9}{20} \times 0 + \frac{5}{20} \times 92.18 + \frac{6}{20} \times 100)$ $= 53.05\%$	$= \frac{(\frac{100(1-1)}{3-1} - 0) + \frac{100(2-1)}{3-1} - 92.18)}{100(\frac{1-1}{3-1} + \frac{2-1}{3-1})}$ $= -0.84$	$I_3 = 0.26(1-0.5305) = 0.12$
Global	$y^{*1} = 0$ $y^{*2} = \frac{100 \times z_1}{z_1+z_2} = \frac{100 \times 51.17}{51.17+48.83} = 51.17\%$ $y^{*3} = \frac{100 \times (z_1+z_2)}{z_1+z_2} = \frac{100 \times (51.17+48.83)}{51.17+48.83} = 100\%$	-	$= \frac{1}{100}(\frac{6}{20} \times 0 + \frac{8}{20} \times 51.17 + \frac{6}{20} \times 100)$ $= 50.47\%$	$= \frac{(\frac{100(1-1)}{3-1} - 0) + \frac{100(2-1)}{3-1} - 51.17)}{100(\frac{1-1}{3-1} + \frac{2-1}{3-1})}$ $= -0.02$	-

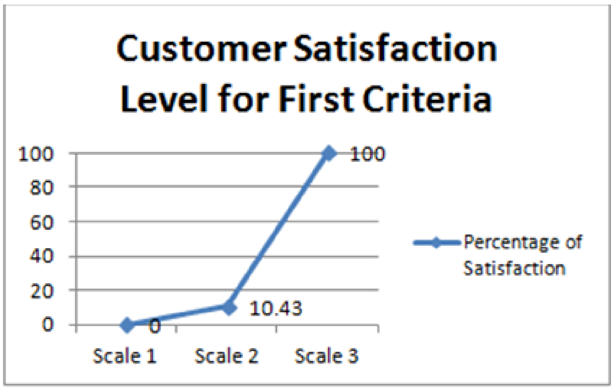

Fig. 13: Customer Satisfaction Level for First Criteria.

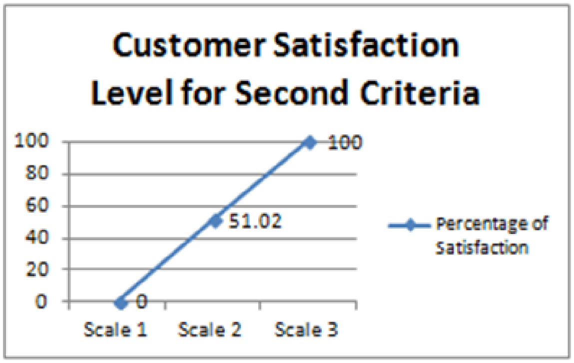

Fig. 14: Customer Satisfaction Level for Second Criteria.

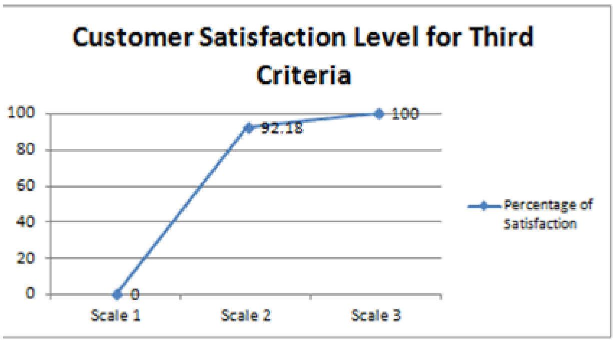

Fig. 15: Customer Satisfaction Level for Third Criteria.

Fig. 16: Customer Satisfaction Level for Global Criteria.

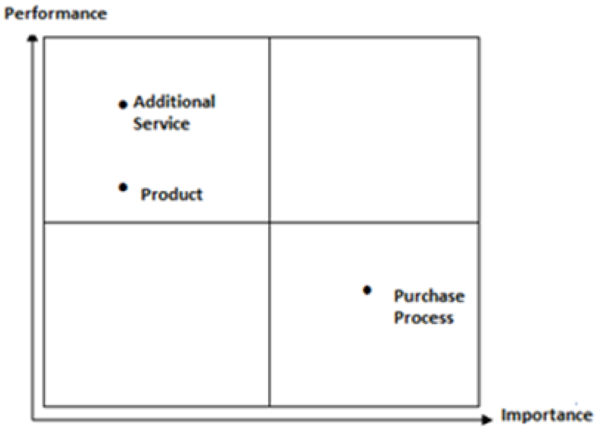

Fig. 17: Relative Action Diagram

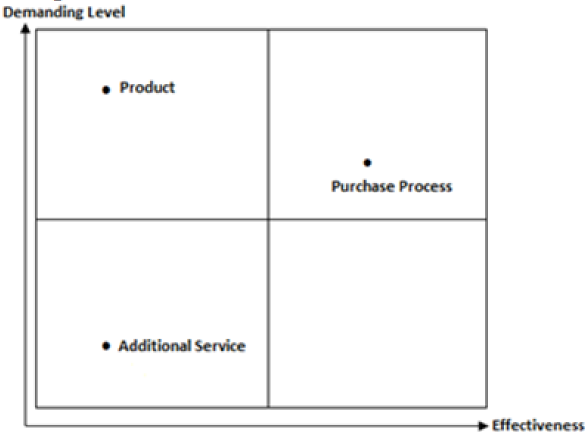

Fig. 18: Relative Improvement Diagram

3. Conclusion

Based on the discussion above, it is proven that Multi-criteria Satisfaction Analysis (MUSA) can also be build using Excel Software which is cheaper in cost, but still analysis well.

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