

# **CHAPTER III**

## **ANALYSIS AND PROBLEM SOLVING**

### **3.1 Combining AHP and TOPSIS Method to Determine the Rank of Alternatives**

In this research, two step methods consist of AHP and TOPSIS are used for the decision-making processes in the android smartphone selection. In first step, AHP is used for calculating the weight of criteria. In second step, these weights are considered and used in TOPSIS process to determine the rank of alternatives.

### **3.2 Using AHP to Analyze the Criteria**

In this research, AHP is used for calculating the weight of criteria, as shown in the following steps:

- 1 Identify the Criteria
- 2 Identify the Alternatives
- 3 Create the Hierarchy
- 4 Create the Pairwise Comparison Matrix
- 5 Calculate the Normalized Pairwise Comparison Matrix
- 6 Calculate the Weight of Criteria

#### **3.2.1 Identify the Criteria**

As a first step, the student determine the criteria that will be used in the comparison between the alternatives in the selection of android smartphone, namely:

1. Price in Rupiah
2. Android OS Version
3. Screen Size
4. Screen Resolution
5. Primary Camera
6. Secondary Camera
7. Processor Cores
8. Internal Memory
9. RAM (Random Access Memory)
10. Battery Capacity

### **3.2.2 Identify the Alternatives**

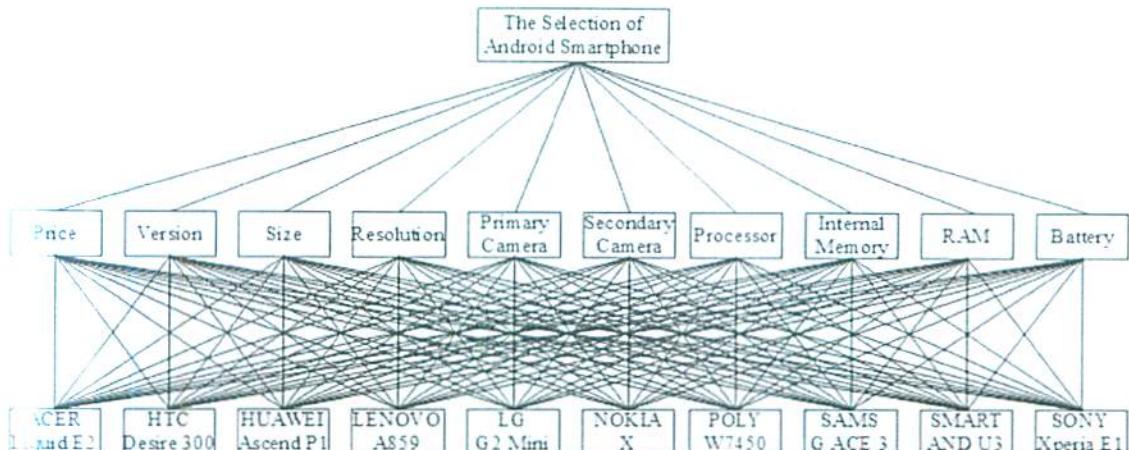
The student took the data from [bhinneka.com](http://www.bhinneka.com) (April 2014), an online electronic store and select products from different brands, namely:

1. ACER Liquid E2
2. HTC Desire 300
3. HUAWEI Ascend P1
4. LENOVO A859
5. LG G2 Mini
6. NOKIA X
7. POLYTRON W7450
8. SAMSUNG Galaxy Ace 3
9. SMARTFREN Andromax U3
10. SONY Xperia E1

### **3.2.3 Create the Hierarchy**

In the hierarchy diagram that is intended to illustrate the decision-making with AHP, there are three main levels, namely:

1. the main objective
2. the criteria
3. the possible alternatives



**Figure 3.1 Hierarchy Diagram**

### 3.2.4 Create the Pairwise Comparison Matrix

In the pairwise comparison matrix, participants analyze it through a sequence of pairwise comparison to obtain the values of numerical scale from the measurement of nodes. The criteria compared pairwise to how important is the objective. The alternatives compared pairwise to each criterion for preference. Comparison processed mathematically and the priority obtained for every node. The pairwise comparison matrix in AHP use the Saaty's 9-point scale as the fundamental scale for assigning the numerical scale values on the pairwise comparison matrix.

**Table 3.1 Saaty's 9 Point Scale**

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities have equal contribute to the objective
3	Moderate Importance	Experience and judgment slightly favor one activity over another
5	Strong Importance	Experience and judgment slightly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically

While the pairwise comparison matrix table is as follows:

**Table 3.2 Pairwise Comparison Matrix**

Criteria	Price	Version	Screen		Camera		Processor	Memory		Battery
	Size	Res	Primary	Second				Internal	RAM	
Price	1	3	3	5	7	9	5	7	3	5
Version	0.3333	1	3	5	7	9	5	7	1	5
Screen	Size	0.3333	0.3333	1	3	7	9	5	7	1
	Res	0.2	0.2	0.3333	1	7	9	3	5	0.2
Camera	Primary	0.1428	0.1428	0.1428	0.1428	1	5	0.3333	0.3333	0.1428
	Second	0.1111	0.1111	0.1111	0.1111	0.2	1	0.2	0.1428	0.1111
Processor	0.2	0.2	0.2	0.3333	3	5	1	3	0.3333	1
Memory	Internal	0.1428	0.1428	0.1428	0.2	3	7	0.3333	1	0.1428
	RAM	0.3333	1	1	5	7	9	3	7	1
Battery	0.2	0.2	0.2	0.3333	3	5	1	5	0.3333	1
Column Total	2.9966	6.33	9.13	20.1205	45.2	68	23.8666	42.4761	7.2633	23.7333

The formula of elements in table 2 are as follows:

- Element  $a[i, j]=1$

$$i = 1, 2, 3, \dots, n$$

For this pairwise comparison matrix,  $n$ (number of criteria) = 10.

- Elements of the upper triangular matrix as input.
- Elements of the lower triangular matrix using formula:

$$a[j, i] = \frac{a}{a[i, j]} \text{ for } i \neq j$$

From the pairwise comparison matrix table above, will be calculated the total of elements for each column, the calculation for column 1 is as follows:

$$\begin{aligned} \text{Column 1 total} &= 1 + 0.3333 + 0.3333 + 0.2 + 0.1428 + 0.1111 + 0.2 + 0.1428 + \\ &0.3333 + 0.2 = 2.9966 \end{aligned}$$

The results from the calculation are inserted into row Column Total in table 3.2.

### 3.2.5 Calculate the Normalized Pairwise Comparison Matrix

To normalize the pairwise comparison matrix, each element will be divided by the total value of each column of the pairwise comparison matrix table, the calculation for column 1 row 1 is as follows:

$$\text{Normalized column 1 row 1} = \frac{\text{the value of column 1 row 1}}{\text{the total value of column 1}} = \frac{1}{2.9966} = 0.3337$$

**Table 3.3 Normalized Pairwise Comparison Matrix**

Criteria	Price	Version	Screen		Camera		Processor	Memory		Battery	Row Total
			Size	Res	Primary	Second		Internal	RAM		
Price	0.3337	0.4739	0.3285	0.2485	0.1548	0.1323	0.2094	0.1647	0.413	0.2106	2.6694
Version	0.1112	0.1579	0.3285	0.2485	0.1548	0.1323	0.2094	0.1647	0.1376	0.2106	1.8555
Screen	0.1112	0.0526	0.1095	0.1491	0.1548	0.1323	0.2094	0.1647	0.1376	0.2106	1.4318
Size	0.1112	0.0315	0.0365	0.0497	0.1548	0.1323	0.1256	0.1177	0.0275	0.1264	0.8687
Res	0.0667	0.0225	0.0156	0.007	0.0221	0.0735	0.0139	0.0078	0.0196	0.014	0.2436
Camera	0.0476	0.0175	0.0121	0.0055	0.0044	0.0147	0.0083	0.0033	0.0152	0.0084	0.1264
Primary	0.037	0.0121	0.0055	0.0044	0.0147	0.0083	0.0083	0.0066	0.0458	0.0421	0.4767
Second	0.0476	0.0225	0.0156	0.0099	0.0663	0.1029	0.0139	0.0235	0.0196	0.0084	0.3302
Processor	0.0667	0.0315	0.0219	0.0165	0.0663	0.0735	0.0418	0.0706	0.0458	0.0421	0.4767
Internal	0.0476	0.0225	0.0156	0.0099	0.0663	0.1029	0.0139	0.0235	0.0196	0.0084	0.3302
Memory	0.1112	0.1579	0.1095	0.2485	0.1548	0.1323	0.1256	0.1647	0.1376	0.1264	1.4685
RAM	0.1112	0.0315	0.0219	0.0165	0.0663	0.0735	0.0418	0.1177	0.0458	0.0421	0.5238
Battery	0.0667	0.0315	0.0219	0.0165	0.0663	0.0735	0.0418	0.1177	0.0458	0.0421	0.5238

After the normalization of pairwise comparison matrix is completed, the next step is calculate the total of each row, the calculation for row 1 is as follows:

$$\text{Total row 1} = 0.3337 + 0.4739 + 0.3285 + 0.2485 + 0.1548 + 0.1323 + 0.2094 + 0.1647 + 0.413 + 0.2106 = 2.6694$$

The results from the calculation are inserted into column Row Total in table 3.3.

### **3.2.6 Calculate the Weight of Criteria**

After each row total is obtained, the next step is to calculate the weight of each criterion by dividing each row total with the number of criteria, so that the weight of criteria is as follows:

**Table 3.4 Weight of Criteria**

	Criteria	Calculation	Weight of Criteria
	Price	2.6694 / 10	0.2669
	Version	1.8555 / 10	0.1855
Screen	Size	1.4318 / 10	0.1431
	Resolution	0.8687 / 10	0.0868
Camera	Primary	0.2436 / 10	0.0243
	Secondary	0.1264 / 10	0.0126
	Processor	0.4767 / 10	0.0476
Memory	Internal	0.3302 / 10	0.033
	RAM	1.4685 / 10	0.1468
	Battery	0.5238 / 10	0.0523

### **3.3 Using TOPSIS to Rank the Alternatives**

After the weight of criteria calculated, TOPSIS will be used to determine the rank of alternatives, as shown in the following steps:

1. Determine the Criteria Score
2. Identify the Alternative Specifications
3. Convert the Alternative Specifications to the Decision Matrix
4. Calculate the Normalized Decision Matrix
5. Calculate the Weighted Normalized Decision Matrix
6. Determine the Positive and Negative Ideal Solutions
7. Calculate the Separation Measure for Each Alternative from the Positive and Negative Ideal Solution
8. Calculate the Relative Closeness to the Positive Ideal Solution
9. Determine the Rank of Alternatives

### 3.3.1 Determine the Criteria Score

The next step is to determine the criteria score to be used as the reference for the conversion of the specification data into the decision matrix.

**Table 3.5 Criteria Score**

Criteria	Data Specification	Weight of Conversion	Explanation
Price	> 3.0 million	1	Very Poor
	2.6 – 3.0 million	2	Poor
	2.1 – 2.5 million	3	Fair
	1.6 – 2.0 million	4	Good
	< 1.6 million	5	Very Good
	< 4.1	1	Very Poor
Version	4.1	2	Poor
	4.2	3	Fair
	4.3	4	Good
	> 4.3	5	Very Good
	< 4.3 inch	1	Very Poor
	4.3 inch	2	Poor
Size	4.5 inch	3	Fair
	4.7 inch	4	Good
	> 4.7 inch	5	Very Good
	< 480x800 pixels	1	Very Poor
	480x800 pixels	2	Poor
	540x960 pixels	3	Fair
Resolution	720x1280 pixels	4	Good
	> 720x1280 pixels	5	Very Good
	< 5 MP	1	Very Poor
	5 – 8 MP	3	Fair
	> 8 MP	5	Very Good
		1	Very Poor
Camera	0.3 (VGA) MP	3	Fair
	> 0.3 MP	5	Very Good
	< 2 cores	1	Very Poor
	2 cores	3	Fair
	> 2 cores	5	Very Good
		1	Very Poor
Processor	< 8 GB	1	Very Poor
	8 GB	3	Fair
	> 8 GB	5	Very Good
	< 512 MB	1	Very Poor
	512 MB	2	Poor
	768 MB	3	Fair

	1 GB	4	Good
	> 1 GB	5	Very Good
	< 1501 mAh	1	Very Poor
	1501 – 1750 mAh	2	Poor
Battery	1751 – 2000 mAh	3	Fair
	2001 – 2250 mAh	4	Good
	> 2250 mAh	5	Very Good

### 3.3.2 Identify the Alternative Specifications

**Table 3.6 Alternative Specifications**

Alternative	Price	Version	Screen		Camera		Processor	Memory		Battery
			Size	Resolution	Primary	Secondary		Internal	RAM	
ACER Liquid E2	2.5 million	4.2	4.5	540x960	8	2	4	4 GB	1 GB	2000
HTC Desire 300	2.6 million	4.2	4.3	480x800	5	0.3 (VGA)	2	4 GB	512 MB	1650
HUAWEI Ascend P1	2.3 million	4.0	4.3	540x960	8	1.3	2	4 GB	1 GB	1670
LENOVO A859	2.4 million	4.2	5.0	720x1280	8	1.6	4	8 GB	1 GB	2250
LG G2 Mini	3.3 million	4.4	4.7	540x960	8	1.3	4	8 GB	1 GB	2440
NOKIA X	1.6 million	4.1	4.0	480x800	3.15	-	2	4 GB	512 MB	1500
POLYTRON W7450	2.15 million	4.1	4.5	540x960	8	1.3	4	4 GB	1 GB	2100
SAMSUNG Galaxy Ace 3	2.0 million	4.2	4.0	480x800	5	0.3 (VGA)	2	4 GB	1 GB	1500
SMARTFREN Andromax U3	2.1 million	4.1	4.7	540x960	8	2	4	4 GB	1 GB	1800
SONY Xperia E1	1.8 million	4.3	4.0	480x800	3	-	2	4 GB	512 MB	1750

### 3.3.3 Convert the Alternative Specifications to Decision Matrix

After the criteria score obtained and the alternative specifications identified, the decision matrix can be constructed. In the decision matrix, the column represent the

existing criteria, whereas the row represent the alternatives. The decision matrix referring to m(the alternatives) that is evaluated based on n(the criteria)

**Table 3.7 Decision Matrix Formula**

Alternative	Price	Version	Screen		Camera		Processor	Memory		Battery
			Size	Res	Primary	Second		Internal	RAM	
$a_1$	$x_{11}$	$x_{12}$	$x_{13}$	$x_{14}$	$x_{15}$	$x_{16}$	$x_{17}$	$x_{18}$	$x_{19}$	$x_{110}$
$a_2$	$x_{21}$	$x_{22}$	$x_{23}$	$x_{24}$	$x_{25}$	$x_{26}$	$x_{27}$	$x_{28}$	$x_{29}$	$x_{210}$
$a_3$	$x_{31}$	$x_{32}$	$x_{33}$	$x_{34}$	$x_{35}$	$x_{36}$	$x_{37}$	$x_{38}$	$x_{39}$	$x_{310}$
$a_4$	$x_{41}$	$x_{42}$	$x_{43}$	$x_{44}$	$x_{45}$	$x_{46}$	$x_{47}$	$x_{48}$	$x_{49}$	$x_{410}$
$a_5$	$x_{51}$	$x_{52}$	$x_{53}$	$x_{54}$	$x_{55}$	$x_{56}$	$x_{57}$	$x_{58}$	$x_{59}$	$x_{510}$
$a_6$	$x_{61}$	$x_{62}$	$x_{63}$	$x_{64}$	$x_{65}$	$x_{66}$	$x_{67}$	$x_{68}$	$x_{69}$	$x_{610}$
$a_7$	$x_{71}$	$x_{72}$	$x_{73}$	$x_{74}$	$x_{75}$	$x_{76}$	$x_{77}$	$x_{78}$	$x_{79}$	$x_{710}$
$a_8$	$x_{81}$	$x_{82}$	$x_{83}$	$x_{84}$	$x_{85}$	$x_{86}$	$x_{87}$	$x_{88}$	$x_{89}$	$x_{810}$
$a_9$	$x_{91}$	$x_{92}$	$x_{93}$	$x_{94}$	$x_{95}$	$x_{96}$	$x_{97}$	$x_{98}$	$x_{99}$	$x_{910}$
$a_{10}$	$x_{101}$	$x_{102}$	$x_{103}$	$x_{104}$	$x_{105}$	$x_{106}$	$x_{107}$	$x_{108}$	$x_{109}$	$x_{1010}$

In table 3.7,  $x_{11}, \dots, x_{1010}$  represent performance with the criteria referring to the criteria score table for every alternatives, as follows:

$x_{ij}$  is the alternative performance-i for the criteria-j.

$a_i$  ( $i = 1, 2, 3, \dots, m$ ) is the possible alternatives.

$x_j$  ( $j = 1, 2, 3, \dots, n$ ) is the criteria which the alternative performance is evaluated.

The result of conversion from alternative specifications to the decision matrix according to the criteria score is below:

**Table 3.8 Decision Matrix**

Alternative	Price	Version	Screen		Camera		Processor	Memory		Battery
			Size	Res	Primary	Second		Internal	RAM	
ACER Liquid E2	3	3	3	3	3	5	5	1	4	3
HTC Desire 300	2	3	2	2	3	3	3	1	2	2
HUAWEI Ascend P1	3	1	2	3	3	5	3	1	4	2
LENOVO A859	3	3	5	4	3	5	5	3	4	4
LG G2 Mini	1	5	4	3	3	5	5	3	4	5

NOKIA X	2	2	1	2	1	1	3	1	2	1
POLYTRON W7450	3	2	3	3	3	5	5	1	4	4
SAMSUNG Galaxy Ace 3	2	3	1	2	3	3	3	1	4	1
SMARTFREN Andromax U3	3	2	4	3	3	5	5	1	4	3
SONY Xperia E1	2	4	1	2	1	1	3	1	2	2

### 3.3.4 Calculate the Normalized Decision Matrix

The purpose of normalization of the decision matrix is to minimize the distance(range) of data, in order to facilitate the calculation of TOPSIS and save on memory usage. The formula of the decision matrix normalization is as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}}$$

$r_{ij}$  is an element of the normalized decision matrix.

$x_{ij}$  is an element of the decision matrix.

$i = 1, 2, 3, \dots, m$  (number of alternatives)

$j = 1, 2, 3, \dots, n$  (number of criteria)

The calculation for the row 1 of price column is as follows:

$$r_{11} = \frac{x_{11}}{\sqrt{x_{11}^2 + x_{21}^2 + x_{31}^2 + x_{41}^2 + x_{51}^2 + x_{61}^2 + x_{71}^2 + x_{81}^2 + x_{91}^2 + x_{101}^2}}$$

$$= \frac{3}{\sqrt{3^2 + 2^2 + 3^2 + 3^2 + 1^2 + 2^2 + 3^2 + 2^2 + 3^2 + 2^2}} = \frac{3}{\sqrt{62}} = \frac{3}{7.874} = 0.381$$

**Table 3.9 Normalized Decision Matrix**

Alternative	Price	Version	Screen		Camera		Process or	Memory		Battery
			Size	Res	Primary	Second		Internal	RAM	
ACER Liquid E2	0.381	0.3162	0.3234	0.3418	0.3487	0.3834	0.3834	0.196 1	0.359 2	0.318
HTC Desire 300	0.254	0.3162	0.2156	0.2279	0.3487	0.23	0.23	0.196 1	0.179 6	0.212
HUAWEI Ascend P1	0.381	0.1054	0.2156	0.3418	0.3487	0.3834	0.23	0.196 1	0.359 2	0.212

LENOVO A859	0.381	0.3162	0.5391	0.4558	0.3487	0.3834	0.3834	0.588 3	0.359 2	0.424
LG G2 Mini	0.127	0.527	0.4313	0.3418	0.3487	0.3834	0.3834	0.588 3	0.359 2	0.53
NOKIA X	0.254	0.2108	0.1078	0.2279	0.1162	0.0766	0.23	0.196 1	0.179 6	0.106
POLYTRON W7450	0.381	0.2108	0.3234	0.3418	0.3487	0.3834	0.3834	0.196 1	0.359 2	0.424
SAMSUNG Galaxy Ace 3	0.254	0.3162	0.1078	0.2279	0.3487	0.23	0.23	0.196 1	0.359 2	0.106
SMARTFREN Andromax U	0.381	0.2108	0.4313	0.3418	0.3487	0.3834	0.3834	0.196 1	0.359 2	0.318
SONY Xperia E1	0.254	0.4216	0.1078	0.2279	0.1162	0.0766	0.23	0.196 1	0.179 6	0.212

### 3.3.5 Calculate the Weighted Normalized Decision Matrix

The weighted normalized decision matrix is calculated by multiply each column of the normalized decision matrix by it's associated weight, calculated by AHP and shown in table 4, the weight of criteria. The formula is as follows:

$$v_{ij} = w_j r_{ij}$$

$v_{ij}$  is an element of the weighted normalized decision matrix.

$w_j (w_1, w_2, w_3, \dots, w_n)$  is the weight of criteria-j.

$r_{ij}$  is an element of the normalized decision matrix.

$i = 1, 2, 3, \dots, m$  (number of alternatives)

$j = 1, 2, 3, \dots, n$  (number of criteria)

The calculation for the row 1 of price column is as follows:

$$v_{11} = w_1 r_{11} = 0.2669 * 0.381 = 0.1016$$

**Table 3.10 Weighted Normalized Decision Matrix**

Alternative	Price	Version	Screen		Camera		Processor	Memory		Battery
			Size	Res	Primary	Second		Internal	RAM	
ACER Liquid E2	0.101 6	0.0586	0.0462	0.0296	0.0084	0.0048	0.0182	0.006 4	0.052 7	0.0166

HTC Desire 300	0.067 7	0.0586	0.0308	0.0197	0.0084	0.0028	0.0109	0.006 4	0.026 3	0.011
HUAWEI Ascend P1	0.101 6	0.0195	0.0308	0.0296	0.0084	0.0048	0.0109	0.006 4	0.052 7	0.011
LENOVO A859	0.101 6	0.0586	0.0771	0.0395	0.0084	0.0048	0.0182	0.019 4	0.052 7	0.0221
LG G2 Mini	0.033 8	0.0977	0.0617	0.0296	0.0084	0.0048	0.0182	0.019 4	0.052 7	0.0277
NOKIA X	0.067 7	0.0391	0.0154	0.0197	0.0028	0.0009	0.0109	0.006 4	0.026 3	0.0055
POLYTRON W7450	0.101 6	0.0391	0.0462	0.0296	0.0084	0.0048	0.0182	0.006 4	0.052 7	0.0221
SAMSUNG Galaxy Ace 3	0.067 7	0.0586	0.0154	0.0197	0.0084	0.0028	0.0109	0.006 4	0.052 7	0.0055
SMARTFREN Andromax U3	0.101 6	0.0391	0.0617	0.0296	0.0084	0.0048	0.0182	0.006 4	0.052 7	0.0166
SONY Xperia E1	0.067 7	0.0782	0.0154	0.0197	0.0028	0.0009	0.0109	0.006 4	0.026 3	0.011

### 3.3.6 Determine the Positive and Negative Ideal Solutions

The positive and negative ideal solution are used to determine the distance between the value of each alternative. The formula for determine the positive ideal solution is:

$$\begin{aligned} A^+ &= \{ (\max v_{ij} \mid j \in J), (\min v_{ij} \mid j \in J) \}, i = 1, 2, 3, \dots, m \} \\ &= \{ v_1^+, v_2^+, v_3^+, \dots, v_n^+ \} \end{aligned}$$

While the formula for determine the negative ideal solution is:

$$\begin{aligned} A^- &= \{ (\min v_{ij} \mid j \in J), (\max v_{ij} \mid j \in J) \}, i = 1, 2, 3, \dots, m \} \\ &= \{ v_1^-, v_2^-, v_3^-, \dots, v_n^- \} \end{aligned}$$

$v_{ij}$  is an element of the weighted normalized decision matrix.

$v_+$  ( $j = 1, 2, 3, \dots, n$ ) is an element of the positive ideal solution.

$v_-$  ( $j = 1, 2, 3, \dots, n$ ) is an element of the negative ideal solution.

$J^+$  ( $j = 1, 2, 3, \dots, n$  and  $J$  is a set of benefit criteria).

$J^-$  ( $j = 1, 2, 3, \dots, n$  and  $J$  is a set of cost criteria).

The calculation for the positive ideal solution for the price criteria is as follows:

$$\begin{aligned}
 &= \max(v_{11}, v_{21}, v_{31}, v_{41}, v_{51}, v_{61}, v_{71}, v_{81}, v_{91}, v_{101}) \\
 &= \max(0.1016, 0.0677, 0.1016, 0.1016, 0.0338, 0.0677, 0.1016, 0.0677, \\
 &\quad 0.1016, 0.0677) \\
 &= 0.1016
 \end{aligned}$$

**Table 3.11 Positive Ideal Solutions**

$A^+$	$v_1^+$	$v_2^+$	$v_3^+$	$v_4^+$	$v_5^+$	$v_6^+$	$v_7^+$	$v_8^+$	$v_9^+$	$v_{10}^+$
	0.1016	0.0977	0.0771	0.0395	0.0084	0.0048	0.0182	0.0194	0.0527	0.0277

While the calculation for the negative ideal solution for the price criteria is as follows:

$$\begin{aligned}
 &= \min(v_{11}, v_{21}, v_{31}, v_{41}, v_{51}, v_{61}, v_{71}, v_{81}, v_{91}, v_{101}) \\
 &= \min(0.1016, 0.0677, 0.1016, 0.1016, 0.0338, 0.0677, 0.1016, 0.0677, \\
 &\quad 0.1016, 0.0677) \\
 &= 0.0338
 \end{aligned}$$

**Table 3.12 Negative Ideal Solutions**

$A^-$	$v_1^-$	$v_2^-$	$v_3^-$	$v_4^-$	$v_5^-$	$v_6^-$	$v_7^-$	$v_8^-$	$v_9^-$	$v_{10}^-$
	0.0338	0.0195	0.0154	0.0197	0.0028	0.0009	0.0109	0.0064	0.0263	0.0055

### 3.3.7 Calculate the Separation Measure for Each Alternative from the Positive and Negative Ideal Solutions

Separation measure is a measurement of the distance of an alternative to the ideal solution. The formula for the positive separation measure is:

$$s_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2}$$

$i = 1, 2, 3, \dots, m$

While the formula for the negative separation measure is:

$$s_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}$$

$j = 1, 2, 3, \dots, n$

- ✓ is the alternative-i distance from the positive ideal solution.
- ✓ is the alternative-i distance from the negative ideal solution.
- ✓ is an element of the weighted normalized decision matrix.
- ✓ is an element of the positive ideal solution.
- ✓ is an element of the negative ideal solution.

The separation from the positive ideal solution calculation for the first alternative, ACER Liquid E2 is as follows:

$$\begin{aligned}
 s_1 &= \sqrt{\frac{(v_{11}-v_1^+)^2 + (v_{12}-v_2^+)^2 + (v_{13}-v_3^+)^2 + (v_{14}-v_4^+)^2 + (v_{15}-v_5^+)^2}{(0.1016-0.1016)^2 + (0.0586-0.0977)^2 + (0.0462-0.0771)^2 + (0.0296-0.0395)^2 + (0.0084-0.0084)^2}} = \sqrt{\frac{(0)^2 + (0.0391)^2 + (0.0309)^2 + (0.0099)^2 + (0)^2}{(0)^2 + (0)^2 + (0.013)^2 + (0)^2 + (0.0111)^2}} = \sqrt{\frac{0.00152881 + 0.00095481 + 0.00009801 + 0 + 0}{0 + 0 + 0.000169 + 0 + 0.00012321}} \\
 &= \sqrt{0.00287384} = 0.053608208
 \end{aligned}$$

**Table 3.13 Separation from the Positive Ideal Solution**

Alternative	$s^+$
ACER Liquid E2	0.053608208
HTC Desire 300	0.08009925
HUAWEI Ascend P1	0.094117586
LENOVO A859	0.039498987
LG G2 Mini	0.07022827
NOKIA X	0.10119664
POLYTRON W7450	0.06846269
SAMSUNG Galaxy Ace 3	0.087155493
SMARTFREN Andromax U3	0.063728643
SONY Xperia E1	0.083505089

While the separation from the negative ideal solution calculation is as follows:

$$\begin{aligned}
 s^- &= \sqrt{\left( (v_{11} - v_1^-)^2 + (v_{12} - v_2^-)^2 + (v_{13} - v_3^-)^2 + (v_{14} - v_4^-)^2 + (v_{15} - v_5^-)^2 \right.} \\
 &\quad \left. + (v_{16} - v_6^-)^2 + (v_{17} - v_7^-)^2 + (v_{18} - v_8^-)^2 + (v_{19} - v_9^-)^2 + (v_{110} - v_{10}^-)^2 \right) / 10 \\
 &= \sqrt{(0.1016 - 0.0338)^2 + (0.0586 - 0.0195)^2 + (0.0462 - 0.0154)^2 + (0.0296 - 0.0197)^2 + (0.0084 - 0.0028)^2} \\
 &\quad + \sqrt{(0.0048 - 0.0009)^2 + (0.0182 - 0.0109)^2 + (0.0064 - 0.0064)^2 + (0.0527 - 0.0263)^2 + (0.0166 - 0.0055)^2} \\
 &= \sqrt{(0.0678)^2 + (0.0391)^2 + (0.0308)^2 + (0.0099)^2 + (0.0056)^2} \\
 &\quad + \sqrt{(0.0039)^2 + (0.0073)^2 + (0)^2 + (0.0264)^2 + (0.0111)^2} \\
 &= \sqrt{0.00459684 + 0.00152881 + 0.00094864 + 0.00009801 + 0.00003136} \\
 &\quad + \sqrt{0.00001521 + 0.00005329 + 0 + 0.00069696 + 0.00012321} \\
 &= \sqrt{0.089957378}
 \end{aligned}$$

**Table 3.14 Separation from the Negative Ideal Solutions**

Alternative	$s^-$
ACER Liquid E2	0.089957378
HTC Desire 300	0.054593039
HUAWEI Ascend P1	0.075536679
LENOVO A859	0.107545153
LG G2 Mini	0.099073709
NOKIA X	0.039158268
POLYTRON W7450	0.084261675
SAMSUNG Galaxy Ace 3	0.058394777
SMARTFREN Andromax U3	0.090237076
SONY Xperia E1	0.068008455

### 3.3.8 Calculate the Relative Closeness to the Positive Ideal Solutions

The relative closeness to the positive ideal solution can be calculated using the following formula:

$$c_i^+ = \frac{s_i^-}{s_i^- + s_i^+}$$

$i = 1, 2, 3, \dots, m$

- $c_i^+$  is the relative closeness from the alternative-i to the positive ideal solution.
- $s_i^-$  is the alternative-i distance from the positive ideal solution.
- $s_i^+$  is the alternative-i distance from the negative ideal solution.

The calculation for the first alternative, ACER Liquid E2 is as follows:

$$c_i^+ = \frac{s_i^-}{s_i^- + s_i^+} = \frac{0.089957378}{0.089957378 + 0.053608208} = 0.62659430094897533452$$

**Table 3.15 Relative Closeness to the Positive Ideal Solutions**

Alternative	$c_i^+$
ACER Liquid E2	0.62659430094897533452
HTC Desire 300	0.40531673643173441057
HUAWEI Ascend P1	0.44523890395564178714
LENOVO A859	0.73138006723695347533
LG G2 Mini	0.58518931429620205444
NOKIA X	0.27899464691323797526
POLYTRON W7450	0.55172385231393825078
SAMSUNG Galaxy Ace 3	0.40120005960827142402
SMARTFREN Andromax U3	0.58608550387765214151
SONY Xperia E1	0.44886056523105287538

### 3.3.9 Determine the Rank of the Alternatives

By comparing the relative closeness values, the ranking of the alternatives are determined. The higher the value of relative closeness means the better the rank. The alternatives ranked from the closest value to 1 and in decreasing order. It means the best alternative have the shortest distance from positive ideal solution and the longest distance from the negative ideal solution.

**Table 3.16 Rank of the Alternatives**

Rank	Alternative	c'
1	LENOVO A859	0.73138006723695347533
2	ACER Liquid E2	0.62659430094897533452
3	SMARTFREN Andromax U3	0.58608550387765214151
4	LG G2 Mini	0.58518931429620205444
5	POLYTRON W7450	0.55172385231393825078
6	SONY Xperia E1	0.44886056523105287538
7	HUAWEI Ascend P1	0.44523890395564178714
8	HTC Desire 300	0.40531673643173441057
9	SAMSUNG Galaxy Ace 3	0.40120005960827142402
10	NOKIA X	0.27899464691323797526

Based on the result of the alternatives ranking on the table 16, the best choice from all alternatives of android smartphone is LENOVO A859, followed by ACER Liquid E2 while the worst choice is NOKIA X.