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Cell Phone Evaluation Base on Entropy and TOPSIS

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ABSTRACT

Hundreds of millions of people own mobile phone. The modern mobile phones market caters for a wide variety of customer tastes and lifestyle. Some phones are tiny and discrete, some offers unique appearances, and whiles others provide a wide range of business and leisure services to their users. With all these high technological features, mobile phone users are faced with difficulties in selecting which mobile phone to purchase. In such situation, the application of Entropy and TOPSIS can aid customer in making the right decision. Results from Entropy and TOPSIS are objective and accurate, eliminating subjective weighting of specification. Using these tools, a customer can purchase the best mobile phone whiles manufactures of mobiles phones can produce mobile with unique technological features aimed at particular users.

Keywords: *Entropy, TOPSIS, Mobile Phone Selection*

1.0 INTRODUCTION

In 1956, the Swedish telecom companies, Telia Sonera and Ericsson created the world's first fully automatic mobile telephone system. This was the first time calls could be made and received in a car using the public telephone network system. Less than ten years later a more improved system called Mobile System B (MTB) was launched which used transistors to enhance the telephone's calling capacity and improve its operational reliability.

By 1981, the so called first generation of mobile telephone systems also known as the Nordic Mobile Telephone System (NMT) emerged. According to Östen Mäkitalo, regarded as the father of the mobile telephone industry,"NMT was the first modern telephone system, the "mother" of all mobile telephones. Other mobile phones produced later were just copies". NMT was the starting point in the mobile revolution, and Sweden and the Nordic countries were in the forefront. NMT was a huge commercial success and after 10 years the system had over one million subscribers in the Nordic region. NMT was replaced by the second generation telephone system, Global System for Mobile Communication (GSM) which was the result of a joint European project. GSM is a success story and no other technology has been used by so many people in such a short period of time. When the GSM system was introduced in 1991, there were a total of 16 million mobile users worldwide. Fifteen years later, out of 2.5 billion users, 2 billion were GSM. By the end of 2007 the number of mobile users exceeded three billion, and keeps increasing on a daily basis.

The weight of the first mobile phone was 40-kilo but now it weighs less than 90 grams. The world is getting smaller, thanks to the mobile phone. We can be anywhere in the world and have access to all the information and communication we could ever want, thanks to this technology and its global standards. Eight out of ten people we met have mobile phones.

The daily usage of mobile phones have created a decision problem for buyers/users nowadays since manufactures have provided different types of mobile phones in the market, which are of great quality, of light weight, great appearance, equipped with great features like in surfing internet , games, Microsoft office application software, camera and others. We may argue that the price of a mobile determines the quality of mobile phone a consumer can purchase. But that is not true since our lifestyle are getting sophisticated and consumers are ready to pay any amount of money to purchase high quality mobile phone. So how can a mobile phone user buy the best mobile phone from the market? This paper aims to answer the stated question by using entropy analysis and fuzzy TOPSIS. Organization of the paper is as follows: the next section describes mobile phone specifications. The third section introduced the evaluation methods, and the fourth section illustrates a numerical example. Finally concluding remarks are provided in section five.

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2.0 EVALUATION CRITERIA OF MOBILE PHONES

There are different types of mobile phones brands in the mobile phone market with various sizes, shapes, colors, functions. The most famous brands popular among users are Nokia, Apple, Samsung, Blackberry, SonyEricsson, HTC and others. Different brands come with its unique specifications. The main specifications that describe a mobile phone are; body, display, sound, memory, data, camera, features and battery as shown below in table 1. Twelfth (12) of these specifications would be utilized in our analysis as shown in Table 2.

3.0 METHODOLOGIES

Multiple–criteria decision making method (MCDM) is a decision making analysis method which has been developed since 1970s. A decision-making problem is the process of finding the best option from all of the feasible alternatives. In almost all such problems the multiplicity of criteria for judging the alternatives is pervasive. That is, for many such problems, the decision maker wants to solve a multiple criteria decision making (MCDM) problem. A MCDM problem can be concisely expressed in matrix format as:

$$\boldsymbol{D} = \begin{array}{c} * \\ \boldsymbol{A_1} \\ \boldsymbol{A_2} \\ \boldsymbol{A_3} \\ \vdots \\ \boldsymbol{A_m} \end{array} \begin{bmatrix} \boldsymbol{C_1} & \boldsymbol{C_2} & \boldsymbol{C_3} & \cdots & \boldsymbol{C_n} \\ \boldsymbol{x_{11}} & \boldsymbol{x_{12}} & \boldsymbol{x_{13}} & \cdots & \boldsymbol{x_{1n}} \\ \boldsymbol{x_{21}} & \boldsymbol{x_{22}} & \boldsymbol{x_{23}} & \cdots & \boldsymbol{x_{2n}} \\ \boldsymbol{x_{31}} & \boldsymbol{x_{32}} & \boldsymbol{x_{33}} & \cdots & \boldsymbol{x_{3n}} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \boldsymbol{x_{m1}} & \boldsymbol{x_{m2}} & \boldsymbol{x_{m3}} & \cdots & \boldsymbol{x_{mn}} \end{bmatrix}, \qquad (*)$$

$$\boldsymbol{W} = [\boldsymbol{w_1} \quad \boldsymbol{w_2} \quad \boldsymbol{w_3} \quad \cdots \quad \boldsymbol{w_n}],$$

Where A_1, A_2, A_3 ...., A_m are possible alternatives among which decision makers have to choose, C_1, C_2, C_3, ..., C_n are criteria with which alternatives performance are measured, x_{ij} is the performance value of alternatives A_i with respect to criterion C_j, w_j is the weight of criterion C_j. In the following sub-sections, 2 MCDM related methods, Entropy Method and Techniques for order preference by similarity to ideal solution (TOPSIS), which are integrated in this research, are discussed.

3.1 Entropy Method for Weight Determination

In this research, we applied the concept of entropy to determine the criteria weight. Entropy is a term in information theory, also known as the average amount of information (Ding and Shi, 2005). The criteria weights are calculated by the Entropy Method. According to the degree of index dispersion, the weight of all indicators is calculated by information entropy. Entropy method is highly reliable and can be easily adopted in information measurement (Zou et al., 2005). The calculation steps are as follows: Suppose we have a decision matrix B with *m* alternatives and *n* indicators:

(1) In matrix B, feature weight p_{ij} is of the *i*th alternatives to the *j*th factor:

$$\boldsymbol{p_{ij} = X_{ij} \Big/ \sum_{i=1}^{m} X_{ij}} \qquad (\boldsymbol{1 \le i \le m, 1 \le j \le n}) \qquad (\boldsymbol{1})$$

(2) The output entropy e_j of the *j*th factor becomes

$$\boldsymbol{e_j = -k \sum_{i=1}^{m} p_{ij} \; In \, p_{ij}} \qquad (\boldsymbol{k = 1/In\, m\,; 1 \le j \le n}) \qquad (\boldsymbol{2})$$

(3) Variation coefficient of the *j*th factor: g_j can be defined by the following equation:

$$\boldsymbol{d_j = 1 - e_j} \qquad (\boldsymbol{1 \le j \le n}) \qquad (\boldsymbol{3})$$

Note that the larger g_j is the higher the weight should be.

(4) Calculate the weight of entropy α_j:

$$\boldsymbol{w_j = g_j \Big/ \sum_{j=1}^{m} g_j} \qquad (\boldsymbol{1 \le j \le n}) \qquad (\boldsymbol{4})$$

(5) Calculate the adjusted weight β_j

$$\boldsymbol{\beta_j = \lambda_j w_j \Big/ \sum_{j=1}^{n} \lambda_j \, w_j} \qquad (\boldsymbol{5})$$

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3.2 Technique for Order Preference by Similarity to Ideal Solution Method (Topsis)

Technique for order preference by similarity to ideal solution TOPSIS was initially developed by Hwang and Yoon (1981), subsequently discussed by many (Chu, 2004; Peng, 2000). TOPSIS finds the best alternatives by minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative-ideal solution (Jahanshahloo et al., 2006). All alternative solutions can be ranked according to their closeness to the ideal solution. Because its first introduction, a number of extensions and variations of TOPSIS have been developed over the years. General TOPSIS process with six steps is listed below:

Step 1
Calculate the normalized decision matrix A. The normalized value a_{ij} is calculated as;

$$a_{ij} = x_{ij} \Big/ \sqrt{\sum_{i=1}^{m} (x_{ij})^2} \qquad (1 \le i \le m, 1 \le j \le n) \qquad (6)$$

Step 2
Calculate the weighted normalized decision matrix

$$V = (a_{ij} * w_j) \qquad (1 \le i \le m, 1 \le n) \qquad (7)$$

where w_j is the weight of the *i*th criterion and $\sum_{i=1}^{n} w_j = 1$.

Step 3
Calculate the ideal solution V * and the negative ideal solution V $^-$

$$V^* = \{v_1^*, \quad v_2^*, \quad \cdots, \quad v_n^*\} = \{(Max \quad v_{ij} | j \in J), (Min \quad v_{ij} | j \in J)\}$$
$$V^- = \{v_1^-, \quad v_2^-, \quad \cdots, \quad v_n^-\} = \{(Min \quad v_{ij} | j \in J), (Max \quad v_{ij} | j \in J)\} \quad (8)$$

Step 4
Calculate the separation measures, using the m-dimensional Euclidean distance

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - V^*)^2} \quad (1 \le i \le m, 1 \le j \le n)$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V^-)^2} \quad (1 \le i \le m, 1 \le j \le n) \qquad (9)$$

Step 5
Calculate the relative closeness to the ideal solution

$$Y_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (1 \le i \le m) \qquad (10)$$

where $Y_i \in (0,1)$. The larger Y_i is, the closer the alternative is to the ideal solution.

Step 6
The larger TOPSIS value, the better the alternative.

4.0 APPLICATION OF ENTROPY AND TOPSIS IN MOBILE PHONE EVALUATION

Suppose a mobile phone user wants to buy a mobile phone from the mobile phone outlet, decision matrix is shown in Table 2. Based on the proposed methodology, 2 steps are applied for weight and selection of mobile phone.

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4.1 Application of Entropy to Determine Weight

In step 1, for the weight using entropy analysis, the procedure is as follows; the decision matrix shown in Table 2. Equation 1 resulted in the data normalization as shown in Table 3 whiles Equation 2, 3, 4 and 5 were applied to obtain the result shown in Table 4.

4.2 Application of Topsis

In step 2, According to TOPSIS algorithm's activities, the results are shown in Tables 5. From the result obtained we can learned that it is feasible to use entropy analysis and TOPSIS to select the best mobile phone from the mobile phone market.

4.3 Analysis of the Decision Result

Mobile phone consumers order of ranking mobile phone specification are; price 13.4%, camera and operating system (OS) 11.97%, battery 8.97%, screen size 7.71%, RAM, speed, and CPU 7.07%, Bluetooth 6.59% and weight, memory, and dimensions 6.06% this was obtained through random selection of mobile phone consumers. Mobile phone consumer way of ranking mobile phone specification is subjective; entropy analysis can be applied to smooth this subjectivity and the result is show in Table 3. During the TOPSIS analysis these assumption were made for mobile phone specification for dimension the bigger the better, for weight the lighter the better and price the cheaper the better whiles the rest of the mobile phone specifications the higher (speed, Bluetooth, CPU, operating System (OS), and camera), bigger (RAM, memory and screen size) and longer (battery) the better. TOPSIS analysis selected the best mobile phone with the best mobile phone specification.

5 CONCLUSIONS

Buying a mobile phone is a MCDM problem that is affected by several specifications. Entropy and TOPSIS analysis can aid customer in making the right decision. Results from Entropy and TOPSIS analysis are objective and accurate, eliminating subjective weighting of specification. Using this tool, a customer can purchase the best mobile phone whiles manufactures of mobiles phones can produce mobile with unique technological features aimed at particular users. The main limitation of this paper is our inability to convert some specification into figures and not including the market demand of the mobile phone.

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TABLES

Table 1, Mobile Phones Specification

Specification	Descriptions
Body	Dimensions, Weight
Display	Screen Size, Type, Multitouch, Phone Protection
Sound	Alert Type, Loudspeaker, 3.5mm Jack
Memory	Card slot, Internal storage
Data	GPRS, EDGE, Speed, WLAN, Bluetooth, NFC, USB
Camera	Primary, Features, Video, Secondary
Features	OS, Chipset, CPU, GPU, Sensors, Messaging, Brower, Radio, GPS, Java, Colors
Battery	Stand-by, Talk time, Music play, battery capacity

Table 2, Specifications of 10 different mobile phones available in the mobile phone market

	Dimensions (mm)	***Weight (g)***	***Screen Size (inc)***	***Memory (GB)***	***RAM (GB)***	***Speed (mbps)***	***Blue Tooth***	***Camera (mp)***	***OS(Honey comb)***	***CPU (GHz)***	***Battery (mAh)***	***Price ($)***
MP 1	86341.0625	135	3.9	64	1	5.7	2.1	8	1.2	1	1450	698
MP 2	115758.15	170.1	4.3	32	1	3.1	3	8	2.4	1.5	1620	719
MP 3	270216	390	8.2	32	1	5.76	2.1	5	3.2	1.2	3960	529.99
MP 4	81884.005	135	4.65	32	1	5.76	3	5	4	1.2	1750	725
MP 5	75031.25	110	3.8	32	0.512	2.9	3	5	2.4	1	1500	359.99
MP 6	***71940***	***90***	***2.44***	***32***	***0.512***	***3.1***	***2.1***	***5***	***7***	***0.8***	***1000***	***479.99***
MP 7	62781.696	140	3.5	64	0.512	5.8	4	8	5	1	1432	870
MP 8	68512.5	117	4.2	32	0.512	5.8	2.1	8	2.4	1.4	1500	420
MP 9	80638.65	141.8	4	32	0.512	5.76	2.1	8	2.2	1	1500	529
MP 10	115584	130	4.3	32	0.512	7.2	2.1	5	2.2	1	1280	679.99

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Table 3, Data after Normalization

	Dimensions (mm)	*Weight (g)*	*Screen Size (inc)*	*Memory (GB)*	*RAM (GB)*	*Speed (mbps)*	*Blue Tooth*	*Camera (mp)*	*OS(Honey comb)*	*CPU (GHz)*	*Battery (mAh)*	*Price ($)*
MP 1	-0.2080	-0.2119	-0.2168	-0.2986	-0.2766	-0.2452	-0.2051	-0.2578	-0.1231	-0.2168	-0.2100	-0.2500
MP 2	-0.2458	-0.2417	-0.2294	-0.2071	-0.2766	-0.1705	-0.2512	-0.2578	-0.1943	-0.2705	-0.2241	-0.2540
MP 3	-0.3512	-0.3466	-0.3152	-0.2071	-0.2766	-0.2466	-0.2051	-0.1973	-0.2303	-0.2405	-0.3394	-0.2141
MP 4	-0.2014	-0.2119	-0.2396	-0.2071	-0.2766	-0.2466	-0.2512	-0.1973	-0.2599	-0.2405	-0.2341	-0.2551
MP 5	-0.1910	-0.1871	-0.2136	-0.2071	-0.1901	-0.1633	-0.2512	-0.1973	-0.1943	-0.2168	-0.2143	-0.1686
MP 6	-0.1860	-0.1647	-0.1621	-0.2071	-0.1901	-0.1705	-0.2051	-0.1973	-0.3325	-0.1896	-0.1667	-0.2018
MP 7	-0.1707	-0.2164	-0.2034	-0.2986	-0.1901	-0.2476	-0.2900	-0.2578	-0.2900	-0.2168	-0.2085	-0.2798
MP 8	-0.1804	-0.1944	-0.2263	-0.2071	-0.1901	-0.2476	-0.2051	-0.2578	-0.1943	-0.2611	-0.2143	-0.1859
MP 9	-0.1996	-0.2181	-0.2201	-0.2071	-0.1901	-0.2466	-0.2051	-0.2578	-0.1841	-0.2168	-0.2143	-0.2139
MP 10	-0.2456	-0.2072	-0.2294	-0.2071	-0.1901	-0.2767	-0.2051	-0.1973	-0.1841	-0.2168	-0.1948	-0.2465

Table 4, Entropy value, the variation coefficient and the entropy of the specifications

	Dimensions (mm)	*Weight (g)*	*Screen Size (inc)*	*Memory (GB)*	*RAM (GB)*	*Speed (mbps)*	*Blue Tooth*	*Camera (mp)*	*OS(Honey comb)*	*CPU (GHz)*	*Battery (mAh)*	*Price ($)*
E_j	0.9466	0.9554	0.9797	0.9788	0.9758	0.9820	0.9878	0.9883	0.9497	0.9930	0.9643	0.9858
d_j	0.0534	0.0446	0.0203	0.0212	0.0242	0.0180	0.0122	0.0117	0.0503	0.0070	0.0357	0.0142
w_j	0.1707	0.1427	0.0649	0.0677	0.0773	0.0575	0.0389	0.0373	0.1609	0.0225	0.1141	0.0455
λ_j	**0.0606**	**0.0606**	**0.0771**	**0.0606**	**0.0707**	**0.0707**	**0.0659**	**0.1197**	**0.1197**	**0.0707**	**0.0897**	**0.1340**
$\lambda j\ wj$	0.0103	0.0086	0.0050	0.0041	0.0055	0.0041	0.0026	0.0045	0.0193	0.0016	0.0102	0.0061
β_j	**0.1264**	**0.1057**	**0.0612**	**0.0501**	**0.0668**	**0.0497**	**0.0313**	**0.0546**	**0.2353**	**0.0194**	**0.1250**	**0.0746**

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Table 5, Separation measure S_i^+, S_i^- , relative closeness (Y_i) and ranking

	S_i^+	S_i^-	Y_i	**Ranking**
MP 1	*0.1448*	*0.0331*	*0.1860*	*7*
MP 2	*0.1237*	*0.0436*	*0.2607*	*5*
MP 3	*0.0582*	*0.1415*	*0.7086*	*1*
MP 4	*0.1263*	*0.0504*	*0.2854*	*4*
MP 5	*0.1449*	*0.0223*	*0.1334*	*10*
MP 6	*0.1379*	*0.0824*	*0.3740*	*2*
MP 7	*0.1304*	*0.0616*	*0.3208*	*3*
MP 8	*0.1449*	*0.0254*	*0.1492*	*9*
MP 9	*0.1397*	*0.0270*	*0.1620*	*8*
MP 10	*0.1332*	*0.0355*	*0.2106*	*6*