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Smart phone selection by the consumer's in Pakistan: FMCGDM fuzzy multiple criteria group decision making approach

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Abstract
Mobile phone is used in different ways and different pattern. Cell phone selection is a challenging problem in current generation. Due to brutal market competition by inventions of different models with innovative designs and characteristics have made the buying decision making more complex. To solve this complexity, a few methods regarding the usage of fuzzy ideas had been proposed. For the few kinds of uncertainty within the selection method fuzzy linguistic method is used. The objective of the study is to investigate the uncertainty in selection criteria of cell phone. This paper, is an attempt to replicate the study in the Pakistani context in order to arrive at the current trends, especially in metros like Lahore where mobile telephony seems to have made an immense impact.

Keywords: smart phone, MCDM (multi criteria decision making), FMCDM, fuzzy TOPSIS

1. Introduction
Mobile/Cell phone are widely used for making call, SMS, MMS, email or to access internet. The first portable cell phone was manifest by in (Martin, 1973), using a handset weighing 4.4 lbs. (Richard, 2008) [8] In the advance world, smartphones have currently overtaken the usage of earlier telecommunication systems. The consumer had a lot of variety on mobile phones. There were variety of designed features included material, shape and their size and color.
The improvement of cell records systems is made relatively a complex activity by using the short-ever-growing wide variety of newly added mobile technology (Ondrus, Bui & Pigneur, 2005) [8]. There may be an outstanding doubt and complications concerning the reputation of cellular technologies by decision makers, providers, traders, and clients alike. to help this selection process amongst different available options for technology evaluation, multi-standards decision-making approach appears to be suitable. it's miles the choices of various concerned actors inside the market on which the fulfillment of introducing a cutting-edge technology in a cellular data gadget (Ling, Hwang & Salvendy, 2007) [6].

2. Literature Review
Due to brutal market competition by inventions of different models with innovative designs and characteristics have made the buying decision making more complex. Mobile phone is used in different ways and different pattern. Sometimes, it is showing up grade the study and sometimes it is showing bad impacts in parts.
The telephones manufacturing is enduring affected changes drove by rapid technical development and governing changes (Oh, Suh, Hong & Hwang, 2009) [7]. It is important in choosing the cell phones by the customers. So, decision making has turn out to be an important component in our daily lives and will be used for complex issues such as multiple conflicting standards. MCDM gives a little by little system for which a consensus decision may be made by using a set of decision makers. they contact the lives of thousands and thousands everywhere on the earth for his or her exercises. (Lin, Chen & Tzeng, 2010) [5] combined AHP and FIM with MCDM techniques to paradigm the value-created evaluation model for planning the new e-era mobile phones.
(Işıklar & Büyüközkan, 2007) [3] in his study, propose a MCDM method to estimate the mobile phone options in respect to the users' preferences order. MCDM approach with group decision making is used to evaluate smart phones as alternative according to consumer preferences (Büyüközkan & Güleryüz, 2016) [2]. MCDM technique TOPSIS, is also used for true ranking to forecast the sports (Saqlain *et al.*, 2019) [11].
Criterion for choosing the cell phone has been identified and then these factors are evaluated on the basis of peoples' choice. On the bases of criterion rank, some cell phone has been ranked according to their criterion. Cell phone selection is a challenging problem in current generation. To solve this complexity, a few methods regarding the usage of fuzzy ideas had been proposed. For the few kinds of uncertainty within the selection method fuzzy linguistic method is used. The objective of the study is to investigate the uncertainty in selection criteria of cell phone.

3. Preliminaries
3.1 Linguistic Set
In crisp set, an element Y in the universe $\aleph$ is either a member of some crisp set **À** or not. It can be represented mathematically with indicator function: **μ À (**У**) = {**1, if *Y* belongs to **À** and **0**, if *Y* doesn't belongs to **À**}. (Riaz, Saeed, Saqlain, Jafar, 2018) [9].

3.2 Fuzzy Set
Fuzzy set μ in a universe $\aleph$ is a mapping $\mu: \aleph \rightarrow [0,1]$ which assigns degree of membership to each element with symbol μ À (*y*) such that μ À (*y*) ϵ [0, 1] (Klir & Yuan, 1995) [4].

3.4 Triangular Fuzzy Number TFN

A fuzzy number ω over the universe of discourse $\aleph$ might be described by a three-sided distribution function parameterized by a triplet (p, q, r). The FN 's and MF is described as;

$$\omega(\varkappa) = \begin{cases} 0 & if\ \varkappa < p \\ \dfrac{a-p}{q-p} & if\ p \le \varkappa \le q, \\ \dfrac{q-a}{r-d} & if\ q \le \varkappa \le r, \\ 0 & if\ \varkappa > r \end{cases}$$

The ω is regarded as a TFN, if the membership function $\omega(\varkappa)$ is piecewise linear (Anand, Clement & Bharatraj, 2017).

4. Material and Method

Zadeh's paper on fuzzy sets (Zadeh, 1965) was the beginning of a new approach in the science and engineering of systems and computers. Thus, in applications triangular fuzzy numbers (TFNs) are normally used due to their computation simplicity, Since, TFNs are very useful in indorsing representation and information processing in a fuzzy environment. In this study TFNs are adopted in the FMCGDM with Generalized Fuzzy TOPSIS method.

Table 1: Fuzzy number and corresponding linguistic variable.

Sr #No	Linguistic variable	Code	Fuzzy Number
1	Extremely short	ES	(0.0,0.0,0.1)
2	Short	S	(0.0,0.1,0.3)
3	Moderately short	MS	(0.3,0.3,0.5)
4	Moderately	M	(0.3,0.5,0.7)
5	Moderately Tall	MT	(0.5,0.7,0.9)
6	Tall	T	(0.7,0.9,1.0)
7	Extremely Tall	VT	(0.9,1.0,1.0)
8	Large	L	(0.2,0.4,0.5)

4.1 Numerical Calculations

Suppose a set of six mobiles as alternatives, $\mathcal{M} = \{M_1, M_2, M_3, M_4, M_5, M_6\}$ are evaluated by four experts $\mathcal{D} = \{X_1, X_2, X_3, X_4\}$ under a fuzzy environment for Operation performance against five criteria's $\mathcal{K} = \{K_1, K_2, K_3, K_4, K_5\}$. Weights given to each criterion $\mathcal{G} = \{0.2, 0.15, 0.35, 0.15, 0.15\}$.

K_1 = RAM
K_2 = ROM
K_3 = Processor
K_4 = Camera
K_5 = Display Size
M_1 = Samsung
M_2 = Nokia
M_3 = HTC
M_4 = Huawei
M_5 = Q-Mobile
M_6 = Rivo

Table 2: Linguistic values assigned by each decision makers to each alternative's criterion

	Strategies	X_1	X_2	X_3	X_4
K_1 = RAM	M_1	S	MT	M	T
	M_2	S	MT	T	T
	M_3	S	M	M	MT
	M_4	S	MT	M	T
	M_5	S	VT	ES	VT
	M_6	MS	S	MT	MS
K_2 = ROM	M_1	S	MT	M	T
	M_2	S	MT	T	T
	M_3	S	M	M	MT
	M_4	S	MT	M	T
	M_5	S	VT	ES	VT
	M_6	S	M	MT	MS
K_3 = Processor	M_1	M	S	T	T
	M_2	MS	L	VT	HL
	M_3	M	M	S	S
	M_4	T	MS	ES	M
	M_5	VT	S	M	MT
	M_6	MT	M	MT	ES
K_4 = Camera	M_1	VT	T	VT	ES
	M_2	M	S	M	T
	M_3	MT	M	MT	MT
	M_4	T	MT	T	M
	M_5	T	MT	T	M
	M_6	T	MT	T	M
K_5 = Display Size	M_1	MT	MS	M	MT
	M_2	VT	S	ES	MT
	M_3	T	ES	M	MT
	M_4	M	M	MT	MT
	M_5	MS	MT	T	MT
	M_6	M	M	MT	MT

Table 3: TFN are assigned by each decision makers to each alternative's criterion

Criteria	M_1	M_2	M_3
K_1	(0.2,0.4,0.6)	(0.2,0.325,0.475)	(0.20,0.40, 0.60)
K_2	(0.375,0.55,0.725)	(0.475,0.625,0.8)	(0.275,0.45,0.65)
K_3	(0.275,0.45,0.625)	(0.275,0.425,0.575)	(0.150,0.30,0.50)
K_4	(0.625,0.725,0.775)	(0.325,0.50,0.675)	(0.450,0.65,0.85)
K_5	(0.325,0.550,0.750)	(0.350,0.4,0.575)	(0.375,0.525,,0.675)

Criteria	M_4	M_5	M_6
K_1	(0.20,0.40,0.60)	(0.425,0.550,0.875)	(0.175, 0.3,0.55)
K_2	(0.375,0.55,0.725)	(0.450, 0.525, 0.60)	(0.325, 0.50,0.70)
K_3	(0.275,0.425,0.575)	(0.425, 0.575,0. 725)	(0.325,0.475,0.65)
K_4	(0.550,0.375, 0.90)	(0.550,0.75, 0.90)	(0.50,0.7, 0.875)
K_5	(0.40, 0.60, 0.80)	(0.45,0.65, 0.825)	(0.40,0.60, 0.80)

By simplifying each step of fuzzy TOPSIS and finally we calculate, closeness coefficient of each alternative by using

$$M_i^* = \frac{d_i^-}{d_i^- + d_i^+}$$

M_1^* = 0.355/0.355+0.422 = 0.457

M_2^* = 0.029/0.029+0.748 = 0.037

M_3^* = 0.025/0.025+0.757 = 0.032

M_4^* = 0.424/0.424+0.352 = 0.547

M_5^* = 0.773/0.773+0 = 1

M_6^* = 0.343/0.343+0.431 = 0.443

Lastly, in table: 4 ranking of each alternative is shown.

Table 4: Alternative rankings

Strategy	Final score	Ranks
M_1	0.457	3
M_2	0.037	5
M_3	0.032	6
M_4	0.547	2
M_5	0.001	1
M_6	0.443	4

5. Result Discussion

In this study TFN's are used in FMCGDM for the selection of mobile phone in metro like Lahore. This study is completely based in Pakistani context and it was done first time. Results of above calculations shows that due to brutal market competition mobile phone selection is a difficult task within the budget, using this algorithm mobile phone can be selected easily.

6. Conclusion

The findings are based totally upon the studies conducted in Lahore and hence might not be relevant immediately to different metropolitan regions on counts of socio-cultural diversity and contextual elements. With a bigger pattern size unfold throughout different metropolitan towns in Pakistan one would possibly arrive at effects with higher self-assurance levels and also at traits for city Pakistan mainly. One of these studies wishes to be undertaken periodically to gauge the exact patron perceptions that they hold converting with time.

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