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"KEY PRODUCT" A FUZZY LOGIC-BASED NEW APPROACH FOR DETERMINING CONSUMER PREFERENCES

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Abstract

Due to the intense competition that prevails in today's markets, it is necessary to constantly monitor target audiences in order to harmonize goods and services with consumer expectations. Many studies have been conducted to date on customer's selection criteria for goods and services, and their levels of perception and expectation. In this study, a fuzzy logic-based new quantitative analysis method was used to assess the extent to which current smart phones can satisfy consumer expectations, and to also determine the most suitable combination of product features based on general consumer preferences.

The study population consisted of university students. In this context, the study sample was specifically composed of the students from the Yuzuncu Yil University in Van, Turkey. The study questionnaire that was administered to 386 students was based on smart phone features and applications.

Using the "Key Product" method analysis performed based on the results of this study, it will be easier and more functional to identify consumers whose preferences are not satisfied in the market, and offer new and suitable combinations for them. In addition, and depending on the number of products to be produced and the consumer demands to be met, this method will also make it easier to determine the number of products with which production processes should be initiated, and the duration of time for which the production stages should be continued.

Proposed fuzzy logic-based new quantitative analysis method determines the most suitable combination of product features according to general consumer preferences.

Keywords: Consumer Prediction, Fuzzy Logic, Key product, Product development

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1. Introduction

Market research conducted for determining product features aim to identify the features of goods or services that have the most impact on consumer preferences, as well as the degree to which these features have an effect. In this context, what most consumers want is for manufactured products to possess the best features possible. Product features include characteristics that help satisfy consumer demands and needs with regards to the use, benefits and possession of the product (Kotler and Amrstrong, 2007). The product features of advanced technological devices such as smart phones there are determined by their hardware and software (Lay-Yee et al., 2013). Despite being relatively recent products, cell phones are nowadays the most widely used technology after computers, and are used by nearly all age groups and segments of society (Ozer et al., 2006). Smart phones have an important place in the communication sector, and have exhibited rapid growth and development in parallel with the advances in technology. They have become an essential and indispensible aspect of daily life, bringing a new dimension to peoples' needs in the field of communications. (Degermen, 2006). While cell phones were, initially, used almost exclusively for communication purposes, they have nowadays become versatile and multi-functional devices. Today, cell phones can fulfill many functions such as taking photographs, recording videos, playing music, providing GPS, accessing the internet, and performing video conferences. Furthermore, they can satisfy a broad range of consumer demands through the numerous uses and benefits they offer. (Ozguren et al., 2013)

According to data from the IDC (International Data Corporation) – an organization that conducts surveys worldwide – the number of cell phone deliveries has increased from 1.301 billion in 2014 to 1.432 billion in 2015. Nowadays, 63% of cell phones sold worldwide are smart phones (http://www.idc.com/prodserv/smartphone-market-share.jsp). In parallel with the developments around the globe, smart phone use is also rapidly increasing in Turkey. While a total of 4.7 million smart phones have been sold in the first five months of 2015, current estimates are that this number will reach 11.4 million by the end of 2015. (report from GFK (Gesellschaft fur Konsumforschung / Society for Consumer Research)).

In Turkey, there is an estimated 60 million smart phones in use, and the number of high-end segment smart phones being purchased is gradually increasing, with consumers spending an average of approximately 2,500 TRY to acquire the most advanced phones available. However, despite this great interest in smart phones, consumers in Turkey still seem to be unaware of or disinterested in the features that set smart phones apart from other phones. For this reason, the utilization of these done phones remain at a very basic level in Turkey, being limited to simple functions such as taking photographs, sending messages, making phone calls, and using popular social media sites. As is the case with cell phones, consumers are often unable to utilize many technological features and functions of the technologies for which they spend considerable sums, while companies continue to unnecessarily allocate significant time and money in developing and producing features and functions that will find limited use among consumers. (Erdil and Baydar, 2007). For this reason, companies use the management tool known as value analysis method in order to improve their products by eliminating unnecessary aspects/features that do not contribute to its value or function. This enables them to design products that better meet consumer demands and performance expectations at a lower cost (Ureten, 1997).

In this context, the aim of this study was to present a new model that helps determine which alternative feature combinations in a multi-featured product best satisfies consumer expectations, and which also assists with selecting the most suitable combinations of features. To this end, we present an application that classifies smart-phone users according to their product feature expectations; that measures the extent to which cell phone feature combinations satisfy the consumer expectations; and which determines the combination of smart phone features that would best satisfy consumer expectations when they were offered with a limited product range. In this model, the fuzzy logic was used, which is a widely employed method for digitizing verbal data.

2. Methods used for determining consumer needs

The most important factor that determines the future of companies is not their profitability, but the extent to which they can satisfy consumers and become irreplaceable in their eyes. For this reason, companies focus on satisfying their consumers to protect their existing consumer base, find new consumers, and regain the lost consumers (Izci and Saydan, 2013). To ensure sustainability, companies need to focus on retaining their existing consumers. The main principles for ensuring consumer continuity includes factor such as knowing the consumers, being close to them, listening to their demands, developing new policies and strategies according to consumer recommendations and complaints, and adopting new product and service designs suitable for the demands and expectations of consumers (Ergunda and Tuncer, 2007). In parallel to the rapid technological changes and developments in today's highly globalized world, it is apparent that impressing and satisfying consumers is not as simple as before. When choosing and purchasing one of many different alternatives, consumers act according to a meticulous, selective and rational perspective, and expect maximum advantages for the products and services they acquire. New and advanced feature products and services offered to consumers further change or increase their expectations. In increasingly competitive environments, companies cannot remain indifferent to such changing expectations, and seek to achieve success by exceeding traditional consumer expectations (Ovali, 2005). However, for companies, identifying consumer needs and demands and acting accordingly is not sufficient by itself, and the speed and activities with which these demands are satisfied also represent important criteria in determining company success. There are many analysis techniques used for determining the expectations and preferences of consumers.

This section discusses the methods and models that are often used for determining consumer preferences and expectations, and also provides information about the "Key product" method based on the fuzzy numbers of the author.

2. 1. Quality function deployment

The QFD method was first presented by Yoji Akao in Japan in 1966 (Akao, 1997) as an approach developed with the aim of supporting project teams in gathering and managing all necessary elements/information for defining, designing and producing a product or service that would satisfy, or even exceed, consumer expectations (Akbaba, 2005)

The Quality Function Deployment – which is used in determining the needs that are important for satisfying consumers as well as the features that would meet these needs – is considered as the best system for creating positive quality, for creating new positive values, and for ensuring greater consumer satisfaction through a proper understanding of consumer demands and needs. The method shortens the time necessary for developing products suitable for consumer expectations, and provides a competitive advantage for companies. This method assists the improvement of design quality not only by helping companies meet function and performance related expectations, but also by helping them design products which combine unexpected and innovative elements that posses an extra appeal for consumers (Sandelands, 1994).

QFD was implemented for first time 1972 in the Kobe Shipyard of Mitsubishi (Hauser and Clausing, 1988). The western world's interest in the QFD was sparked by the success Toyota Company achieved through the implementation of the QFD between 1977 and 1984. QFD was implemented for the first time in USA by the Xerox Company in 1984 (Besterfield et al. 1999). Following Xerox, many leading companies such as Digital Equipment, Hewlett Packard, AT&T and ITT also started to employ this method. (Hauser and Clausing, 1988).

2.2. KANO model

For a company, determining consumer needs and demands is not sufficient by itself for achieving success. In addition to identifying these needs, companies also need to know the degree to which they can influence consumer satisfaction. To investigate approaches for satisfying the consumer needs, Prof. Dr. Noriaki Kano from the University of Tokyo developed a model that classifies product/service features that can satisfy the consumer needs (Akyuz et al., 2013).

In addition to the theoretical model it provides, Kano Model's contributions to the field also include the fact that is an effective method that enables the classification of consumer needs and expectations for a certain product or service based on their degree of impact on the level of satisfaction (Sofyalioglu and Tunail, 2012). The Kano model, which centers on the principle of excellence, aims to maximize the advantage obtained from a product or service purchased by the consumer, while minimizing cost or damage. This method – which is considered as the numerical expression of the relationship between expectations and the satisfaction of these expectations – focuses on three basic features: The basic features that are required in a product or service; the features that are expected; and the features that are exciting and exceed expectations (Akyuz et al., 2013).

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Based on the assumption that consumer demands and needs for a specific product and service does not equally contribute to consumer satisfaction, the Kano Model classifies the needs relating to a product as basic, linear and exciting (Dincel and Yenen, 2011). Knowing the category to which a particular need belongs enables us to determine the extent to which consumer satisfaction will be positively affected by meeting that specific need, and the extent to which failing to meet that need will cause dissatisfaction among consumers. Basic needs are those which result in significant discontent among consumers when they are not met, despite the fact that consumers do not explicitly request them in a product, and the fact that meeting them does not, by contrast, have a noticeably positive impact on their level of satisfaction. Linear needs are those which, in addition to being explicitly expressed and demanded in a product by the consumer, affect consumer satisfaction positively when met, and negatively when not met. Exciting needs, on the other hand, are needs that have a significantly positively effect on consumer satisfaction when met, but do not result in dissatisfaction when not met.

2.3. Analytical hierarchy process

Analytical Hierarchy Process (AHP), which is another method developed for determining consumer preferences and needs, was first proposed by Myers and Albert in 1968 (Yaralioglu, 2001). A method developed later on by Thomas L. Saaty in 1971 was used in 1977 to transform the AHP into a model that facilitates the resolution of decision-making problems, and significantly supports the decision-maker in resolving problems with multiple criteria and choices (Rencber, 2010; Güler, 2012). In case there are more than one criteria when evaluating different options, and in case these criteria are equal in terms of their impact on decisions; it is possible to classify these options by making binary comparisons through the analytical hierarchy process. The analytical hierarchy process developed by Saaty (1994) is a multiple-criteria decision-making method used to solve the complex problems where there are more than one criteria with different levels of significance. In this method, weighted values are determined for each criteria and criteria alternatives through binary comparisons. The weighted values and the weighted scores of each criteria and alternative option are then calculated. By calculating total scores for each decision option, the options are then classified, starting from the one with the highest score (Ozdagoglu and Guler, 2016; Anderson et al., 1998)

2.4. Conjoint analysis

The conjoint analysis enables the determination of the most preferred factors relating to a specific product or service, while also helping with the identification of the combination of factors relating to a product or service that would best satisfy consumers at the time of purchase (McDaniel and Gates, 1993). It is a marketing survey that is effective in determining demand, and which helps examine consumer preferences when it comes to multiple-feature products and services (Tatlidil, 1995). The assumption of this analysis is that the value attached by persons to a certain product is equal to the sum of the benefits they draw from all qualities relating to that product, and that the likelihood of purchasing that product again later on is associated with the level of benefits it provides (Sonmez, 2001). Hair et al. (1998) describe conjoint analysis as a multi-attribute analysis approach used for understanding consumer responses to a product or service. By presenting combinations of various product/service features to the respondents, conjoint analysis asks them to rank or rate these combinations according to their own preferences.

The most important feature of conjoint analysis is its ability to compare the qualities/characteristics through a quantitative approach. The most direct way for determining which features are more important is to directly ask individuals. However, one problem is that respondents generally describe all features as important. For instance, when people chose cars, they seek features such as low fuel consumption, sports car outlook, low cost etc. In conjoint analysis, the respondents are expected to reveal their decisions concerning the features they would be willing to concede or forgo. By identifying which features are desired by consumers to the extent that they would be willing to renounce or forgo other features in order to have them, as well as the features that they are most willing to forgo, conjoint analysis provides useful and sensitive information on consumer preferences (Yalniz and Bilen 1997).

2.5. The "key product method": a new method for determining consumer preferences

Both the quality function distribution and the KANO model are effective models that are commonly used for determining basic product

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features, and these models should be taken into consideration when evaluating such features.

However, these models do not take into account consumer preferences towards alternatives, which, in fact, should be the first and foremost factor to be considered. Furthermore, when determining the product features prioritized by consumers, these models rank features according to a majority opinion without presenting alternative product feature combinations.

In the AHP method, the significance and inter-relationships of decision criteria are taken into consideration, and assessments reflect a rather general view of decision-makers and respondents. In this respect, it is insufficient for the independent evaluation of consumer preferences.

On the other hand, while conjoint analysis evaluates decision criteria combinations according to consumer preferences, the decision is still made according to the general opinion of consumers. Furthermore, it is not possible to implement conjoint analysis in case of there is a multitude of criteria.

Another important shortcoming of all these methods is their inadequacy in measuring the suitability of product feature combinations to consumer preferences.

As it is well-known, to open a lock, the cuts of a key have to be fit exactly with the lock, and each lock has its own a key that requires a specific cut combination. Similarly, each consumer has a different expectation from any product features, and there is always a suitable combination of product features that can fully satisfy a consumer's expectations regarding the product. If consumers are pictured as a lock; to open this lock, the features of a product should be compatible with the feature-related preferences of the consumer. Each product feature determines a cut on the key, and each option related with the feature determines the structure of the cut. Statistically, for a product that has 5 features with 4 options each, there will be 1024 different product feature combinations. To raise consumer satisfaction to the highest level, it is necessary to determine among these numerous alternatives the one that is the most compatible with the consumer's preferences.

In this model, feature preferences (obtained through verbal data) are first transformed into crisp numbers that have as many digit places as the number of features, with each choice/option concerning a feature being shown with a single digit place. Each different number represents a different product feature combination. To determine the degree to which a product feature combination satisfies consumer preferences relating to those features, these crisp numbers are made fuzzy by using isosceles triangular fuzzy numbers. The area of intersection between the possible option for any product feature and the fuzzy numbers representing the consumer preference related with that feature provides the ratio, or extent, to which the product conforms to consumer preferences with regards to the relevant feature.

The frequencies of the numbers representing the feature combinations relating to consumer preferences indicate the number of consumers for whom that feature combination is preferred. By determining, based on the number of the products to be produced, the feature combinations having the highest frequency, it becomes possible to calculate the extent to which feature combinations will satisfy consumer expectations. The feature combinations having the least contribution to consumer satisfaction are sequentially removed from the model, until reaching the number of products to be produced, or meeting the minimum satisfaction ratio that was targeted. The last remaining feature combinations in the model are presented as the products satisfying the consumer preference at the optimum level in accordance with the goal of the decision maker.

In the evaluation of verbal data, the data is first transformed into crisp numbers, and evaluations are made based on these numbers. However, these crisp numbers are not sufficient for representing verbal data, which might have broad or uncertain meanings. For this reason, using fuzzy number is more appropriate for digitizing this type of data. Fuzzy numbers are values that are represented by fuzzy cluster membership functions within the frame of the fuzzy logic developed by Lutfi Zadeh, and are able to represent the uncertainty in the structure of verbal variables.

In many current applications of fuzzy logic, a simple structure in the form of triangular or trapezoid membership functions is used, and the number of verbal values is generally taken between 3 to 7 (Zadeh, 1994). When deciding which type of membership function should be used, two criteria are considered, which are simplicity and suitability (Tutmez and

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Tercan, 2006). In this study triangular fuzzy numbers were preferred for the process of making fuzzy.

2.5.1. Fuzzification of the feature options

In the developed model, the options relating with product features and consumer preferences were first expressed in crisp numbers, and then by transforming these values into fuzzy numbers. In all fuzzification operations, isosceles triangular fuzzy numbers were preferred due to suitability and ease of use.

In transforming the options into fuzzy numbers, the c_{ij} i. feature being the crisp value for the j. option, the fuzzy value for the i. feature and j. option (c_{ij}):

$$\underline{c}_{ij}= (c_{ij}-1, c_{ij}+1) \qquad (1)$$

This isosceles triangular fuzzy number with a membership degree of 1 in c_{ij}, a unit base of 2, and an area equal to 1.

2.5.2. Fuzzification of consumer preferences

When consumer preferences were being made fuzzy, the relevant assessment of importance by the consumer was taken into account. To display the p_{ij} consumer preference:

High importance level	$\underline{p}_{ij}=(p_{ij}-1. p_{ij}+1)$	(2)
Medium importance level	$\underline{p}_{ij}=(p_{ij}-2. p_{ij}+2)$	(3)
Low importance level	$\underline{p}_{ij}=(p_{ij}-3. p_{ij}+3)$	(4)

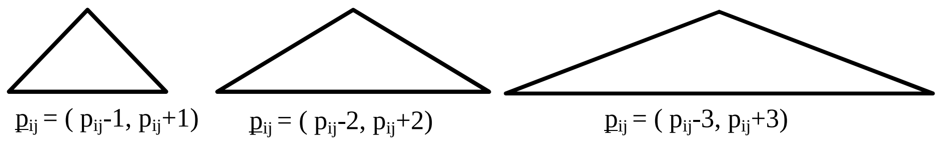

Figure 1. Fuzzy numbers for Consumer Preferences

2.5.3. Determining levels of suitability to preferences

The options related with features were given for some of the features in accordance with the grading scale, and for some of the features according to the classification scale. When measuring the levels of suitability to preferences, we considered the scale for which the options were given.

Determining levels of suitability to preferences according to the grading scale

In options given according to the grading scale, the suitability level is measured according to the intersection area of the fuzzy number related with the product feature and the fuzzy number related with the consumer preference. As s_{ij} i. being the feature and j.being the level of satisfaction from the option:

$$s_{ij}=\underline{c}_{ij}\cap\underline{p}_{ij} \tag{5}$$

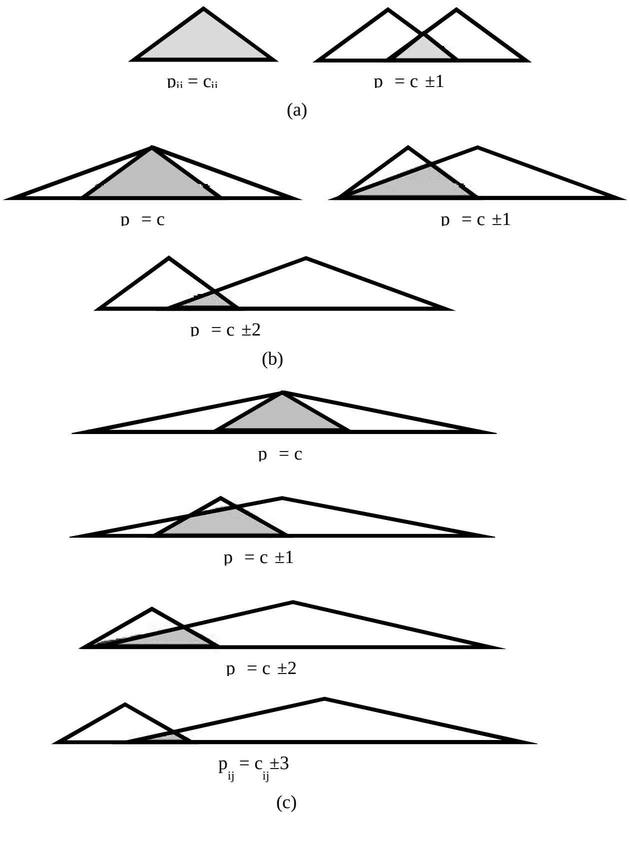

Figure 2. Levels of suitability to preferences for grading scale(a- High importance level, b- Medium importance level, c- Low importance level)

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After completing the necessary geometrical operations:

High importance level

$$\begin{aligned} &p_{ij} = c_{ij} \Rightarrow s_{ij} = 1 \\ &p_{ij} = c_{ij} \pm 1 \Rightarrow s_{ij} = 0{,}25 \\ &c_{ij} - 2 \leq p_j \leq c_{ij} + 2 \Rightarrow s_{ij} = 0 \end{aligned} \quad (6)$$

Medium importance level

$$\begin{aligned} &p_{ij} = c_{ij} \Rightarrow s_{ij} = 1 \\ &p_{ij} = c_{ij} \pm 1 \Rightarrow s_{ij} = 2/3 \approx 0{,}67 \\ &p_{ij} = c_{ij} \pm 2 \Rightarrow s_{ij} = 1/6 \approx 0{,}17 \\ &c_{ij} - 3 \leq p_{ij} \leq c_j + 3 \Rightarrow s_{ij} = 0 \end{aligned} \quad (7)$$

Low importance level

$$\begin{aligned} &p_{ij} = c_{ij} \Rightarrow s_{ij} = 1 \\ &p_{ij} = c_{ij} \pm 1 \Rightarrow s_{ij} = 7/8 = 0{,}875 \\ &p_{ij} = c_{ij} \pm 2 \Rightarrow s_{ij} = 1/2 = 0{,}5 \\ &p_{ij} = c_{ij} \pm 3 \Rightarrow s_{ij} = 1/8 = 0{,}125 \\ &c_{ij} - 4 \leq p_{ij} \leq c_{ij} + 4 \Rightarrow s_{ij} = 0 \end{aligned} \quad (8)$$

Determining the level of suitability to preferences

In the classification scale, if the consumer preference was the same with the product feature, this option was considered as fully satisfied (s_{ij}=1). However, if it was not the same, or was different than, the grading scale, all the other product features were considered at the same distance from the consumer. For this reason, all the options outside the consumer preference would provide suitability at the same level. μ being the degree of membership, the level of suitability for options different than the consumer preference is measured as, 0 at high importance level, the area under the $\mu_{\underline{c}}$ = 0,33 line of $\underline{c}_j$ at medium importance level, and the area under the line of $\mu_{\underline{c}}$ = 0,66 at the low importance level, with respect to the level of importance.

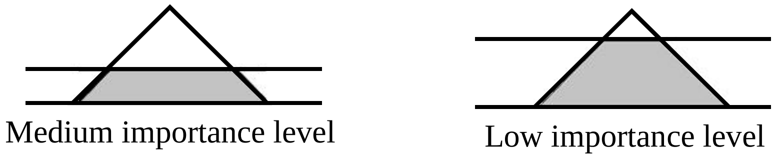

Figure 3. Level of suitability to preferences for classification scale

High importance level $p_{ij} = c_{ij} \Rightarrow s_{ij} = 1$

$c_{ij}-1 \leq p_{ij} \leq c_{ij}+1 \Rightarrow s_{ij} = 0$ (9)

Medium importance level $p_{ij} = c_{ij} \Rightarrow s_{ij} = 1$

$c_{ij}-1 \leq p_{ij} \leq c_{ij}+1 \Rightarrow s_{ij} = 5/9 \approx 0{,}56$ (10)

Low importance level $p_{ij} = c_{ij} \Rightarrow s_{ij} = 1$

$c_{ij}-1 \leq p_{ij} \leq c_{ij}+1 \Rightarrow s_{ij} = 8/9 \approx 0{,}89$ (11)

The level of suitability for a product feature combination is the sum of the level of suitability of all the features. For each feature, the maximum value that the level of suitability can have is 1. Therefore, the cumulative suitability for the six features can be 6 at maximum.

The total level of suitability for each consumer is $\sum s = S = \sum_{i=1}^{n_f} s_i$ (12)

(n_f = number of features, for this sample $n_f = 6$)

The mean level of suitability for each consumer is $\bar{s} = \frac{\sum_{i=1}^{n_f} s_i}{n_f}$ (13)

The total level of suitability for feature combination $\sum S = \sum_{k=1}^{n_q} S_k$ (14)

(n_q = number of questionnaires; for this sample $n_q = 386$)

The mean level of suitability for feature combination $\bar{S} = \frac{\sum_{k=1}^{n_q} S_k}{n_q}$ (15)

3. Methodology

3.1. Study purpose

The purpose of this study was to present a new model that helps determine which alternative choice of combinations for a multi-featured product best satisfies consumer expectations, and assists with selecting the most suitable combinations of features. To this end, we present a method that classifies smart-phone users according to their expectations relating to the features of the product; that measures the extent to which the combinations of phone features satisfy consumer expectations; and which determines the combination of smart phone features that would best satisfy consumer expectations if they were offered with limited product range. In this model, the fuzzy logic was used, which is a widely employed approach for digitizing verbal data.

3.2. Study method and sample

In this study, the questionnaire method was selected as the main data collection tool. The current study was based on an exploratory design. In many industries, the internet is used for obtaining information on product features and determining preferences (Urban and Hauser, 2003). In this study, to determine which smart phone preferences were to be considered, websites selling smart phones were examined and 15 features were selected. Among these features, the six most commonly used ones were operating system, operational capability, camera properties, screen size, RAM capacity and internal memory. These features were selected for assessing ease of use. In the questionnaire, respondents were asked to describe which of these features they considered and preferred when purchasing phones, and to rank the importance they attached to these features according to a 3-point Likert-scale (low importance, medium importance, high importance).

The study population consisted of university students from Yuzuncu Yil University. According to data from student affairs, there were nearly 20,000 enrolled students studying at the university during the 2015-2016 academic year. Based on this number, which constituted the study population, the study sample size was calculated as 377 for a population exceeding 10,000, with a 95% confidence interval and a 5% margin of error. To select a sample from the study population, the random sampling method (which is a probability sampling method) was used. From the 400 questionnaires that were distributed, 14 were excluded from study assessments due to incomplete data, with the remaining 386 being evaluated. This number large enough to be representative of the study population.

In this study, 47.9% (185) of the 386 students who participated to the survey were female students, while 52.1% (201) were male students. Concerning the age distribution, it was observed that 1.6% (6) of the participants were under 18 years of age; 34.7% (134) were between 18 and 21 years of age; 56.2% (217) were between 22 and 25 years of age; 6.5% (25) were between 26 and 29 years of age; and 1% (4) were over 29 years of age.

4. Results and analysis

During the application of the study procedures with the aim of demonstrating the effectiveness of the key product method, we calculated the percentage of consumers who were satisfied, as well the ratio of satisfaction for the first three products and for a single product. In order to perform calculations for both frequency of preferability according to the key product method, verbal data was first digitized using crisp numbers.

4.1. Determining the crisp numbers that represent product feature options

The six features determined within the scope of the study, as well as the available alternatives based on these features and the crisp numbers representing the different options are all provided in Table 1.

Table 1. Smart phone features and options

		Options(c_{ij})							
Features(f_i)	Operating System (f_1)	IOS (c_{11})	Android (c_{12})	Windows (c_{13})	Blackbery OS (c_{14})	Symbian (c_{15})	Nokia OS (c_{16})	MeeGo OS (c_{17})	
	Camera Resolution(f_2)	4.9MP and less (c_{21})	Between 5-9.9 MP (c_{22})	Between 10-14.9MP (c_{23})	Between 15-19.9MP (c_{24})	20 MP and more (c_{25})			
	Internal Memory (f_3)	1 GB (c_{31})	2GB (c_{32})	4GB (c_{33})	8GB (c_{34})	16GB (c_{35})	32GB (c_{36})	64GB (c_{37})	
	RAM (f_4)	128MB (c_{41})	256MB (c_{42})	512MB (c_{43})	768MB (c_{44})	1GB (c_{45})	1.5GB (c_{46})	2GB (c_{47})	3GB (c_{48})
	Screen Size (f_5)	3" and less (c_{51})	Between 3.1"-4" (c_{52})	Between 4.1"-5" (c_{53})	Between 5.1"-6" (c_{54})	6.1" and more (c_{55})			
	Processor Speed (f_6)	1.6 GHz and less (c_{61})	Between 1.7-2.2 GHz (c_{62})	2.26 GHz and more (c_{63})					
Crisp numbers (c_{ij})		(c_{i1}) =1	(c_{i2}) =2	(c_{i3}) =3	(c_{i4}) =4	(c_{i5}) =5	(c_{i6}) =6	(c_{i7}) =7	(c_{i8}) =8

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There are 39,200 possible combinations for these 6 features and 34 options. Each product feature combination is represented by a 6 digit number (c_{1j}, c_{2j}, c_{3j}, c_{4j}, c_{5j}, c_{6j}).

4.1. Determining suitable feature combinations according to frequency

The frequency data regarding consumer preferences for product features are shown in Table 2.

Table 2. Frequency table related with consumer preferences

Operating System		Camera Resolution		Internal Memory		RAM		Screen Size		Processor Speed	
c_{1j}	f	c_{2j}	f	c_{3j}	f	c_{4j}	f	c_{5j}	f	c_{6j}	f
1	49	1	29	1	9	1	12	1	24	1	44
2	274	2	92	2	26	2	22	2	43	2	175
3	24	3	115	3	40	3	34	3	151	3	164
4	9	4	148	4	68	4	17	4	73		
5	1	5	0	5	95	5	74	5	95		
6	17			6	52	6	20				
7	12			7	96	7	89				
						8	118				

Each consumer preference combination is represented by a six-digit number (c_{1j}, c_{2j}, c_{3j}, c_{4j}, c_{5j}, c_{6j}). The most preferred product combination according to the frequency values is “247832”. This was followed by “135753” and “324541.”

In present-day competition, there are many alternative brands and models for products. The expectations of consumers from products are clear, and products not matching their demands will cause them to choose competitor products instead. For this reason, when the study evaluations were made, if the level of suitability was 0 for any one of the features having a high level of importance for consumers, the total suitability level of that feature combination was also considered as 0.

When consumer preferences were evaluated in terms of these three feature combinations, the following results were obtained:

Table 3. First three feature combinations determined according to the frequency

	Product Features	Number of Consumers	Total Suitability	Mean Suitability
247832	Android, 15-19.9 MP, 64GB, 3GB, 4.1"-5", 1.7-2.2 GHz	33	101.94	3.09
135753	IOS, 10-14.9 MP, 16GB, 2GB, 6.1" and more, 2.26 GHz and more	40	141.42	3.54
324541	Windows, 5-9.9 MP, 8GB, 1GB, 5.1"-6", 1.6 GHz and less	50	189.46	3.79
Not Suitable		263		

These three products match to the demands of 123 (32%) of the consumers to a certain extent. The total level of suitability was 432.82, while the mean level of suitability was 3.52 (59%).

If consumers wish to choose a single product feature combination, the most preferred combination would be "247832" – as determined according to the frequency value.

Table 4. Single feature combination determined according to frequency

Product Features		Number of Consumers	Total Suitability	Mean Suitability
247832	Android, 15-19.9 MP, 64GB, 3GB, 4.1"-5", 1.7-2.2 GHz	89	249.2	2.,8 (%47)
Not Suitable		297		

An evaluation of the preferability frequency of the options indicates that the product for which a single product combination will be selected will be suitable, to varying extents, for 89 (23%) of the consumers. When the combinations of the most preferred features were evaluated, it was observed that at least one preference/feature considered as very important was not met/satisfied for 297 out of 386 participants. Therefore, consumers would not prefer this product. With this feature combination, the preferences of 89 people were satisfied at the same level. The total level of suitability for these people was 249.2, while the mean level of suitability was 47%.

4.2. Determining suitable feature combinations according to key product method

In the evaluations performed according to the key product method, we first determined the 10 most recurring 6 digit numbers that represent the consumer preferences.

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Table 5. First 10 product feature combinations having the highest frequency according to consumer preferences

	1.	2.	3	4.	5.	6.	7.	8.	9.	10.	Total
Frequency	27	5	5	4	4	4	4	4	4	3	64
Features combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	245853	

These options reflected the common preferences of consumers. Since it was observed that the frequency value was reduced by one more digit after the ninth product, nine product combinations were selected to begin the evaluation. The total levels of suitability of preferences other than the determined nine product combinations to these combinations were calculated and they were matched with the product giving the highest suitability value. When making the matches, no matching was performed the feature combinations whose level of suitability was 0 for the features with the highest level of importance; such combinations were considered to be associated with dissatisfied consumers.

Table 6. Key product method 1. Stage

1. Stage										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	38	11	26	11	52	17	15	58	51	107
Total Suitability Level	219.58	50.75	129.24	59.39	249.15	88.44	77.24	254.11	234.01	
Mean Suitability Level	5.78	4.60	4.97	5.40	4.79	5.20	5.15	4.38	4.59	

A look at the table above indicates that the preferences of 107 consumers were not met with the relevant feature combinations. Shown below is the table obtained when the feature combinations number 2 that had the lowest total level of suitability was taken out of the options, and the consumers associated with this option were distributed to other options in order to move onto the 2nd stage.

Table 7. Key product method, Stage 2

Stage 2										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	40		26	11	52	17	15	58	51	116
Total Suitability Level	230.7		129.2	59.39	249.2	88.44	77.24	254.1	234	
Mean Suitability Level	5.77		4.97	5.40	4.80	5.20	5.15	4.38	4.59	

Likewise, the operations continued by taking out the option having the lowest total level of suitability at each following stage, until there were only three options left.

Table 8. Key product method for Stages 3, 4, 5, 6 and 7

Stage 3										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	46		26		52	21	15	59	51	116
Total Suitability Level	262.58		129.24		249.15	107.94	77.24	258.32	234.01	
Mean Suitability Level	5.71		4.97		4.791	5.141	5.15	4.38	4.59	
Stage 4										
Features Combination No:	1	2	3	4	5	6		8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	47		29		59	23	59		52	117
Total Suitability Level	266.58		143.19		282.71	115.4	258.32		237.74	
Mean Suitability Level	5.672		4.94		4.79	5.08	4.38		4.57	
Stage 5										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	60		39		59			59	52	117
Total Suitability Level	325.76		184.5		282.71			258.32	237.74	
Mean Suitability Level	5.43		4.73		4.79			4.39	4.57	
Stage 6										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	74				70			59	55	128
Total Suitability Level	388.18				324.99			258.32	250.88	
Mean Suitability Level	5.25				4.64			4.38	4.56	
Stage 7										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	76				92			63		155
Total Suitability Level	394.68				422.92			275.93		
Mean Suitability Level	5.19				4.60			4.38		

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If three product feature combination is preferred, the solution process should be ended at the 7th stage.

Table 9. First three feature combinations determined according to key product method

	Product Features	Number of Consumers	Total Suitability	Mean Suitability
235732	Android, 10-14.9 MP, 16GB, 2GB, 4.1”-5”, 1.7-2.2 GHz	92	422.92	4.6
247853	Android, 15-19.9 MP, 64GB, 3GB, 6.1”and more, 2.26 GHz and more	76	394.68	5.19
224732	Android, 5-9.9 MP, 8GB, 2GB, 4.1”-5”, 1.7-2.2 GHz	53	275.93	4.38
Not Suitable		155		

An analysis of this table clearly reveals the differences between the preference made according to the preferability frequency and the preferences made according to the key product method. Three products conformed to the preferences of 221 (57%) of the consumers. The total level of suitability was 1093.53, while the mean level of suitability was 4.95 (82%).

Depending on the type of product to be produced or the consumer preferences, the solution process can be terminated at any desired stage. In case the stages were to be continued and reduced into the single feature combination, the following result would be obtained:

Table 10. Key product method, Stages 8 and 9

Stage 8										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency	77				138					171
Total Suitability Level	398.81				591.75					
Mean Suitability Level	5.179				4.288					
Stage 9										
Features Combination No:	1	2	3	4	5	6	7	8	9	
Features Combination	247853	147853	246843	237853	235732	247843	236733	224732	235542	0
Frequency					164					222
Total Suitability Level					686.07					
Mean Suitability Level					4.183					

Table 11. Single feature combination determined according to key product method

		Number of Consumers	Total Suitability	Mean Suitability
235732	Android. 10-14.9 MP, 16GB, 2GB, 4.1”-5”, 1.7-2.2 GHz	164	686.07	4,183(%70)
Not Suitable		222		

According to the evaluation performed according to the key product method, the product for which the single feature combination will be selected is suitable for 164 (42%) of the consumers. For these 163 consumers, the total suitability was 681.57, while the mean level of suitability was 70%. The determined product combination was not suitable for 222 (58%) of the 386 consumers.

5. Conclusion

In this study, we used a fuzzy logic-based new method that measured the extent to which a product satisfies consumer expectations, and helped determine the product feature combinations most suitable for consumer preferences. Smart phones were selected as a model in this study, and an attempt was made to determine the most suitable product combination for six features.

It was observed that the feature combinations determined through the “Key product” method are suitable for more consumers than the feature combinations determined by the most preferred options, and this method ensured a higher mean level of suitability.

According to our results, the preferred product features based on the most preferred options include the Android operating system, camera between 15-19.9 mp, 64GB memory, 3 GB Ram, screen size between 4.1-5”, and 1.7-2.2 GHz processor speed. A product having these features was suitable to varying degrees for 89 (23%) of consumers. Total suitability score for 89 consumers was 249.6, while the mean level of suitability was 46%. The said product combination was not suitable for 297 (77%) of the 386 participating consumers. The preferred product features determined according to the key product method include Android operating system, camera between 10-14.9 MP, 16GB memory, 2 GB Ram, screen size between 4.1-5”, and 1.7-2.2 GHz processor speed. A product having these features was suitable to varying degrees for 164 (42%) of consumers. Total suitability score for 164 consumers was 686.07, while the mean level of suitability was 70%. The determined product combination was not suitable for 222 (58%) of the 386 participating consumers.

The demands of 123 (32%) of the consumers were satisfied to varying degrees by three product feature combinations determined based on the most preferred options. Total satisfaction level was 432.82, while the mean satisfaction ratio was 3.52 (59%). When three product feature combinations were determined according to the key product method, the preferences of 221 (57%) of the consumers were satisfied to varying degrees. The total level of suitability was 1093.53, while the mean level of suitability was 4.95 (82%).

With the method proposed in this study, it is possible to determine – depending on the number of products to be produced and the consumer demands to be met – the number of products with which production processes should be initiated, and the duration of time for which the production stages should be continued. The method can be used to determine the consumers whose preferences are not satisfied by the market and the most suitable product feature combinations for them.

The first stage of the method, which measures the level of suitability for consumer preferences, can also be used in models assessing different feature combinations in order to assess the level of suitability for consumer preferences.

In this study, the levels of suitability of all the options were considered as equal, except for the product features that were suitable according to the classification scale. It is likely that in daily life, consumers have alternative preferences with regards to the options relating with these features. For this reason, in other studies that might be conducted, consumers could be asked to rank their preferences for features suitable for the classification scale, allowing these features to be evaluated according to the classification scale.

When evaluating the findings of the present study, there are certain limitations that should be considered. First of all, the study findings are limited to the study sample. It is not possible for us to claim that the findings for this sample can be generalized for all consumers. More studies on this subject are necessary before the results can be generalized and accepted.

When using the model presented in this study, an increase in the number of product features and options will also lead to an increase in the number of possible feature combinations. For this reason, to be able to determine the most preferred feature combinations more realistically, the sample size should be increased in parallel with any increases in the number of features and options.

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