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ANP application for evaluating Turkish mobile communication operators

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Abstract The proposed decision model, based on Analytic Network Process (ANP), has been developed in order to determine the dynamics of the Global System for Mobile Communications (GSM) market. In accordance with the sequence of ANP, first of all, the problem was structured and modeled. At the next step, a quantitative analysis was conducted with the customers in order to assess the importance of the related factors and forecast the market shares of the Turkish mobile communication operators. The forecasted market share values were compared with actual ones for the validation of the decision model. The assessed importance of the factors in a valid model would be a potential competitive advantage for the mobile operators.

Keywords Mobile communication · Multiple criteria decision making in marketing · Analytic network process

1 Introduction

In recent years, communication has been developing and growing rapidly in Turkey as all over the world. People around the today's global world have the common need to communicate with friends, family, and colleagues wherever they are. Within this common need, people have different communication requirements. Some may need constant and real time access

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to their email. Others may want to download music and games. Others just want to talk. However, all of them desire simplicity and transparency. This situation increases the usage of mobile phones among people and makes them require mobile communication operators. An increasing demand in the mobile phone sector brings about the rise in the mobile communication operators (Bekkers et al. 2002). To cover this new market, many firms have made investments and waited to gain profit. These firms tend to develop their markets according to some strategies that are relevant with the growth. Although the sector is very profitable, the increasing competitiveness made some firms leaders of the sector, force some others to merge, and have some others leave the sector. For instance, today there are only three firms remained in the Turkish GSM (Global System for Mobile Communications) market.

The strain of the market urges companies do something new and attractive by customers glance. Certainly these are all for customer retention and also for expanding number of customers. It is not attractive to look at just the statistics reports to see which firm gained market share with its activities. The important thing is not the result but the process. So that, process of how telecommunication companies sustain in the business and manage their market share in that competitive environment must be analyzed.

Identifying the factors influencing the preference for a specific mobile communication operator, defining the effects of these factors on each other, and determining the importance of them from the Turkish customers' point of view is a very complicated problem that can not be treated with a decision matrix and requires an effective decision making process. When the nature of problem on hand is complicated and the problem can only be modeled as a hierarchy or network, most of the MCDA methods fail for analysis. The Analytic Network Process (ANP) is one of the approaches that can treat problems having complex interrelationships among criteria (dependences and feedbacks) so that it can handle the complexities of real-world problems for making societal, governmental, and corporate decisions.

As it is expected that identifying the factors influencing the preference for a specific mobile communication operator and defining the effects of these factors on each other will cause dependence and feedbacks among related factors; this study proposes a decision model, based on ANP, in order to assess the relative importance of the related factors as well as forecast the market share values of mobile communication operators in Turkish GSM market. The model has a process consisting of several steps such that structuring the problem, constructing the decision model, and analyzing the problem.

After the decision making process has been completed, the market shares of mobile communication operators and also the importance of the related factors are determined. The forecasted market share values are compared with actual ones for validation of the whole process. In order to do this comparison, Saaty Compatibility Index (SCI) is calculated for checking the closeness of two priority vectors (www.creativedecisions.net). In this study, the first priority vector is the forecasted market shares and the second priority vector is the actual market shares. The success of SCI proves that the relative importance of the related factors is reliable. Mobile communication operators can take this information into the consideration for exploring the factors affecting market share and deciding for the actions to increase their company's market share.

There are also statistical techniques that can be used to analyze GSM market shares in Turkey; however, most of them have limitations for our model. One of the statistical techniques is 'multiple regression' in which relations can be included in a single model with only one dependent variable and a number of independent variables (Smith and Langfield-Smith 2004). In our GSM market share model we have several variables (factors) affecting each other. Another statistical technique is "path analysis" which involves sets of relations between variables. This means a dependent variable in one equation becomes independent in

another. As a result of this procedure we could calculate the effects of independent variables over dependent ones. One of the major restrictions of path analysis is, we are not able to distinguish the mutual relations among variables. Our aim is not only understanding the effects of independent variables over dependent ones, but also calculate market shares of each GSM operator in Turkey. Besides multi regression and path analysis, "Structural Equation Modeling" (SEM) is also a statistical technique that allows a series of analysis in which a dependent variable in an equation becomes independent in another one (Hair et al. 1998). It is used for building and testing statistical models, which are sometimes called causal models. It is a hybrid technique that encompasses aspects of confirmatory factor analysis, path analysis and regression, which can be seen as special cases of SEM. One of the strengths of SEM over path analysis and multiple regression is the usage of estimated variables or variables that cannot be measured directly. SEM analysis consists of two stages; the analysis of the measurement models and analysis of the structural model (Smith and Langfield-Smith 2004). Additionally SEM does not use a single statistical test, it has several fit indices to assess goodness of fit. Moreover, SEM needs past statistical data to analyze further situations. This is one of the reasons that we have used ANP model to calculate GSM operators' market shares in Turkey. We could not have any opportunity to collect any past statistical data about GSM operators' market shares and also relations about the both dependent and independent variables that are used in our ANP model.

This paper provides an examination of the current practices of the GSM Market in Turkey (Sect. 2), a brief explanation of ANP (Sect. 3) and successive steps of decision making process (Sects. 4 and 5). Conclusions and further suggestions for research are then presented.

2 The GSM market in Turkey

Since technology and need for communication among people increase rapidly, the GSM market gains importance for mobile communication operators in Turkey, as a developing country. In the future, though, there will be restrictions by law and extreme poverty, with the help of 3rd generation (3G) technology, both in the developed and developing countries, there will be an increase in the mobile accounts (Boretos 2007). People who want to take advantage of mobile communicating have to use mobile communication operators which are totally three in Turkey. These operators namely, Turkcell, Telsim, and Avea, cover the entire GSM market. Since the launch of the first two mobile communication operators, Turkcell and Telsim, subscriptions have risen sharply, reaching a penetration rate of about 40% of population in 2003 and 50% in 2004 (www.pyramidresearch.com). Although demand was good, some of the new mobile communication operators were in poor financial shape, suffering the fallout from the global crash in technology stocks and Turkey's 2001 financial crisis. So, in 2004, Aycell and Is-Tim (Aria), the third and fourth largest Mobile communication operators after Turkcell and Telsim, merged to form Avea. In the last quarter of 2005 (when the research of this study was done), the market shares of the mobile operators were 57% for Turkcell, 23% for Telsim, and 20% for Avea (www.sabah.com.tr).

The first mobile communication operator founded in Turkey was Turkcell. In February 1994, Turkcell introduced mobile communication in Turkey with its GSM services. Having signed a 25-year GSM license contract with the Turkish Ministry of Transportation on April 1998, Turkcell has made continuous improvements to the range and quality of the voice and data communication services it offers; and hence, increased its number of subscribers. Having invested approximately $4.7 billion since its inception (as of December 31, 2005—domestic operations only, including license fee), Turkcell provides services to 27.9 million

subscribers as of December 31, 2005 (www.turkcell.com.tr). Only in 2005, despite the competition among operators in market, Turkcell gained 4.5 million subscribers and increased the subscriber rate 19% (www.mobildunya.com). Turkcell is the first Turkish company to be listed on the New York Stock Exchange (NYSE) where its shares have been traded since July 11, 2000 along with trading on the Istanbul Stock Exchange (IMKB). Principal founding shareholders of Turkcell are Sonera Holding, formerly known as Telecom Finland Ltd. and currently owned by TeliaSonera, and the Cukurova Group. The percentage of share capital for Turkcell Holding A.S. is 51% and Sonera Holding B.V. is 13.07%. About 16.59% of shares are publicly traded (www.turkcell.com.tr).

After the foundation of Turkcell, Telsim started to offer services in the GSM market of Turkey in May 1994. Telsim has brought lots of accelerations to the Turkish GSM market in 1998 when took the GSM license in April of that year which is valid to the year 2023. Today, Telsim has more than 7 million active subscribers (www.telsim.com.tr). Vodafone Group, an English mobile communication operator, acquired Telsim from the Turkish Savings Deposit and Investment Funding in December 2005. Vodafone aimed to increase its profit and market share around the world by investing in developing countries including Turkey. After Vodafone bought Telsim, authorities believe that the competition level between the operators in Turkey will increase and companies will apply different strategies to increase the profit and market share because in today's world, Vodafone is the second company with regard to subscribers and the first company when revenues are taken into consideration (turk.internet.com).

The third player in GSM market is TT&TIM Iletisim Hizmetleri A.S which was officially founded on February 19, 2004 with the merger of Turk Telekom's Mobile communication operator Aycell with Is-TIM, joint venture of Is Bank (51%) and TIM (49%). The commercial name of "TT&TIM Iletisim Hizmetleri A.S." was changed as "Avea Iletisim Hizmetleri A.S." on October 2004 (www.avea.com.tr). During the period of merging the total market share of Aycell and Aria was 12% and after the merging the market share of Avea sharply increased to the value of 20%. Middle term target of the Mobile communication operator is 35% of the market share. Avea is now composed of three companies; Turk Telecom, Telecom Italia Mobile International, and Isbank.

3 Analytic network process

When the nature of problem on hand is complicated and the problem can only be modeled as a hierarchy or network, most of the MCDA methods fail for analysis. As can be seen in Fig. 1a, hierarchies having a goal (definition of the problem) at the top level and other clusters at each level are special networks that do not have inner dependences and feedbacks. In Fig. 1a, the arc from a cluster at a higher level to a cluster at a lower level indicates the influences of the criteria (factors) in the lower-level cluster (affecting nodes) on a criterion in the higher-level cluster (affected node). In Fig. 1b, on the other hand, the arc from cluster C4 to C2 indicates the outer dependence of the criteria in C2 on the criteria in C4 with respect to a common criterion, while a loop in a cluster indicates the inner dependence of the criteria in that component with respect to a common criterion. If a feedback exists at the network (as can be seen in Fig. 1b), it means that there are mutual outer dependences of criteria in two different clusters.

Saaty (1980, 1996) proposed the Analytic Hierarchy Process (AHP) and ANP approaches those can be utilized for examining hierarchy and network model representations. The power of AHP/ANP lies in their use of special ratio scales to capture all kinds of interactions between tangible and intangible criteria for making accurate predictions and better decisions.

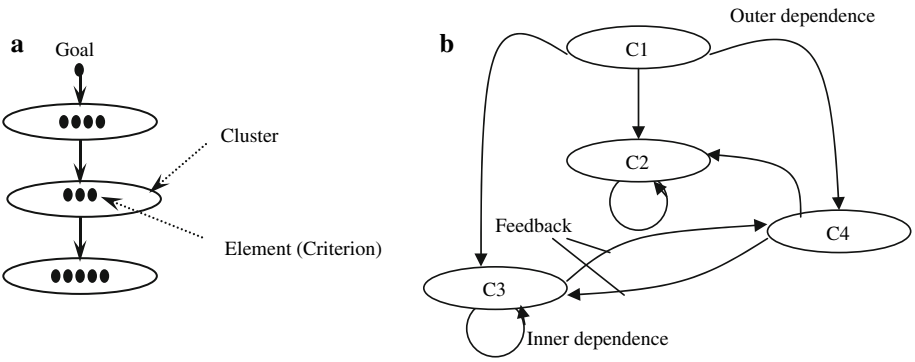

Fig. 1 A hierarchy and a network sample

Both methods are claimed to possess qualitative and quantitative components. They not only employ the procedure for assigning importance to the criteria but also assess the global preferences for the alternatives. These characteristics are other advantages of AHP/ANP approaches. However, AHP is restrictive to solve problems having a linear unidirectional hierarchical relationship among criteria. The ANP, the general form of AHP, does not require this strictly hierarchical structure and therefore can treat problems having complex interrelationships among criteria (dependences and feedbacks) so that it can handle the complexities of real-world problems for making societal, governmental, and corporate decisions (Salo and Hamalainen 1997; Saaty 2003). Unfortunately, ANP applications have been noticeably limited when compared with AHP, due to its complexity and time consuming nature. So far, the ANP approach has proven itself to be successful when expert knowledge is used within business (Lee and Kim 2000, 2001; Meade and Sarkis 1998; Partovi 2001; Sarkis and Sundarraj 2002; Agarwal and Shankar 2002; Sarkis and Talluri 2002), social (Sarkis 1998, 1999, 2003), and manufacturing (Meade and Sarkis 1999; Karsak et al. 2003) decision contexts or used to predict sports outcomes (Partovi and Corredoira 2002) and economic turns (Blair et al. 2002).

The decision makers are asked to make pairwise comparisons of the criteria of the network using a nine-point scale suggested by Saaty (1980). Saaty's scale asks "of the dependent criteria, which one influences the common criteria more and how much more?". In this scale, a value of 1 between two criteria indicates that both equally influence the affected node, whereas a value of 9 indicates that the influence of one criterion is extremely more than that of the other. Decision analysts compute the geometric means of all paired-comparison judgments of different decision makers for each question in order to reveal the aggregated group judgments. Group judgments then are arranged in pairwise-comparison matrices, which will be input for Super Decisions software (www.superdecisions.com). In the aggregated pairwise-comparison matrix, the value for an (i, j)-pair is in the range 1–9 if the influence of criterion i is more than that of criterion j, while the value of that pair is in the range 1–1/9 if the influence of criterion i is less than that of criterion j. Regardless, the value of an (i, i) pair is 1, and given the (i, j)-value, the corresponding (j, i)-value will be the reciprocal of the (i, j)-value.

The relative importance of each criterion and global preference for each alternative is computed at the next stage. The importance can be regarded as the influence of the criteria to the goal. For this purpose, necessary calculations, in order to synthesize aggregated judgments, are done by Super Decisions software. These calculations include the computation

of eigenvector for each pairwise comparison matrix, the formation of a supermatrix and a weighted supermatrix (if necessary), and the computation of the convergence of the supermatrix (limit matrix). The eigenvector consists of priorities of the sub-nodes with respect to their parent node (Saaty 1980). The easiest way for the computation of eigenvector starts with the normalization of the pairwise comparison matrix—dividing each element by its column sum—so that each column adds to one. The arithmetic mean (average) of the values of each row is an element of the eigenvector. In a supermatrix, each is represented at one row and one respective column (i.e. the goal is at the first row and first column). The computed eigenvector of the sub-nodes with respect to their parent node is placed to the column representing the parent node and the rows representing the sub-nodes. If the column sum of any column in the composed supermatrix is greater than 1 (there are more than one eigenvector), that column will be normalized. Such a supermatrix is called as weighted supermatrix. The weighted supermatrix is then raised to a significantly large power in order to have the converged or stable values. The values of this limit matrix (importance of related criteria and preference for alternatives) are the desired priorities of the elements of the decision network with respect to the goal.

4 Structuring the problem and constructing the model

The proposed approach based on ANP was utilized in order to examine the dynamics of the GSM market. First of all, the factors related with the problem on hand were determined. For this purpose, some questions were asked to the 196 participants who constituted the sample of the study. A non-probabilistic sampling method, namely judgmental sampling, was used in this study. The judgment criteria for participation in the survey were using mobile phone in daily life and being aged more than 14 years. Although the judgmental sampling brings to diverge from random, it is quite representative since it serves to contact with consumers most suitable for the research concern. At this point, after asking the question "Which mobile communication operator do you prefer?" to people using mobile phone in daily life, the main question "Why did you prefer that company?" was asked.

Although there would be a validation at the end of the decision making process, to check consistency, "Why people prefer your company?" question was also asked to the professionals in GSM sector. Additionally, literature review was conducted and similar studies were examined.

As a result, the factors affecting the preference for a specific mobile communication operator were revealed. These factors were, then, assigned into meaningful clusters: "services offered by operator", "customer segments (age groups)", "campaigns", "social responsibilities", "advertisement", and "after-sales services". The clusters and the factors in each cluster were as follows:

A Campaigns
- A1 Tariff
- A2 Discounts
- A3 Extra Activities

B Customer segments (age groups)
- B1 15–25
- B2 26–45
- B3 45+

C Services
- C1 Coverage Area
- C2 Official Website
- C3 Access to Sellers

D Social Responsibilities
- D1 Base Stations' Placement
- D2 Environmental Responsibility
- D3 Charity
- D4 Sponsorship

E After Sales Services
- E1 Customer Satisfactions
- E2 Speed of Services

F Advertising
- F1 Television
- F2 Radio
- F3 Internet
- F4 Print Media
- F5 Word of Mouth

Avea, Telsim, and Turkcell (the mobile operators in Turkey) were included into an additional cluster named as "alternatives".

G Alternatives
- G1 Telsim
- G2 Turkcell
- G3 Avea

After structuring the problem, the professionals were asked to indicate the relationship between pairs of nodes in each cluster. The authors filled pairwise relationship matrices by

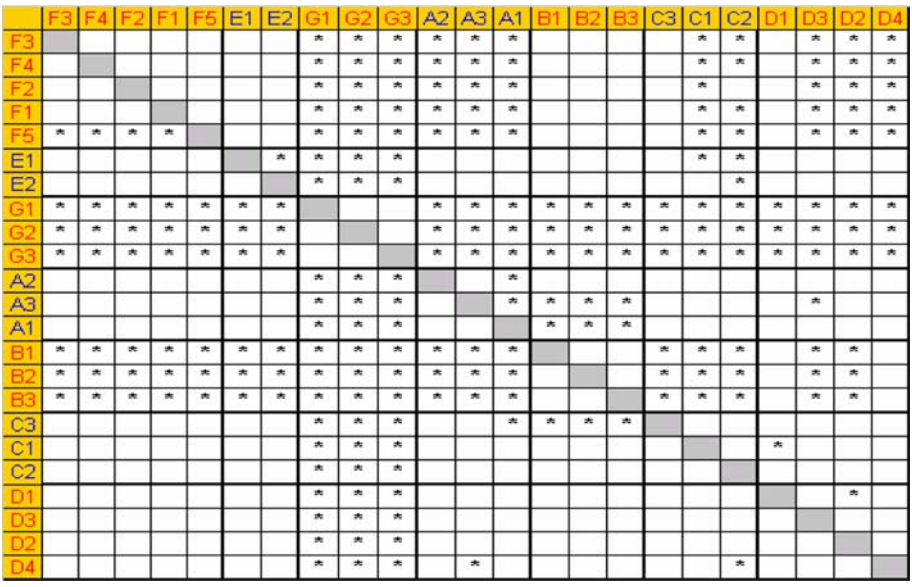

Fig. 2 Aggregated pairwise relationship matrix

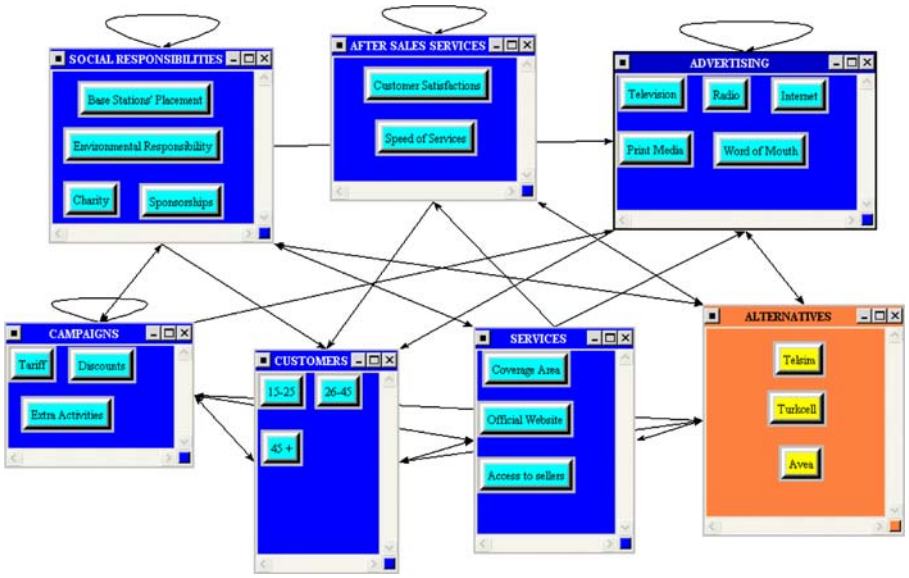

Fig. 3 Network model

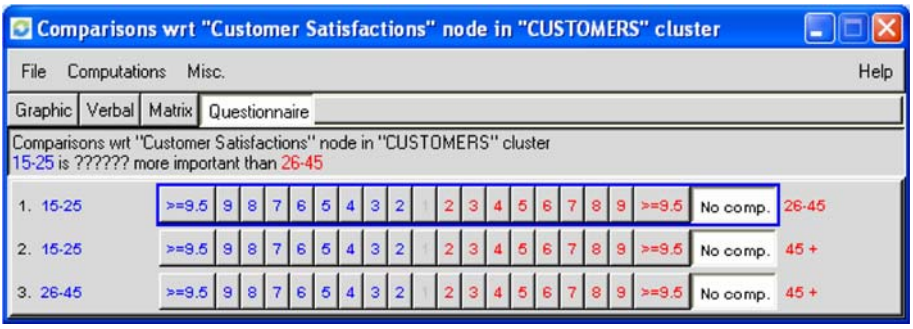

Fig. 4 A part of pairwise comparison questionnaire

using the responses and then aggregated these matrices into a single matrix using majority rule (Fig. 2). Finally, this aggregated matrix seen in Fig. 2 was converted to a signed digraph.

The dependences and feedback among the identified factors revealed that the most suitable model for the problem on hand was network form. So the authors constructed the network model utilizing the design module of the Super Decisions software (Fig. 3). This software converts the direction of effect relations, i.e. the arc between clusters takes exactly the opposite direction of that of a effect relation among factors.

After constructing the network model, a pairwise comparison questionnaire, a part of which can be seen at Fig. 4, was conducted to the mobile phone users in order to assess their judgments representing the relative influence of affecting nodes on the affected node for all possible pairs. Authors computed geometric means of all paired comparison judgments for each question in order to reveal the aggregated group judgments. And then, utilizing the assess/compare module of the Super Decisions software, the authors arranged these group judgments in pairwise comparison matrices.

5 Analysis of the problem

At the final stage of the process, the relative importance of the nodes was computed utilizing the computations module of the same ANP software which does all the matrix algebra. As aforementioned the output of the limit matrix can be converted to the descending priority orders: global preferences for the alternatives (the forecasted market shares of the mobile operators) that can be seen in Table 1 and the relative importance of the factors that can be seen in Table 2.

Table 1 The global preferences for the alternatives

GSM operators	Priorities (%)
Turkcell	50.68
Telsim	26.50
Avea	22.82

Table 2 The importance of the factors

Clusters and factors	Limiting priorities (%)	Normalized by cluster (%)
A Campaigns		
A1 Tariff	13.83	56.60
A2 Discounts	7.70	31.51
A3 Extra Activities	2.90	11.89
B Customer segments (age groups)		
B1 15–25	8.87	48.87
B2 26–45	5.03	27.73
B3 45+	4.25	23.41
C Services		
C3 Access to Sellers	8.94	70.89
C1 Coverage Area	3.34	26.51
C2 Official Website	0.33	2.69
D Social Responsibilities		
D4 Sponsorship	0.42	43.93
D1 Base Stations' Placement	0.35	37.06
D3 Charity	0.11	11.78
D2 Environmental Responsibility	0.07	7.24
E After Sales Services		
E1 Customer Satisfactions	2.32	83.55
E2 Speed of Services	0.46	16.45
F Advertising		
F5 Word of Mouth	10.19	46.54
F1 Television	7.52	34.33
F4 Print Media	2.65	12.09
F2 Radio	0.98	4.46
F3 Internet	0.56	2.57

As can be seen in Table 1, the most preferred mobile communication operator is Turkcell (51%), followed by Telsim (26%). Avea is the least preferred operator (23%) among other alternatives. These global preferences represent the forecasted market share of each operator.

The forecasted market share values can be compared with actual ones for validation of the whole process. As aforementioned, SCI is computed for checking the closeness of two priority vectors. In other words, SCI is used to find how close market share estimations using ANP are to actual data. Two pairwise comparison matrices are generated from the priority vectors representing the forecasted market share data and actual market share data: pairwise comparison matrix from actual data and transpose of comparison matrix from estimations. Hadamard (cell-wise) multiplication of these two comparison matrices is calculated. The sum of the row sums of this resulting matrix is divided to the number of entries. The calculated value is SCI. If the SCI is near to 1, it means that the ANP model is valid and therefore one can rely on the importance of the related factors at the model.

The actual market share values for the mobile operators are 57% for Turkcell, 23% for Telsim, and 20% for Avea as given in Sect. 2. SCI was computed in order to find the closeness of two priority vectors (forecasted and actual market share values) of the research. The resulting value 1.013, which is very close to 1, indicates that the proposed ANP model was valid and therefore one can rely on the importance of the related factors at the model.

After justifying the validity of the decision model, relative importance of the related factors can be examined. Regarding to limiting priorities in Table 2, tariff (13.83%) and word of mouth (10.19%) can be regarded as more important than other related factors. According to normalized priorities in Table 2, the most important campaigns factor is tariff (56.60%) followed by discounts (31.51%). 15–25 age customer segment (48.87%) is the most important group. Among services related factors, the most important one is access to sellers (70.89%). Sponsorship has the most significant value (43.93%) followed by base stations' placement (37.06%) in the cluster of social responsibilities. Customer satisfaction (83.55%) is regarded as the most important goal in after sales services. When advertising is taken into consideration, the most important factor is word of mouth (46.54%).

6 Conclusions and further suggestions

With rising customer expectations and increasing choice in this attractive and growing Turkish GSM market, effective customer management is becoming increasingly important. Understanding and analyzing customer preference in a scientific way will be a potential competitive advantage for the existing operators as well as new-comers.

The proposed decision model, based on ANP, has been developed in order to determine the dynamics of the GSM market. In accordance with the sequence of ANP, first of all the problem was structured and modeled. At the next step, a quantitative analysis was conducted with the customers in order to assess the importance of the related factors and forecast the market shares of the Turkish mobile communication operators. The forecasted market share values were compared with actual ones for the validation of the decision model.

Being aware of the important factors in a valid model and emphasizing these factors during marketing activities can be a potential competitive advantage for the strategic decision makers of mobile operators. These factors are; "Word of Mouth" in Advertising cluster, "Customer Satisfaction" in After Sales Services cluster, "Tariff" in Campaigns cluster, "15–25 Age Customer Segment" in Customer Segment cluster, "Access to Sellers" in Service cluster, and "Sponsorships" in Social Responsibilities cluster.

It is possible in ANP to do sensitivity with respect to judgments, priorities, or the entries in the supermatrix. Sensitivity is different in a network than it is in a hierarchy. In a hierarchy, one can pick a node—the goal for instance, vary the priorities of a criterion connected to the goal and see how the priorities of the alternatives change. In the ANP, one needs to pick a node that corresponds to the goal node, then pick a "with respect to" node that is connected from it (any one of them), then get the priorities of the alternatives as the "with respect to" node changes its priority. Therefore sensitivity analysis in simple networks is very hard to interpret and very time consuming. In a complex BCOR (benefit-cost-opportunity-risk) network, on the other hand, one can generally do sensitivity with respect to the BCOR nodes in the top level in an easy way just like doing sensitivity in a hierarchy. That is why, as a further suggestion, a research avenue can be converting the simple network constructed in this research to a BCOR network and doing sensitivity analysis on the results of this BCOR network.

Based on the basic features of SEM and other statistical methods aforementioned, our study could also be supported by these techniques. But compared to SEM which has several advantages over multi regression and path analysis, ANP approach is not required to collect a large amount of statistical past data. But it could be interesting to utilize SEM as a further research and compare the results of SEM with those of ANP.

The proposed decision model can be utilized for the same market in other countries and if the forecasted market share values are close to actual ones, in other words it the model is still valid, cross cultural differences can be revealed. The results of such a study would be very interesting for multinational mobile communication operators. They can understand which factors are important and how much important for residents of different countries.

Another research avenue can be including strategies and policies, which will sustain or increase market shares of the operators, into the network model and analyzing this expanded model.

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The website for Pyramid Research Consulting (http://www.pyramidresearch.com)
The website for Sabah Newspaper (http://www.sabah.com.tr)
The website for Super Decisions Software for Decision-making (http://www.superdecisions.com).
The website for Telsim (http://www.telsim.com.tr)
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