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A FUZZY AHP-TOPSIS MODEL BASED CASE STUDY FOR SELECTING VEHICLES TO BUY CASCO INSURANCE UNDER LIMITED BUDGET

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Abstract

Traffic insurance is compulsory but car insurance (Casco) is optional in Turkey. Although there is a tendency to buy Casco insurance, the rate of people who do not buy Casco insurance is also worth to study on. Private and public companies which own many vehicles allocate significant amount of budget to buy Casco insurance every year. The economic crises periods usually force them to select the vehicles to buy Casco insurance among all vehicles they have.

The design of the study as follows. First, the criteria about selecting the vehicles to buy Casco insurance are defined. Next, the weights of the criteria are found by using fuzzy AHP methodology. The alternative vehicles are sorted with respect to their priorities by using TOPSIS methodology. At the end of this study, a case study is performed that includes a proposal for private and public companies to select the vehicles among all vehicles they own to buy Casco insurance.

Keywords: *Casco Insurance, Compulsory Traffic Insurance, Fuzzy AHP, TOPSIS.*

KISITLI BÜTÇE İLE KASKO YAPTIRILACAK ARAÇLARIN SEÇİMİ İÇİN BULANIK AHP-TOPSIS TEMELLİ ÖRNEK BİR ÇALIŞMA

Özet

Türkiye'de trafik sigortası zorunlu ancak kasko iste*ğe bağlı* bir sigortadır. Genel eğilim kasko yaptırma yönündedir ancak kasko yaptırmayan insanların oranı da *üzerinde çalışmaya* değerdir. *Çok sayıda araca sahip* özel ve kamu kuruluşları araçlarına kasko yaptırmak için her yıl *önemli oranda bütçe ayırmak*tadırlar. Ekonomik kriz periyotları, onları tüm araçları arasından hangi araçlarına kasko yaptırmaları konusunda seçim yapmaya zorlamaktadır.

Bu çalışmanın dizaynı şu şekildedir. *İlk olarak* kasko yaptırmak için araç seçiminde kullanılacak kriterler belirlenmiştir. Sonraki adım olarak bulanık AHP yöntemi kullanılarak bu kriterlerin ağırlıkları belirlenmiştir. TOPSIS metodu kullanılarak alternatif araçlar öncelik derecesine göre sıralanmıştır. Çalışmanın sonunda, *özel ve kamu kurumları için* mevcut araçları arasından kasko yaptırması gereken araçların seçimini *öner*en *örnek bir çalışma yapılmıştır*.

Anahtar Kelimeler: *Kasko Sigortası, Zorunlu Trafik Sigortası, Bulanık AHP, TOPSIS.*

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1.INTRODUCTION

Car insurance (Casco) is not compulsory in Turkey. Public and private companies are free to decide whether to buy Casco insurance for their vehicles or not. The companies can decide either to buy Casco insurances for their vehicles by paying their costs or not to buy Casco insurance and tolerate all required repair costs of their vehicles after accidents. Generally, they prefer to buy Casco insurance for all the vehicles they own. However, if the number of vehicles increases and they have limited budgets; it becomes a conflict for them to decide which vehicles should have Casco insurance. The problem emerges as selecting the vehicles to buy Casco insurance among all the vehicles they have. In this study, the problem for a public institution about selecting the vehicles to buy Casco insurance is examined. The vehicles that must have Casco insurance according to the regulations of the institution are not taken into consideration in the study. This public institution has a limited budget and 40 vehicles. So, 40 vehicles are taken into consideration. They are only sorted according to their priorities to buy Casco insurances by using fuzzy AHP and TOPSIS methodologies. The decision is left to the logistics director of the institution. Since the problem emerges as a decision problem for the institution, Multi Criteria Decision Making (MCDM) methods which are the most common way to sort or choose the alternatives are used in this study. The criteria that will be used to sort the alternatives must be determined first. After defining the criteria, a fuzzy AHP methodology is used to find out the weights of the criteria. TOPSIS is used to sort the vehicles and point out the priority of vehicles to buy Casco insurance by using the weights obtained from fuzzy AHP methodology.

Many articles can be found which uses fuzzy AHP and TOPSIS methodologies together when the related studies are searched. Gümüş (2009) uses these two methodologies together to evaluate hazardous materials waste transportation firms. Mahmoodzadeh et al., (2007) study on project selection by using fuzzy AHP and TOPSIS. Sachin K.P. and Kant R., (2014) propose a fuzzy AHP-TOPSIS framework for ranking the solutions of knowledge management adoption in supply chain to overcome its barriers. In this study, fuzzy AHP and TOPSIS are used to determine the criteria to buy Casco insurance and sort the vehicles according to those criteria. For this point of view, this study contributes to the literature for the determination of the criteria to buy Casco insurance. As a case study, the vehicles of a public institution with a limited budget are sorted with respect to its priority to buy Casco insurance. The design of the study is as follows, in second part general information about Casco insurance is given; in third part the criteria to buy Casco insurance are defined; in fourth part fuzzy AHP and TOPSIS methodologies are described; in fifth part a case study is performed for 40 vehicles of the public institution and in the last section, the results and future works are described

2.CAR INSURANCE (CASCO)

The name of Casco is an acronym build from the first letters of “casse” and “collision” from French language. Casco is a type of insurance purchased for cars, trucks, motorcycles and other road vehicles. Its primary use is to provide financial protection against physical damage and/or bodily injury resulting from traffic collisions and against liability that could also arise there from the specific terms of Casco with legal regulations (Çilesiz, 2010). The specific terms of vehicle insurance vary with legal regulations in each region. To a lesser degree, vehicle insurance may additionally offer financial protection against theft of the vehicle and possible damage to the vehicle sustained from things other than traffic collisions.

Casco insurance includes special conditions and regulations. The subject, geographical boundaries, scope and special conditions of Casco insurance is arranged by the law “The Guide for General Terms of Vehicle Casco Insurance” in 1994 in Turkey, and updated in April 2007 (Karakaya, 2010). Casco insurance can limited or widen according to the needs of customers. Despite the damage frequency is very high, insurance companies never give up from Casco insurance since the cash flow proportion in Casco insurance is the highest among all insurance types. According to "Insurance Attitude and Behavior Research" (made by Nielsen Company in 2008 with 3033 participants) which measures the awareness, the Casco insurance comes first with a proportion of 46%, while Private Pension is 42% and Life Insurance is 40%.

Insurance has two main types in general; "Life Insurance" and "Non-Life Insurance". Casco insurance is accepted in the "Non-Life Insurance". According to the statistics which can be seen in Table 1, Non-Life Insurance's share is 84.33% while Life Insurance's 15.66% in 2011.

Table 1: Insurance percentages in Turkey (%)

YEAR	*Non-Life Insurance (%)*				*Non-Life Insurance TOTAL*	*Life Insurance*
	Vehicle Insurance (CASCO)	Health	Fire and Disasters	Vehicle Insurance (Compulsory Traffic Insurance)		
2008	24.20	11.26	15.52	17.51	86.62	13.38
2009	21.43	11.52	15.56	17.94	85.24	14.76
2010	22.06	12.07	14.01	18.02	84.51	15.50
2011	22.07	11.65	13.46	17.33	84.34	15.66

Source: http://www.tsb.org.tr/resmi-istatistikler.aspx?pageID=909

People pay high amounts of money for car insurances all over the world. Therefore insurance companies have important roles in the economies of the countries. The insurance amounts of some countries in 2012 can be seen in Table 2.

Table 2: Insurance amounts of some countries for the year 2012

2012	Car Insurance	Non-life Insurance	2012	Car Insurance	Non-life Insurance
Country	(Million Dollars)		Country	(Million Dollars)	
USA	199775.00	977228.00	Nederland	5766.07	26206.94
Germany	27293.79	125641.02	Mexico	4777.05	12348.67
France	24991.46	84986.11	Turkey	4484.84	9154.32
Canada	19894.90	60317.34	Poland	4476.63	7886.22
UK	19232.57	88320.28	Sweden	4321.76	9707.49
Australia	12540.37	33761.91	Norway	3336.72	11702.15
Korea	11506.98	60063.60	Israel	2767.94	5868.25

Source: http://stats.oecd.org/Index.aspx?DataSetCode=PT5

There are 59 non-life insurance companies in Turkey and 31 of them offers Casco insurance. The contribution payments of the costumers to the first 10 insurance companies in Turkey can be seen in Table 3. Although there are 31 Casco insurance companies in Turkey, first 10 companies are the most important shareholders in insurance sector.

Table 3: Market shares of Casco insurance companies (Turkish Lira)

	Contribution Payments (Turkish Lira)				
COMPANIES	2008	2009	2010	2011	2012
Anadolu	356,465,384	346,698,323	471,409,527	670,260,748	744,295,948
Axa	507,033,534	433,697,868	463,463,509	598,684,535	696,231,197
Allianz	187,356,134	170,942,179	194,566,252	259,769,772	427,175,559
Ak	286,800,568	263,508,734	308,110,692	406,039,323	405,387,017
Groupama	237,123,023	180,140,660	204,690,380	231,173,605	271,246,527
Ergo	218,515,189	202,892,091	227,944,823	231,307,010	241,963,419
Gunes	200,589,601	186,817,241	170,915,777	152,304,853	220,880,267
Eureko	117,108,608	105,354,751	152,283,374	194,126,620	216,216,078
Yapı Kredi	114,023,582	99,728,087	147,683,262	159,624,000	213,750,488
Mapfre Genel	98,461,370	103,228,273	112,550,488	142,222,006	175,257,867
First 10 Company	2,323,476,994	2,093,008,206	2,453,618,084	3,045,512,473	3,612,404,366
Sector Total	2,850,270,696	2,632,269,343	3,116,701,275	3,787,525,920	4,533,997,871

Source: http://www.tsb.org.tr/resmi-istatistikler.aspx?pageID=909

All the vehicles which are used on roads must have compulsory traffic insurance according to the rules of Turkish Highway Administration. Compulsory traffic insurance is used for the repair cost of damaged vehicle after an accident. It can only be used for the repair cost of the other side which is involved in the accident. The vehicle owner should have Casco insurance for the repair cost of his own vehicle. With respect to the data supplied by Traffic Insurance Center (in Turkish: Trafik Sigorta Merkezi (TRAMER)) of Turkey, there are 17,795,712 (https://www.sbm.org.tr/tr/Sayfalar/Trafik-Sigortasi-Raporlari.aspx) vehicles which have traffic insurance among 19,793,995 total vehicles by December 2015 (http://www.milliyet.com.tr/trafige-kayitli-arac-sayisi/ Date:16.12.2015). This means that despite it is a must to buy compulsory traffic insurance, 1,998,283 vehicles do not have compulsory traffic insurance in Turkey. So, approximately 10 % of total vehicle owners do not obey the insurance rules in Turkey.

The reasons that vehicle owners buy Casco insurance are the risk of accident, theft, etc. According to the statistics of TUIK (Turkish Statistics Administration) among 17,653,281 total vehicles 12,951,358 of them do not have Casco insurance by October 2013 in Turkey.

The rate of vehicles which have compulsory traffic insurance is 89% while the rate of voluntary Casco insurance is only 26.6% in Turkey.

The institutions and vehicle owners should determine cost-effective decisions to buy Casco insurance with respect to the budget they have. The vehicle owners and public-private institutions are advised by the insurance authorities to buy Casco insurance if there is no budget constraint. Regarding the budget limitations, they may be forced to select some vehicles among all vehicles they have to buy Casco insurance. Due to the need of criteria determination and requirement of decision making to select the vehicles to buy Casco insurance, Multi-Criteria-Decision-Making (MCDM) methodology would fit best to find the optimal solution about Casco insurance problem.

Many articles are found related to Casco insurance, Casco insurance fraud (Morales et al., 2012), finding risks about car accidents (Blows et al., 2003), finding the criteria that have great role on the decision of vehicle owners (Eygü and Soğukpınar, 2012), insurance politics determination, Casco insurance general features and the scope of Casco insurance for vehicles. However, no article is found related to deciding the number of vehicles to buy Casco insurance among all vehicles owned by the company with a limited budget.

3.DEFINING THE CRITERIA

Figure 1 shows the rate of Casco insurance with respect to vehicle types. Usually most often used (trucks, buses, automobiles) vehicles on the roads are preferred to buy Casco insurances. This shows that one of the most important criteria to buy Casco insurance should be "the case of being frequently used on the roads (traffic)".

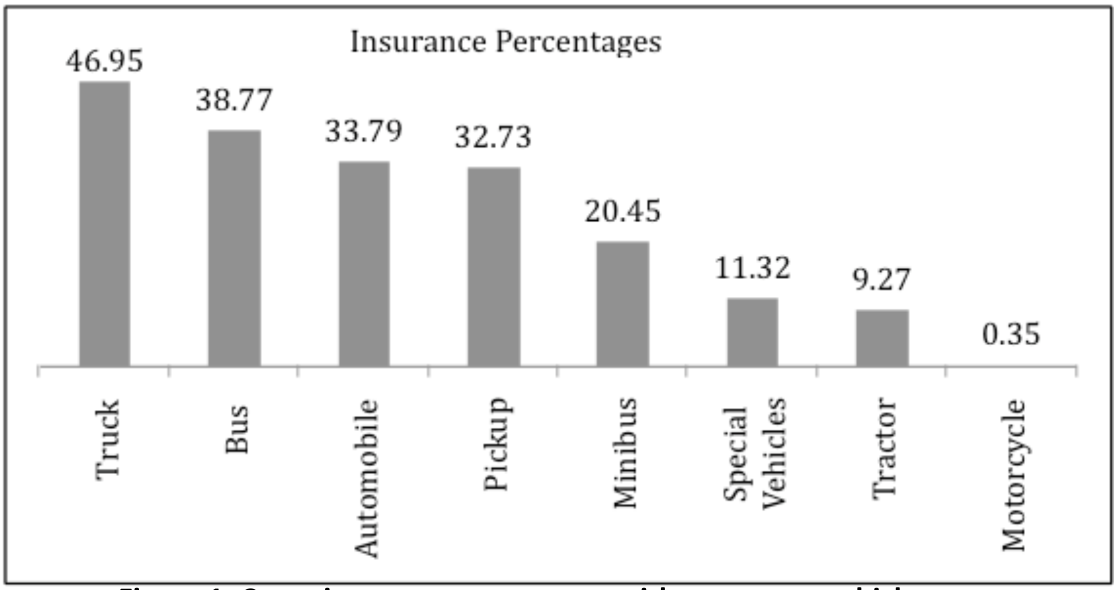

Figure 1: Casco insurance percentage with respect to vehicle types

Source: http://www.sbm.org.tr/?p=haberGoster&objectId=24

People would prefer to buy more comfortable and expensive vehicles as their economic conditions improved. The high prices of the vehicles force the owners to buy Casco insurance (Durmuş, 2011). So, "the price of the vehicle" can be accepted as a second criterion to buy Casco insurance. It is pointed out in the study of Durmuş(2011) that, the owner of the car who had a car accident before, commonly prefer to buy Casco insurance (Durmuş, 2011). The sequence of having car accident can also be another criterion to buy Casco insurance. So, by examining literature, three important criteria (the case of being frequently used on the roads, price of the vehicle, and sequence of having car accident) are accepted as the main reasons to buy Casco insurance.

As a second step, interviews are made with the experts in insurance sector about the criteria to buy Casco insurance. They also point out the importance of above three criteria and propose three more criteria (the condition that vehicles have more technical equipment, the special types of vehicles like ambulance and fire vehicle) and the characteristic of drivers (age, experience etc.) to buy Casco insurance. Since the experience and ages of the drivers are almost same in the public institution that the case study is carried out, this criterion is neglected. The focus is on five other criteria to buy Casco insurance.

After determination of five criteria, the next step is finding the weights of these five criteria. AHP which is developed by Saaty (1980 and 1994) is the most effective and commonly used methodology for determining the weights of criteria. But giving numerical scores to the questionnaire usually cause hesitations among repliers. So, fuzzy AHP methodology is preferred to be used in order to minimize this hesitation of the experts who will answer the questionnaire about criteria. So, fuzzy AHP is used to calculate the weights of criteria and TOPSIS methodology is used to sort the vehicles with respect to their priorities to buy Casco insurance.

4.METHODOLOGY

Two MDCM methodologies are used in the study namely fuzzy AHP and TOPSIS. The reason to choose fuzzy AHP methodology is; the experts who are expected to answer the questionnaire usually hesitate to give certain scores to the questionnaire. In fuzzy AHP methodology they only define the priorities and we adopt the priorities to fuzzy numbers by using fuzzy preference scale. The reason to choose TOPSIS methodology for sorting the alternatives can be explained as: in our study the alternatives have different values with respect to criteria. The prices of the vehicles are used for one criterion while in another criterion sequence of being in traffic is used. So, the alternatives have different values for different criteria. In this case, TOPSIS methodology is the best way among all MCDM methodologies to sort the alternatives. The brief descriptions of these two methodologies are as follows.

4.1.Fuzzy AHP Methodology

The Analytic Hierarchy Process (AHP) is a methodology for organizing and analyzing compound decisions, based on mathematics. It was developed by Thomas L. Saaty in 1970s and has been extensively used since then. AHP is firstly used for finding a solution to defense planning problem by USA Defense Ministry in 1971. After being used by many researchers, the researchers have begun to criticize the methodology for its lack of defining uncertain and unstable situations. In the quantification of verbal expression and joining of different ideas on a common framework it is better to use fuzzy AHP methodology. Thus, the uncertainty of decision problem can more easily be overcome (Ertuğrul and Karakaşoğlu, 2010).

There are plenty of articles about fuzzy AHP in the literature. The first studies are made by Van Laarhoven and Pedrycz (1983). In the following years, Buckley(1986), Boender et al.(1989), Chang (1996) and Cheng (1996) have found different solving algorithms and claims about fuzzy AHP methodology (Göksu, 2008).The common scale used by fuzzy AHP is made up of triangular fuzzy numbers which can be seen in Table 4.

Table 4: Fuzzy preference scale

Absolutely important (A. I.)	(7/2, 4, 9/2)
Strongly important (S. I.)	(5/2, 3, 7/2)
Fairly important (F. I.)	(3/2, 2, 5/2)
Weakly important (W. I.)	(2/3, 1, 3/2)
Equally important (Eq. I.)	(1, 1, 1)

Fuzzy logic is a form of logic in which the true values of variables may be any real number between 0 and 1. The term fuzzy logic was introduced in 1965 by a study about fuzzy set theory by Lotfi A. Zadeh (1965). Fuzzy logic is not explained in the study. There are plenty of articles that can be examined to understand fuzzy logic.

The fuzzy logic is also used in decision making methodologies such as AHP and ANP (Analytical Network Process). There are many fuzzy AHP methods proposed by different authors. The methodology that is used in our study is the geometric mean method proposed by Buckley (1985). The method can be described in two steps:

Step 1: By using the replies to the questionnaires, the fuzzy pair wise comparison matrix is described as synthetic pair wise comparison matrix (equation one which is proposed by Buckley for finding geometric means).

$$\tilde{a}_{ij} = \left(\tilde{a}_{ij}^{1} \otimes \tilde{a}_{ij}^{2} \otimes \ldots \otimes \tilde{a}_{ij}^{n}\right)^{\frac{1}{n}} \qquad (1)$$

In equation one, $\tilde{a}_{ij}$ is the triangular fuzzy number which is obtained by the i^th^ column and j^th^ row of pair wise comparison matrix. $\tilde{a}_{ij}^{n}$ shows the value of n^th^ questionnaire obtained from pair wise comparison matrix. (2) and (3) equations are used to calculate fuzzy geometric means ($\tilde{r}_i$) and fuzzy weights for each criterion ($\tilde{w}_i$).

$$\tilde{r}_i = \left(\tilde{a}_{i1} \otimes \ldots \otimes \tilde{a}_{ij} \otimes \ldots \otimes \tilde{a}_{in}\right)^{1/n} \tag{2}$$

$$\tilde{w}_i = \tilde{r}_i \otimes \left[\tilde{r}_1 \oplus \ldots \oplus \tilde{r}_i \oplus \ldots \oplus \tilde{r}_n\right]^{-1} \tag{3}$$

Step 2: The fuzzy criteria weights obtained from first step are defuzzified to find best non-fuzzy performance value (BNP-Best Nonfuzzy Performance Values). The fuzzy numbers are defuzzified by using equation 4 which uses the Center of Area method.

$$BNP_{wi} = \left[(U_{wi} - L_{wi}) \oplus (M_{wi} - L_{wi})\right] / 3 \oplus L_{wi}$$

L_{wi}, M_{wi} ve U_{wi} values in equation 4 shows low, medium and high values of each triangular fuzzy numbers.

4.2.TOPSIS Methodology

TOPSIS methodology was first proposed by Hwang and Yoon (1981). It is one of the most popular MCDM which is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. The recent studies which use TOPSIS method are as follows: İç, Y.T. (2014) used TOPSIS to sort the companies, Wang, T. C., & Chang, T. H.(2007) used it to compare the training aircrafts, Chen, Li and Lu (2011) used hybrid OWA and TOPSIS methods for multi-criteria decision analysis, Gümüş, A.T. (2009) used fuzzy AHP and TOPSIS methods together to analyze the hazardous waste transportation firms, Dağdeviren et al. (2009) used it for selecting best gun, Demireli, E.(2010) used it for a case study on public banks. TOPSIS method is carried out as follows:

Step 1: In the basic matrix i = 1,2,…..,m and j = 1,2,…….,n values are normalized by using vector normalization below.

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

The rows show alternatives while columns show criteria in the matrix below.

$$D = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1j} & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2j} & X_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ X_{i1} & X_{i2} & \cdots & X_{ij} & X_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ X_{m1} & X_{m2} & \cdots & X_{mj} & X_{mn} \end{bmatrix}$$

Step 2: Calculate the weighted normalized decision matrix by multiplying the values by their criteria weights. The total weights of criteria should be 1.

$$W_J = \left[w_1, w_2, \dots, w_n \right] \qquad \sum_{j=1}^{n} W_j = 1 \qquad V_{ij} = W_j r_{ij}$$

Step 3: Determine the positive ideal and negative ideal solutions. Where A^+ associated with the criteria having a positive impact, and A^- with the criteria having a negative impact;

$$\begin{aligned} A^+ &= \left\{ \left(\max_i V_{ij} / j \in J \right) \right\} = \left\{ \left(\max_i V_{ij} / j \in J' \right) / i = 1, 2, \dots, m \right\} \\ &= \left\{ V_1^-, V_2^-, \dots, V_j^-, \dots, V_n^- \right\} \end{aligned} \tag{5}$$

$$\begin{aligned} A^- &= \left\{ \left(\max_i V_{ij} / j \in J / i = 1, 2, \dots, m \right) \right\} = \left\{ \left(\max_i V_{ij} / j \in J' \right) / i = 1, 2, \dots, m \right\} \\ &= \left\{ V_1^-, V_2^-, \dots, V_j^-, \dots, V_n^- \right\} \end{aligned} \tag{6}$$

Step 4: The distance between alternatives from positive and negative ideal values can be calculated with the equations 7 and 8.

$$S_i^+ = \sqrt{\sum_{i=1}^{n} (V_{ij} - V_j^+)^2} \tag{7}$$

$$S_i^- = \sqrt{\sum_{i=1}^{n} (V_{ij} - V_j^-)^2} \tag{8}$$

Step 5: Calculate the similarity to the worst condition:

$$C_i^+ = \frac{S_i^-}{S_i^+ + S_i^-} \tag{9}$$

Step 6: Rank the alternatives according to C_i^+.

5.CASE STUDY

In this study, the focus is on selecting the vehicles to buy Casco insurance among 40 vehicles of a public institution with a limited budget. First the literature is searched for defining the criteria to choose vehicles to buy Casco insurance. Three criteria are found in the literature survey; the price of the vehicle, frequency of using the vehicle on roads, sequence of being involved in a traffic accident. Interviews are made with the experts in insurance sector about the criteria to buy Casco insurance. The insurance experts also point out the importance of those three criteria and add three more criteria which are; the condition that vehicles have more technical equipment, the special types of vehicles like ambulance and fire vehicle and the characteristic of drivers (age, experience etc.) to buy Casco insurance. Since the experience and ages of the drivers in the public institution are almost same, this criterion is neglected in the study.

The age, sexuality, educations, experience of drivers are very important for the insurance companies to determine and offer insurance prices to their consumers. The researchers must include this criterion in their studies if the drivers have different characteristics. The hierarchical structure of our study (which includes 5 criteria and 40 alternatives) can be seen in Figure 2.

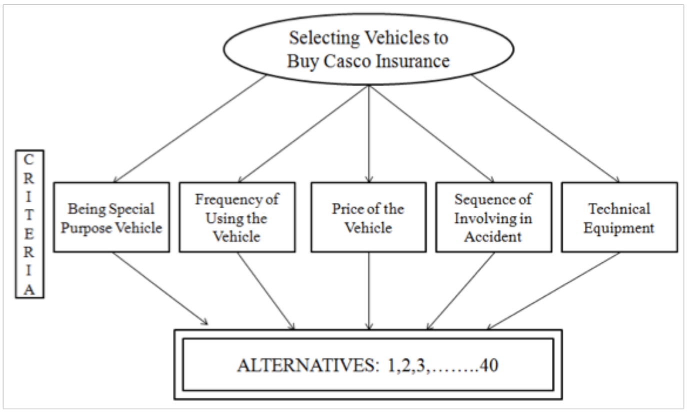

Figure 2: The hierarchical structure of case study

A questionnaire is prepared to find the weights of the criteria which can be seen in Table 5. Five insurance experts and five experts who work in the repairing and maintenance department of the public institution replied our questionnaire separately. The questionnaire is prepared by using importance scale used in fuzzy AHP methodology. The answer of one expert to the questionnaire is given in Table 5.

Table 5: Criteria comparison questionnaire

QUESTIONNAIRE										
Criteria	A.I.	S.I.	F.I.	W.I.	Eq.I.	W.I.	F. I.	S. I.	A.I.	Criteria
C-1			√							C-2
C-1		√								C-3
C-1			√							C-4
C-1		√								C-5
C-2			√							C-3
C-2				√						C-4
C-2		√								C-5
C-3		√								C-4
C-3		√								C-5
C-4			√							C-5

The expert answers the questionnaire in Table 5, according to the importance of the criteria. For example, if the first row of the questionnaire is referred, the expert thinks that the criterion 1 (C1) is fairly important (F.I.) than criterion 2 (C2). So he marked the F.I. box in the C1 side of first row.

The answers to the questionnaire are changed into pairwise comparison matrix by using triangular fuzzy numbers. The pairwise comparison matrix of first questionnaire is given in Table 6.

Table 6: Pairwise comparison matrix for first questionnaire

1st Questionnaire For Comparison of Criteria															
	Criteria-1 (Special Vehicle)			Criteria -2 (Frequency of Using the Vehicle on Roads)			Criteria -3 (Price)			Criteria -4 Sequence of Accident)			Criteria -5 (Technical Equipment)		
Criteria-1	1.00	1.00	1.00	1.50	2.00	2.50	2.50	3.00	3.50	1.50	2.00	2.50	2.50	3.00	3.50
Criteria-2	0.40	0.50	0.67	1.00	1.00	1.00	1.50	2.00	2.50	0.67	1.00	1.50	2.50	3.00	3.50
Criteria-3	0.29	0.33	0.40	0.40	0.50	0.67	1.00	1.00	1.00	2.50	3.00	3.50	2.50	3.00	3.50
Criteria-4	0.40	0.50	0.67	0.67	1.00	1.50	0.29	0.33	0.40	1.00	1.00	1.00	1.50	2.00	2.50
Criteria-5	0.29	0.33	0.40	0.29	0.33	0.40	0.29	0.33	0.40	0.40	0.50	0.67	1.00	1.00	1.00

The fuzzy pair wise comparison matrix is described as synthetic pair wise comparison matrix by using equation one which is proposed by Buckley for finding geometric means. The calculated synthetic pair wise comparison matrix is given in Table 7.

Table 7: Synthetic pairwise comparison values

Synthetic Pairwise Comparison Values															
	Criteria -1			Criteria -2			Criteria -3			Criteria -4			Criteria -5		
Criteria-1	1.00	1.00	1.00	0.30	0.36	0.42	0.43	0.50	0.60	0.48	0.58	0.69	0.70	0.84	0.99
Criteria-2	2.38	2.81	3.28	1.00	1.00	1.00	1.70	2.02	2.36	2.27	2.77	3.30	2.15	2.55	2.96
Criteria-3	1.67	2.00	2.34	0.42	0.49	0.57	1.00	1.00	1.00	1.07	1.28	1.53	1.03	1.25	1.50
Criteria-4	1.44	1.73	2.07	0.30	0.36	0.44	0.65	0.78	0.94	1.00	1.00	1.00	1.16	1.41	1.69
Criteria-5	1.01	1.20	1.44	0.34	0.39	0.46	0.67	0.80	0.97	0.59	0.71	0.86	1.00	1.00	1.00

2nd and 3rd equations are used to calculate fuzzy geometric means and fuzzy weights for each criterion (Table 8).

Table 8: Fuzzy geometric means and fuzzy weights of criteria

	Fuzzy Geometric Means			Fuzzy Weights		
Criteria-1	0.53449	0.61187	0.70362	0.08487	0.11132	0.14742
Criteria-2	1.81644	2.09316	2.37617	0.28843	0.38080	0.49785
Criteria-3	0.95129	1.09558	1.25019	0.15105	0.19932	0.26194
Criteria-4	0.80117	0.92865	1.07744	0.12722	0.16895	0.22574
Criteria-5	0.66946	0.76743	0.89036	0.10630	0.13962	0.18655

The fuzzy criteria weights that are obtained from first step are defuzzified by using equation 4 to find best non-fuzzy performance value (Table 9).

Table 9: Weights of criteria calculated by using fuzzy AHP

Weights of Criteria	
C-1, If the vehicle is being used for special purposes	0.11454
C-2, Frequency of the vehicles being used on the roads	**0.38903**
C-3, The price of the vehicle,	0.20410
C-4, Sequence of being involved in a traffic accident	0.17397
C-5, Technical equipment that the vehicle has	0.14415

The most important criterion is calculated as "Frequency of the vehicles being used on the roads" with the value of 0.38903. Second important criterion is C3 (the price of the vehicle) with the importance percentage of 0.2041. Third, fourth and last criteria are C4, C5 and C1 respectively.

In the study, first the weights of the criteria which are very important to select the vehicles to buy Casco insurance are calculated by using fuzzy AHP methodology. For the next step, TOPSIS methodology is used to sort the alternatives. The real values of 40 alternative vehicles according to 5 criteria are obtained from the records of transportation department of public institution and given in Table 10.

Table 10: The calculated values of alternative vehicles for each criterion

Alt.	C1	C2	C3	C4	C5	Alt.	C1	C2	C3	C4	C5
1	0	26	25700	0	7	21	0	4	25600	0	4
2	0	22	25700	0	7	22	0	50	30000	0	4
3	0	11	24535	0	5	23	0	43	30000	0	4
4	0	18	24439	0	5	24	0	64	59670	0	4
5	0	27	24439	0	5	25	0	0	59670	0	4
6	0	27	24439	0	5	26	0	17	139423	0	2
7	0	28	24439	1	5	27	0	17	135750	0	4
8	0	73	23100	0	5	28	0	0	82641	0	1
9	0	48	23100	1	5	29	1	1	137046	0	2
10	0	5	24800	0	5	30	0	26	24439	0	5
11	0	7	36103	0	5	31	0	6	114076	1	6
12	0	2	22750	0	5	32	0	12	100000	0	6
13	0	85	22750	1	5	33	1	20	42100	0	3
14	0	79	22750	1	6	34	1	12	42100	0	1
15	0	94	80500	1	3	35	0	19	22750	0	5
16	0	61	80500	1	3	36	0	21	22750	0	5
17	0	98	72285	1	4	37	0	18	72285	1	4
18	0	60	72285	0	4	38	0	16	98400	0	1
19	0	45	72285	0	4	39	1	1	98046	0	1
20	0	43	72285	0	4	40	1	1	140750	0	1

In Table 10, C1 shows whether the vehicle is used for special purposes (1: if it is a special purpose vehicle, 0: if it is not a special purpose vehicle). C2 values are the average monthly usage of vehicles in 2014 (for example the first alternative vehicle was used on the average of 26 times in a month), C3 is the price of the vehicle in Turkish Lira (TRY), C4 is the value if the vehicle had an accident in 2014, C5 is value which represents the number of technical equipment that the vehicle has.

The values in Table 10 are normalized by using vector normalization as it is explained in the first step of TOPSIS methodology and then they are multiplied by their criteria weights found by fuzzy AHP methodology. The calculated weighted and normalized values of alternatives are given in Table 11.

Table 11: Weighted and normalized values

Alt.	C1	C2	C3	C4	C5	Alt.	C1	C2	C3	C4	C5
1	0.00000	0.03923	0.01209	0.00000	0.03632	21	0.00000	0.00604	0.01204	0.00000	0.02075
2	0.00000	0.03319	0.01209	0.00000	0.03632	22	0.00000	0.07544	0.01411	0.00000	0.02075
3	0.00000	0.01660	0.01154	0.00000	0.02594	23	0.00000	0.06488	0.01411	0.00000	0.02075
4	0.00000	0.02716	0.01150	0.00000	0.02594	24	0.00000	0.09656	0.02807	0.00000	0.02075
5	0.00000	0.04074	0.01150	0.00000	0.02594	25	0.00000	0.00000	0.02807	0.00000	0.02075
6	0.00000	0.04074	0.01150	0.00000	0.02594	26	0.00000	0.02565	0.06558	0.00000	0.01038
7	0.00000	0.04225	0.01150	0.05799	0.02594	27	0.00000	0.02565	0.06385	0.00000	0.02075
8	0.00000	0.11014	0.01087	0.00000	0.02594	28	0.00000	0.00000	0.03887	0.00000	0.00519
9	0.00000	0.07242	0.01087	0.05799	0.02594	29	0.05122	0.00151	0.06446	0.00000	0.01038
10	0.00000	0.00754	0.01166	0.00000	0.02594	30	0.00000	0.03923	0.01150	0.00000	0.02594
11	0.00000	0.01056	0.01698	0.00000	0.02594	31	0.00000	0.00905	0.05366	0.05799	0.03113
12	0.00000	0.00302	0.01070	0.00000	0.02594	32	0.00000	0.01811	0.04704	0.00000	0.03113
13	0.00000	0.12825	0.01070	0.05799	0.02594	33	0.05122	0.03018	0.01980	0.00000	0.01556
14	0.00000	0.11919	0.01070	0.05799	0.03113	34	0.05122	0.01811	0.01980	0.00000	0.00519
15	0.00000	0.14183	0.03786	0.05799	0.01556	35	0.00000	0.02867	0.01070	0.00000	0.02594
16	0.00000	0.09204	0.03786	0.05799	0.01556	36	0.00000	0.03168	0.01070	0.00000	0.02594
17	0.00000	0.14786	0.03400	0.05799	0.02075	37	0.00000	0.02716	0.03400	0.05799	0.02075
18	0.00000	0.09053	0.03400	0.00000	0.02075	38	0.00000	0.02414	0.04628	0.00000	0.00519
19	0.00000	0.06790	0.03400	0.00000	0.02075	39	0.05122	0.00151	0.04612	0.00000	0.00519
20	0.00000	0.06488	0.03400	0.00000	0.02075	40	0.05122	0.00151	0.06620	0.00000	0.00519

The positive (A max) and negative (A min) ideal solutions are obtained by using the equations 5, 6. The results of positive and negative ideal solutions with respect to the criteria are given in Table 12.

Table 12: Positive and negative ideal solutions

	C1	C2	C3	C4	C5
A max	0.05122	0.14786	0.06620	0.05799	0.03632
A min	0	0	0.01170	0	0.00262

As an example, for criterion 2 (C2), the positive ideal value is 0.14786 which is the highest value of column 2 that belongs to alternative vehicle 17 in Table 11.

Next, the equations 7 and 8 are used to calculate the distances from positive and negative ideal solutions.

The 9th equation is used to as the last step and 40 vehicles of the public organization are sorted according to their priorities to buy Casco insurance.

6.CONCLUSION AND FUTURE WORKS

The results obtained from TOPSIS are given in Table 13. The vehicles are sorted with respect to Ci values. The priorities of the vehicles to buy Casco insurance are given in order in Table 13. The vehicle-17 has the first priority value while the vehicle-21 has the last priority to buy Casco insurance.

Table 13: Ranking the alternatives according to closeness coefficient

Alt.	C_i*	Alt.	C_i*	Alt.	C_i*	Alt.	C_i*
17	0.72079	19	0.38591	26	0.29265	36	0.20099
15	0.71422	20	0.37267	39	0.27808	35	0.18794
13	0.64379	7	0.36504	34	0.26509	4	0.18186
14	0.62526	23	0.34683	1	0.25820	3	0.14082
16	0.57417	31	0.34198	5	0.24178	28	0.14077
8	0.52146	37	0.33962	6	0.24178	11	0.12723
24	0.49446	40	0.32008	32	0.24022	25	0.11946
18	0.47984	29	0.31816	30	0.23496	10	0.11530
9	0.47009	33	0.30254	2	0.23459	12	0.10775
22	0.39295	27	0.29552	38	0.22218	21	0.08915

All alternatives are sorted for the public institution so that the logistics manager in charge can select exact number of the vehicles to buy Casco insurance according to budget of the institution. First five vehicles that the public institution should buy Casco insurance are 17,15,13,14 and 16 respectively.

In this study, the problem for a public institution about selecting the vehicles to buy Casco insurance is examined. The institution has a limited budget. 40 vehicles of the institution are the focus of the study to buy Casco insurance. It is very important to decide the number of vehicles to buy Casco insurance with a limited budget for the institutions which have many vehicles. It is obvious that, buying Casco insurance for all vehicles will be preferred under no budget constraint. The Casco insurance is usually bought for one year. It is always a risk not to buy Casco insurance for a vehicle. By accepting this risk, the institution will save money of buying Casco insurance for that vehicle if there is no accident in that year. If the vehicle has an accident, the institution must bear the cost of repairing the vehicle. So, it arises as a decision problem for the institutions to buy Casco insurances for their vehicles.

To find a solution to this kind of decision problems, fuzzy AHP methodology is proposed to find out the weights of the criteria and TOPSIS methodology is proposed to sort the vehicles according to their priorities to buy Casco insurance.

A questionnaire is prepared for the people who are specialists about this subject to define the criteria. Next, five criteria are defined about choosing the vehicles to buy Casco insurance. The weights of these criteria are found by using fuzzy AHP. The problem emerges as a decision problem for the institution. TOPSIS method is used in the study to sort the vehicles according to their priorities to buy Casco insurance, since it is a commonly used methodology among MCDM to sort the alternatives. At the end of this study, by using weighted criteria, the priorities of the vehicles are found to buy Casco insurance for the public institution.

For the future studies proposed hybrid fuzzy AHP and TOPSIS methodology can be used to find the priorities of the vehicles to buy Casco insurance. The methodology can also be used to buy different kind of insurance after defining the criteria for that insurance type.

Five different criteria are defined in the study to sort the vehicles according to their priorities to buy Casco insurance with respect to the needs of the public institution. The age, sexuality, educations, experience of drivers are also very important criteria for the insurance companies while they are offering insurance prices to their customers. The future researchers should think to include these criteria in their studies if the drivers have different characteristics. The criteria which will be used in future studies should be adopted according to the needs of the public or private institutions.

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