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Tire Selection with TOPSIS and GRA Methods in Multi Criteria Decision Making[1]

TOPSIS ve GİA Çok Kriterli Karar Verme Yöntemleri ile Lastik Seçimi

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Abstract

For safe driving, the tires used in vehicles must be assessed effectively. In general, users do not depend on a single criterion such as price in the buying process, but consider more than one criterion. In this regard, the choice of tires is also a complicated process for customers to consider many criteria such as handling, durability, noise, fuel consumption. Because of this, the choice of tires can be modeled as a Multi-Criteria Decision Making (MCDM) problem. Such problems with multiple criteria and alternatives are easily resolved with Multi Criteria Decision Making methods. For this purpose, the main criteria for tire selection are wet / dry road performance, noise, wear and fuel consumption. In this study, the test data of ADAC (Europe's largest automobile club) was used as input to solve the Multi-Criteria Decision problem. Alternatives are ranked with the help of the basic scale created by ADAC. GRA (Gray Relational Analysis) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods are widely used in classification / ranking problems. Therefore, the decision problem of 5 criteria and 16 alternatives is solved by GIA and TOPSIS methods. Findings resulting from the analysis were compared with the ADAC test results and all ranking results were interpreted.

Anahtar kelimeler: GRA, Multi-Criteria Decision Making, Tire Selection, TOPSIS.

Özet

Güvenli sürüş için, araçlarda kullanılan lastikler etkin bir şekilde değerlendirilmelidir. Kullanıcılar genel olarak satın alım süreçlerinde fiyat gibi tek bir kritere bağlı kalmayıp, birden çok kriteri gözönüne almaktadır. Bu bakımdan lastik seçimi de, müşterilerin yola tutunma, dayanıklılık, gürültü, yakıt tüketimi gibi bir çok kriteri göz önüne almaları gereken karmaşık bir süreçtir. Bu nedenden dolayı, lastiklerin seçimi bir Çok Kriterli Karar Verme (MCDM) problemi olarak modellenebilir. Birden çok kriter ve alternatif barındıran bu tür problemler, Çok Kriterli Karar Verme yöntemleri ile kolaylıkla çözümlenmektedir. Bu amaçla lastik seçiminde öne çıkan temel kriterler ıslak/kuru zemin performansı, gürültü, aşınma ve yakıt tüketimi olarak belirlenmiştir. Bu çalışmada, ADAC'ın (Avrupa'nın en büyük otomobil kulübü) test verileri Çok Kriterli Karar problemini çözmek noktasında girdi olarak kullanılmıştır. ADAC'ın oluşturduğu temel ölçek yardmıyla alternatifler derecelendirilmiştir. GİA (Gri İlişkisel Analiz) ve TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) yöntemleri sınıflandırma/derecelendirme problemlerinde yaygın olarak kullanılmaktadır. Bundan dolayı, 5 kriter ve 16 alternatif barındıran karar problemi GİA ve TOPSIS yöntemleri ile çözümlenmiştir. Analiz sonucunda ortaya çıkan bulgular, ADAC test sonuçlarıyla karşılaştırılmış ve tüm sıralama sonuçları yorumlanmıştır.

Key Words: *Gri İlişkisel Analiz, Çok Kriterli Karar Verme, Lastik Seçimi, TOPSIS*

Introduction

In 2015, World tire market reached 1.7 billion units that is increased by 1%. The motor vehicle market will remain the largest outlet for tire demand, accounting for two-thirds of the total in 2019. Demand for tires in this market will rise 3.3 percent per year to 2.0 billion units. Leading players in the World Tires Market are Bridgestone Corp., Group Michelin, Goodyear Tire & Rubber Co. and Continental A.G. (Freedonia).

Cars are one of the most important transportation vehicles of our time. Today, millions of people use their cars for hours every day. Tires are one of the most important parts of these cars. Also the tires have in their lifetimes and need to be replaced when it's time. Other than that, the people may need to change the tire due to various accidents and changing climate conditions. Selecting the right tires for vehicles is very important decision for both commercial and private vehicles.

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In order to ensure traffic safety and prevent accidents that may occur, legal regulations made at national and international level and consumers are informed about them. Additionally, it can be said that customers are becoming more sensitive with their security. Consumers are considering many factors in new tire selection such as dry-wet road performance, sound, fuel consumption, etc. Because of the tire selection criteria is too many, this is a Multi-Criteria Decision Making (MCDM) problem.

The ADAC (Allgemeiner Deutscher Automobil-Club e.V.) (General German Automobile Club) is an automobile club in Germany, founded on May 24, 1903 as German Motorbiker Association ("Deutsche Motorradfahrer-Vereinigung"), and was renamed to its present name in 1911. The ADAC is currently more than 19 million members of the largest automobile club in Europe and the second largest in the world.

In this study, ADAC's test data will be used to solve the MCDM problem of selecting tires. Analyses is based on basic selection criteria which used to asses summer tires. Selection criteria for summer tires are: dry road, wet pavement, noise, fuel consumption, tire wear. Selection of 16 pieces of summer tires that subjected to testing by ADAC considered as a multi-criteria decision making problem. GRA (Grey Relational Analysis) and TOPSIS methods that are commonly used sorting / grading problems will be used in the study. Finally, the results provided by these methods will be compared with ADAC's test results and all results will be interpreted. Consequently, results will help customers to make right decision about selecting.

Multiple Criteria Decision Making

The decision makers' judgments vary in many forms and dimensions. The degree of judgment skill also varies. For instance, we may list the different preferences information on decision criteria like standard level, ordinal, cardinal etc. MCDM methods differentiate to meet these various judgments. The classification is made in three clusters. Cluster 1 represents information about attribute or alternative. Cluster 2 represents the significant feature of the information needed. Cluster 3 represents basic methods which are formed from previous clusters (Hwang and Yoon; 1981).

Table 1. Classification of MCDM Methods (Hwang and Yoon; 1981)

	Cluster 1	Cluster 2	Cluster 3		
Multiple Criteria Decision Making	No Information		Dominance	Maxmin	Maxmax
	Information on Attribute	Standard Level	Conjunctive Method	Disjunctive Method	
		Ordinal	Lexicographic Method	Elimination by Aspects	Permutation Method
		Cardinal	Linear Assignment Method	ELECTRE	TOPSIS
		Marginal Rate of Substition	Hierarchical Tradeoffs		
	Information on Alternative	Pairwise Preference	LINMAP	Interactive SAW Method	
		Order of Pairwise Proximity	MDS with Ideal Point		

There are two basic forms of MCDM methods. One is compensatory while the other is non-compensatory. Non-compensatory MCDM methods don't let tradeoffs between criteria. In other words, an undesirable value in one criterion cannot be tolerated by desirable criteria. Each criterion should evaluate separately. This type of MCDM methods are known with their simplicity. Dominance method, Maxmin, Maxmax, Conjunctive method etc.

Compensatory methods can let tradeoffs between decision criteria. A little decrease in one criterion can be compensated any criterion that has desirable value on decision criteria. SAW, AHP, TOPSIS, GRA, Linear assignment method etc. This work is based on TOPSIS and GRA from compensatory methods.

TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method is presented in (Opricovic & Tzeng; 2004), with the reference to Hwang and Yoon (1981). TOPSIS method is grounded on that the best alternative should have the shortest distance from positive the ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS). The PIS is the solution that maximizes the benefit and also minimizes the total cost. In contrast, the NIS is the solution that

minimizes the benefit and also maximizes the total cost (Yousefi & Vencheh; 2010). These are the basic features of TOPSIS methodology (Deng; 2000):

- The TOPSIS concept is understandable and rational
- Computation procedure is simple to practice
- The concept is capable of presenting the pursuit of the best performance of an alternative for each evaluation criteria in a simple mathematical form
- It allows for integrating objective or subjective weights to the model.

TOPSIS procedure performs the following computation steps (Opricovic & Tzeng; 2004):

Step 1: Calculate the normalized decision matrix. In MCDM problems, decision matrix which consists of m alternatives and n decision criteria is normalized different normalization procedure.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}(x_{ij})^2}} \quad (i=1,....m\ ;\ j=1...n) \text{ for benefit criteria} \qquad (1)$$

$$r_{ij} = 1 - \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}(x_{ij})^2}} \quad (i=1,....m\ ;\ j=1...n) \text{ for cost criteria} \qquad (2)$$

Step 2: Calculate the weighted normalized decision matrix. When " w_{ij} " is the weight of the criteria and " r_{ij} " is the normalized decision matrix value, the weighted normalized "v_{ij} " value is determined as:

$$V_{ij} = w_{ij} * r_{ij} \quad (i=1,....m\ ;\ j=1...n) \qquad (3)$$

Step 3*:* Determine the positive and negative ideal solutions. A^+ is the PIS point that has best scores in weighted normalized decision matrix where A^- is the NIS point that has worst scores in weighted normalized decision matrix.

$$A^+ = (v_1^+, v_2^+, ...v_n^+)$$
$$V_j^+ = (\max v_{ij}, j \in N'), (\min v_{ij}, j \in N'') \text{ where } i=1,....m \qquad (4)$$
$$A^- = (v_1^-, v_2^-, ...v_n^-)$$
$$V_j^- = (\min v_{ij}, j \in N'), (\max v_{ij}, j \in N'') \text{ where } i=1,....m \qquad (5)$$

N' is associated with benefit criteria and N'' is associated with cost criteria.

Step 4: Determine the distance from PIS (D*) and NIS (D^-). Calculate the separation measures, using the n-dimensional Euclidean distance.

$$D^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2}\ , (i=1,....m\ ;\ j=1...n) \qquad (6)$$

$$D^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}\ , (i=1,....m\ ;\ j=1...n) \qquad (7)$$

Step 5: Calculate the relative closeness to the ideal solution. Closeness coefficient C_i^* presents the closeness of the alternative "a_j "to the ideal solution.

$$C_i^* = \frac{d_i^-}{d_i^+ + d_i^-} \quad C_i \in [0,1]\ i=1,....m \qquad (8)$$

***Step 6*:** Rank the alternatives. The best alternative is the one that has the highest C_i^* score. The worst is the lowest.

GRA (Grey Relation Analysis) Method

GRA (Grey Relation Analysis) method was firstly developed by Deng and widely used to overcome the MCDM problems. It is one of the popular MCDM methods to analyze various relations in multiple criteria environment. The basic purpose of GRA is to obtain primary relationships among the factors and alternatives (Fu; 2001). It is an impact evaluation model that

measures the degree of similarity or difference between two sequences based on the grade of relation (Chan; 2007). There are major advantages of this GRA method (Wu; 2002).

- Results are based on original data set.
- Calculation procedure is pretty simple and smooth.
- It is one of MCDM methods that frequently uses in literature.

The steps of GRA method are shown below:

Table 2. Procedure of grey relational analysis (Kuo; 2008)

Step 1: Grey relational generating
Step 2: Reference sequence definition
Step 3: Grey relational coefficient calculation
Step 4: Grey relational grade calculation

Step 1: Generate the reference series and compared series.

Compared serial $x_i=(x_i(1),(x_i(2),\ldots\ldots (x_i(n))$ i=1, 2, 3...n

The compared series can be represented in a matrix form:

$$X_i = \begin{bmatrix} x_1(1) & x_1(2) & x_1(n) \\ x_2(1) & x_2(2) & x_2(n) \\ x_m(1) & x_m(2) & x_m(n) \end{bmatrix}$$

Normalize the decision matrix.

$x_i^*j = \frac{x_ij - \min x_ij}{\max x_ij - \min x_ij}$ for benefit criteria $\max x_i j$ (Maximum value of criterion) (9)

$x_i^*j = \frac{\max x_ij - x_ij}{\max x_ij - \min x_ij}$ for cost criteria $\min x_i j$ (Minimum value of criterion) (10)

Step 2: Determine the reference sequence.

Reference serial $x_0 = (x_0(1),(x_0(2),\ldots\ldots (x_0(n))$
After the normalization procedure, referential serial values must be equal to 1.

Step 3: Calculate the grey relational coefficient.

$y(x_{0j}, x_{ij}) = \frac{\Delta_{min} + \delta\Delta_{max}}{\Delta_{ij} + \delta\Delta_{max}}$ For i=1,2,3,...m j=1,2,3,....n (11)

$y(x_{0j}, x_{ij})$ is the grey relational coefficient between "x_{ij}" and "x_{0j}":

$\Delta_{ij} = |x_{0j} - x_{ij}|$

Δ_{min}= Min (Δ_{ij}, i=1,2,3,...m j=1,2,3,....n)

Δ_{max}= Max (Δ_{ij}, i=1,2,3,...m j=1,2,3,....n) where "δ" is the distinguishing coefficient between (0-1).

Step 4: Calculate the grey relational grade. The grey relational grade indicates the degree of similarity between the comparable sequence and the reference sequence. The higher grey relational score signifies the better alternative while lower does worse.

$r(x_0, x_i) = \sum_{j=1}^{n} y(x_{0j}, x_{ij})$ (12)

Literature Review

In Multiple Criteria Decision Making literature, lots of methods and applications are used. Supply Chain Management, personnel selection, business and marketing management, health, safety, environment and human resource management are the specific areas of these MCDM methods. Here are some literature examples of these methods chronologically below:

Table 3. TOPSIS & GRA Literature Review (Revised with reference to Behzadian; 2012)

Authors	Year	Method	Subject
Hwang, Lai, Liu	1993	TOPSIS	Solving Nutrition Problem
Lai, Liu, Hwang	1994	TOPSIS	Water quality management problem
Triantaphyllou, Lin	1996	TOPSIS &AHP &SAW etc.	Fuzzy MCDM methods and applications
Chang, Lin	1999	Grey relational Analysis	Identifying key factors affecting industrial CO2
Liang	1999	Grey relational Analysis	Hydroelectric generation scheduling
Feng, Wang	2000	Grey Relation Analysis & TOPSIS	Evaluation of Airlines with regard to financial ratios
Deng, Yeh, Willis	2000	Entropy weight & Modified TOPSIS	Ranking companies in textile industry
Chen	2000	Extended TOPSIS with Fuzzy	Selecting the most suitable candidate for hiring
Chang et al.	2000	Grey relational Analysis	Optimization of the injection moulding process
Tsaur, Chang, Yen	2002	AHP&TOPSIS (Fuzzy Environment)	Airlines' Service Quality
Chen, Tzeng	2004	Fuzzy AHP & Grey relational model	Selection process for staffing
Jahanshahloo et al.	2006	TOPSIS with interval data	Comparing bank branches through financial ratios
Fan, Feng	2009	Fuzzy TOPSIS	Dean selection in the business school
Chang, Lin, Chiang	2010	TOPSIS with different distance measures	Performance Evaluation of mutual funds
Sun	2010	Fuzzy AHP & Fuzzy TOPSIS	Evaluating notebook computer ODM companies
Dagdeviren	2010	ANP & Modified TOPSIS	Personnel selection problem
Dai et al.	2010	Grey relational Analysis & Factor Analysis	Water resource security evaluation
Özcan et al.	2011	AHP& Grey Theory	Warehouse location selection
Yan et al.	2011	Gray correlation degree	Performance evaluation of coal enterprises
Li et al.	2011	Entropy & TOPSIS	Safety evaluation of coal mines

When the literature was examined, it was found that there were no studies on multi-criteria decision making and tire selection. From this point of view, the work keeps its originality. In consumer purchasing decisions, the price of the product is not the only variable. Therefore, variables such as rain performance, comfort and fuel economy are important for the driving safety of tires. In our study, we have selected from many tires using these criteria. Findings presented at the end of the study are suggestions for consumers who purchase tires and tire-making businesses.

Methodology

In this decision problem, 16 summer tires (185/65/R15 H) and five decision criteria were determined for year 2016. The initial data is provided from ADAC (General German Automobile Club). ADAC is the largest automobile club in Europe. Also ADAC carries out many tire tests through all tire firms all over the world. With the help of these tests, consumers decide the best tire alternative. In this study, five decision criteria are measured (ADAC; 2016):

- Dry Road: General driving behavior of the tire below the critical limit, such as straight-line stability, steering response, cornering driving safety. Slowing down length with ABS braking.
- Wet Road: Slowing down length with ABS braking from 80 km / h to 20 km / h on wet asphalt and concrete pavement.
- Sound: Subjective evaluation of interior noise by two people in a vehicle coast down between 80 km / h and 30 km / h on asphalt and concrete road surface with the engine stopped.
- Fuel Consumption: 100 km / h on the same vehicle for a distance of 2 km, two runs with five test runs per tire model. Measurement: fuel consumption in liters per 100 km.
- Tire Wear: Opposite convoys with several identical vehicles over a distance of 15, 000 km a tire, thereby changing drivers and tires.

In conclusion, ADAC has a scale to grade tires. Each tire is graded between these scale numbers. From this view, each criterion has “lower the better” characteristic. This scale is presented below.

Table 4. ADAC Tire Evaluation Scale

Very Good	Good	Satisfying	Sufficient	Inadequate
1,5	2,5	3,5	4,5	5,5

After this step, the initial decision matrix of the problem and criterion weights is obtained:

Table 5. Initial Decision Matrix and Criterion Weights

Criterion Weights	0,2	0,4	0,1	0,1	0,2
Decision Criterion	**Dry Road**	**Wet Road**	**Sound**	**Fuel Consumption**	**Tire Wear**
Vredestein Sportrac 5	1,8	2,0	3,3	2,1	2,0
Continental ContiPremiumContact 5	1,6	2,3	3,4	2,0	2,0
Dunlop Sport BluResponse	1,7	2,3	3,6	1,8	2,0
Goodyear EfficientGrip Performance	2,0	2,1	3,9	2,1	2,0
Hankook Kinergy Eco K425	1,7	2,2	3,1	2,0	2,5
Nokian Line	1,7	2,3	3,6	1,8	2,5
Kumho Ecowing ES01 KH27	1,9	2,4	3,2	2,1	2,5
Sava Intensa HP	2,7	2,2	3,9	2,2	2,0
Infinity Ecosis	2,6	2,8	2,5	2,3	2,5
Michelin Energy Saver+	2,1	2,8	3,5	1,6	1,0
Barum Brillantis 2	2,5	3,0	3,2	2,2	1,5
Bridgestone Turanza T001	1,6	3,0	2,8	1,7	2,0
Nexen N Blue HD Plus	1,6	3,1	3,8	1,9	2,0
Semperit Comfort-Life 2	2,1	3,2	3,9	2,1	1,5
Nankang Green- Sport Eco-2+	2,4	3,8	3,3	2,4	2,0
GT Radial Champiro VP1	3,2	5,5	3,3	2,2	1,5

For TOPSIS application firstly, initial decision matrix is normalized by formula (1) or (2). Then normalized decision matrix is weighted by formula (3). Then PIS and NIS are determined by formula (4) and (5). Calculate D+ and D- by formula (6) and (7). Calculate C* by formula (8) and rank the alternatives. For GRA, normalize the decision matrix by formula (9) or (10). After determining reference sequence, calculate the grey relational coefficient by formula (11). At the end, determine the grey relational grade by formula (12). Rank the alternatives. After these mathematical procedures final scores and ranks are introduced below:

Table 6. Alternative Scores and Rankings

Score & Rankings	**TOPSIS Scores**	**TOPSIS Ranking**	**Grey Grade**	**GRA Ranking**	**ADAC Ranking**
Vredestein Sportrac 5	0,823	1	0,737	2	1
Continental ContiPremiumContact5	0,769	4	0,721	3	2
Dunlop Sport BluResponse	0,764	5	0,711	4	3
Goodyear EfficientGrip Performance	0,793	2	0,675	8	4
Hankook Kinergy Eco K425	0,781	3	0,707	5	5
Nokian Line	0,760	6	0,691	6	6
Kumho Ecowing ES01 KH27	0,729	8	0,632	9	7
Sava Intensa HP	0,753	7	0,602	11	8
Infinity Ecosis	0,619	11	0,566	12	9
Michelin Energy Saver+	0,682	9	0,739	1	10
Barum Brillantis 2	0,598	13	0,559	13	11
Bridgestone Turanza T001	0,626	10	0,690	7	12
Nexen N Blue HD Plus	0,603	12	0,623	10	13
Semperit Comfort-Life 2	0,571	14	0,558	14	14
Nankang Green- Sport Eco-2+	0,412	15	0,463	15	15
GT Radial Champiro VP1	0,168	16	0,407	16	16

Results and Evaluation

The use of appropriate techniques in decision problems makes the selection process effective and efficient. The use of TOPSIS and Gray Relational Analysis has many advantages in multi-criteria decision problems. These techniques produce simple, clear and consistent results in problems involving multiple evaluation criteria. Even if probing new variables are added, new sequences can be created easily. The techniques used in the study have the following basic advantages:

- Being simple, rational and easily understandable form,
- Reflect people's preferences on a clear basis,
- Easy to calculate and produce consistent results,
- Ability to detect the best and worst alternatives with respect to each criterion.

The advantages mentioned above are obvious in the TOPSIS and GRA techniques used in tire selection. Moreover, when the method is applied, subjective judgments of decision makers are avoided, so that the process is handled objectively.

When the scores and ranking of alternatives were examined; in TOPSIS top three is, Vredestein Sportrac 5, Goodyear EGP and Hankook Kinergy Eco K425, respectively. Top three in GRA method is Michelin Energy Saver+, Vredestein Sportrac 5 and Continental CPC5, respectively. The rank correlation between the TOPSIS and GRA sorting is about 0,8 that mean the rankings indicate close similarity. High similarity between method results is an indication that the techniques used produce consistent and logical results. In ADAC ranking top three is Vredestein Sportrac 5, Continental CPC5 and Dunlop Sport Blu Response, respectively. There is a positive correlation between TOPSIS and ADAC results about 0,953, where GRA vs. ADAC is 0,765. This indicates that the ADAC's rating and the TOPSIS rankings are highly similar. In this regard, TOPSIS ranking results are more factual than GRA ranking results. So, these MCDM methods TOPSIS and GRA presented similar results among and ADAC results are accord with the TOPSIS and GRA. The consistent results of the techniques are an effective recommendation for tire manufacturers operating in the sector and for independent testing organizations.

In conclusion, in tire selection problem, TOPSIS and GRA methods submitted straight-forward and smoothing results with real world. TOPSIS and GRA have desirable procedures in this kind of decision problems. Other MCDM methods such as VIKOR, ELECTRE and PROMETHEE and subjective/ objective weighting methods are applicable for future applications. For example, subjective methods like AHP or Delphi method and objective weighting like Entropy or CRITIC methods can be used for future studies. Because of the reason for no studies found in literature about tire selection or consumer buy ingrocess with MCDM, this study keeps its own originality. Finally, in future studies, out of ADAC test results, expert judgment phase will be initiated for criterion weighting process with ANP, AHP or fuzzy environment.

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Genişletilmiş Özet

2015 yılında Dünya lastik sektörü %1 artarak 1.7 milyar adede yükselmiştir. Motorlu taşıt lastik piyasası, toplam lastik talebinin en büyük kısmını oluşturmaktadır ve 2019'da toplam talebin üçte ikisini oluşturacaktır. Dünya Lastik Piyasası'ndaki lider oyuncular Bridgestone Corp., Grup Michelin, Goodyear Lastik ve Kauçuk Co. ve Continental A.G.'dir.

Otomobiller çağımızın en önemli ulaşım araçlarından biridir. Bugün, milyonlarca insan hergün saatlerce arabalarını kullanmaktadır. Lastikler ise bu otomobillerin en önemli parçalarından biridir. Belirli süre kullanım ömrü olan ve zamanı geldiğinde değiştirilmesi gereken lastiklerin bunun dışında çeşitli kazalar ve değişen iklim şartları nedeniyle de değiştirmeleri gerekebilir. Otomobillerde doğru lastiklerin seçilmesi hem ticari hem de özel araçlar için çok önemli bir karardır. Trafik güvenliğini sağlamak ve meydana gelebilecek kazaları önlemek için, ulusal ve uluslararası düzeyde yasal düzenlemeler yapılmakta ve tüketiciler bilgilendirilmektedir. Günümüzde tıpkı işletmelerin satın alma kararlarında fiyatın ötesinde bütün maliyet unsurlarını dikkate almaları (Orhan, Öndeş & Yazarkan; 2012) gibi tüketiciler de, kuru-ıslak yol performansı, ses, yakıt tüketimi, vb. gibi yeni lastik seçiminde birçok faktörü düşünmektedirler. Lastik seçim kriterlerinin çok olması nedeniyle, bu problem bir Çok Kriterli Karar Verme (ÇKKV) problemidir.

ADAC (Allgemeiner Deutscher Automobil-Club e.V.) (Genel Alman Otomobil Kulübü), 24 Mayıs 1903'te Alman Motorbiker Birliği ("Deutsche Motorradfahrer-Vereinigung") olarak kurulan ve 1911 'de bugünkü adını alan, Almanya'da bulunan bir otomobil kulübüdür. ADAC şu anda 19 milyondan fazla üyesi ile Avrupa'nın en büyük, dünyanın ise ikinci büyük otomobil kulübüdür.Bu çalışmada, ADAC test verileri, lastik seçimi konusundaki ÇKKV problemini çözmek için kullanılacaktır. Analizler, yaz lastiklerini değerlendiren temel seçim kriterlerine dayanmaktadır. Yaz lastikleri için seçim kriterleri: kuru yol, ıslak zemin, gürültü, yakıt tüketimi, lastik aşınması şeklindedir. ADAC tarafından test edilen 16 yaz lastiğinin seçimi, esas olarak bir çok kriterli bir karar verme problemidir. Çalışmada ağırlıklı olarak sıralama / derecelendirme problemlerinin çözümünde kullanılan GRA (Gri İlişkisel Analiz) ve TOPSIS yöntemleri kullanılmıştır.

ÇKKV yöntemlerinin iki temel biçimi vardır. Bunlardan biri telafi edici, diğeri telafi edici olmayandır. Telafi edici olmayan ÇKKV yöntemleri kriterler arasındaki dengeyi sağlayamaz. Başka bir deyişle, bir kriterde istenmeyen bir değer arzu edilen kriterler tarafından tolere edilemez. Her bir kriter ayrı ayrı değerlendirilmelidir. Baskınlık yöntemi, Maxmin, Maxmax, Konjonktif yöntem gibi ÇKKV yöntemleri, basitliği ile bilinmektedir.Telafi edici yöntemler, karar kriterleri arasındaki dengeyi sağlayabilir. Bir ölçütte ufak bir azalma, karar kriterlerinde istenen değere sahip herhangi bir kriterle telafi edilebilir. SAW, AHP, TOPSIS, GRA, Doğrusal atama yöntemleri telafi edici yöntemlerdendir. Bu çalışmada, telafi edici yöntemlerden TOPSIS ve GRA yöntemleri kullanılmıştır.

TOPSIS yöntemi, Hwang ve Yoon (1981) referanslarıyla birlikte (Opricovic & Tzeng) 2004'te sunulmuştur. TOPSIS yöntemi, en iyi alternatifin, ideal çözeltinin (PIS) pozitif olanından en yakın uzaklığa ve negatif ideal çözeltiden (NIS) en uzak mesafeye sahip olması gerektiği üzerine kurulmuştur. PIS, faydayı en üst düzeye çıkaran ve ayrıca toplam maliyeti en aza indiren çözümdür. Buna karşılık, NIS faydayı en aza indirgeyen ve toplam maliyeti en üst düzeye çıkaran çözümdür (Yousefi & Vencheh; 2010).

GRA (Gri İlişki Analizi) yöntemi ilk olarak Deng tarafından geliştirilmiş ve ÇKKV sorunlarının üstesinden gelmek için yaygın olarak kullanılmıştır. Birden fazla kriter ortamında çeşitli ilişkileri analiz etmek için popüler ÇKKV yöntemlerinden biridir. GRA'nın temel amacı faktörler ve alternatifler arasında birincil ilişkiler elde etmektir (Fu; 2001). İlişki derecesine dayalı olarak iki sekans arasındaki benzerlik derecesini veya farklılık derecesini ölçen bir etki değerlendirme modelidir (Chan, 2007).

Bu karar probleminde 2016 yılı için 16 yaz lastiği (185/65 / R15 H) ve beş karar kriteri belirlenmiştir. Başlangıç verileri ADAC (General German Automobile Club) tarafından sağlanmıştır. Bu çalışmada beş karar kriteri belirlenmiştir (ADAC, 2016):

• Kuru Yol: Lastiğin kritik sınırın altındaki genel sürüş davranışı, örneğin düz çizgi kararlılığı, direksiyon yanıtı, virajlı sürüş güvenliği ve ABS frenlemeyle yavaşlama.

• Islak Yol: Islak asfalt ve beton kaplamalarda ABS frenleme ile 80 km/s'den 20 km/s'e yavaşlama uzunluğu.

• Ses: Asfaltta 80 km/s ile 30 km/s arasındaki bir arazide iki kişi tarafından iç gürültünün öznel değerlendirilmesi.

• Yakıt Tüketimi: Aynı araçta 2 km'lik bir mesafe için 100 km/saat, her lastik modeli için beş test sürerek iki kez ölçüm. Yakıt tüketimi 100 km başına litre.

• Lastik malzemesi: 15.000 km yol boyunca bir lastiğin farklı konvoylarla ve sürücülerle test edilmesi.

ADAC her lastiği, 1.5 ile 5.5 arasında değişen beş farklı ölçekte derecelendirmektedir. TOPSİS ve GRA yöntemleri ile analizler sonunda, alternatif lastiklerin puanları ve sıralaması incelendiğinde; TOPSIS'in ilk üçünde Vredestein Sportrac 5, Goodyear EGP ve Hankook Kinergy Eco K425 bulunmaktadır. GRA yönteminin ilk üçünde Michelin Enerji Tasarrufu +, Vredestein Sportrac 5 ve Continental CPC5 markaları gelmektedir. TOPSIS ve GRA sıralaması arasındaki sıra korelasyonu yaklaşık 0,8'dir ki bu da sıralamaların birbirine yakınlık gösterdiği anlamına gelmektedir. ADAC sıralamasında ilk üç sırayı Vredestein Sportrac 5, Continental CPC5 ve Dunlop Sport BluResponse oluşturmaktadır. TOPSIS ve ADAC sonuçları arasında 0,953 civarında bir pozitif korelasyon vardır; burada GRA ve ADAC arasındaki korelasyon 0,765'tir. Bu bağlamda, TOPSIS sıralama sonuçları GRA sıralama sonuçlarına göre daha gerçekçidir. Dolayısıyla, bu ÇKKV yöntemlerinden TOPSIS ve GRA benzer sonuçlar vermiştir. ADAC sonuçları TOPSIS ve GRA ile uyumludur.

Sonuç olarak, lastik seçimi probleminde, TOPSIS ve GRA yöntemleri, gerçek dünya ile yakın sonuçlar vermiştir. TOPSIS ve GRA, bu tür karar problemlerinde arzu edilen prosedürlere sahiptir. VIKOR, ELECTRE ve PROMETHEE gibi diğer ÇKKV yöntemleri ve öznel/objektif ağırlıklandırma yöntemleri gelecekteki diğer analizler için de kullanılabilir.