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AHP and GRA-Based Decision Support Model for Classified Ad Websites: A Case Study on Vehicle Selection

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Abstract: This study proposes an application for scoring and ranking vehicles selected from classified ads based on criteria defined by decision-makers. The approach aims to reduce the time wasted in commonly encountered decision-making situations. The criteria weights were determined using the Analytic Hierarchy Process based on relative comparison data separately defined by two decision-makers. The degree and ranking data for the alternatives were obtained through Grey Relational Analysis. For Decision Maker A, the highest-ranking vehicle was a hybrid car with a C-segment, sedan body type, automatic transmission, and a 1.8-liter engine capacity, scoring 91%. For Decision Maker B, the result was a D-segment vehicle with a sedan body type, automatic transmission, and a 1.5-liter engine capacity, ranking first with 85%. In situations where the comparison matrix could not be completed due to time constraints, an analysis based on the assumption of equal weights indicated that the hybrid car with a C-segment, sedan body type, automatic transmission, and a 1.8-liter engine capacity ranked first with a Grey Relational Degree of 81%.

Keywords: Multi-criteria decision making, analytic hierarchy process, grey relational analysis, classified ad websites, vehicle selection.

İlan Sitelerine Yönelik AHP ve GİA Temelli Karar Destek Modeli: Araç Seçimi Problemi Uygulaması

Öz: Bu çalışmada, karar vericiler tarafından tanımlanan kriterlere dayalı olarak ilan sitelerinden seçilen araçların puanlandırılması ve sıralanmasına yönelik bir uygulama önerilmiştir. Bu yaklaşım, sıkça karşılaşılan karar verme durumlarında kaybedilen zamanı azaltmayı amaçlamaktadır. Kriter ağırlıkları, iki karar vericinin ayrı ayrı tanımladığı rölatif karşılaştırma verileri kullanılarak Analitik Hiyerarşi Prosesi ile belirlenmiştir. Alternatiflere ait derece ve sıralama verileri Gri İlişki Analizi kullanılarak elde edilmiştir. Karar verici A'nın kullanım profili, beklenti ve ihtiyaçları doğrultusunda ilk sırayı %91'lik bir puanla C segment, sedan, otomatik şanzıman, 1,8 litre motor hacmine sahip hibrid araç almıştır. Karar verici B için ise sonuç, sedan gövde tipine, otomatik şanzımana ve 1,5 litre motor hacmine sahip D-segment araç olup, %85'lik bir puanla birinci sırada yer almıştır. Karar vericilerin zaman kısıtından dolayı karşılaştırma matrisinin tamamlanamadığı durumlarda, eşit ağırlıklar varsayımına dayalı yapılan analizlerde, yine C segment, sedan, otomatik, 1,8 litre motor hacmine sahip hibrid araç %81'lik bir Gri İlişki Derecesi ile birinci sırada yer almıştır.

Anahtar kelimeler: Çok kriterli karar verme, analitik hiyerarşi prosesi, gri ilişkisel analiz, ilan siteleri, araç seçimi.

1. Introduction

In today's world, where online shopping methods have become an essential part of our lives, customers conduct extensive research to obtain the best product at the most suitable cost. As it becomes increasingly difficult to choose among hundreds of brands and models, e-commerce websites have developed various filtering, sorting, and comparison algorithms to assist users in the decision-making process. While selecting from only a few criteria and alternatives can be easily achieved with the help of these applications, situations involving dozens of alternatives and criteria transform the decision-making process into a complex problem that goes beyond human cognitive abilities. This decision problem can be simplified by grounding it on a scientific basis through Multi-Criteria Decision Making (MCDM) techniques.

In today's world, with technological advancements, consumers' shopping habits have undergone a profound transformation. In particular, large-scale purchases, such as housing or vehicles, are often made online. In this context, listing websites play a crucial role in such acquisitions, emerging as significant shopping platforms for consumers.

This study develops a comprehensive decision support model based on the Analytic Hierarchy Process (AHP) and Grey Relational Analysis (GRA) methods to solve the vehicle selection problem on listing websites. Although listing sites generally serve to rank, compare, and list vehicles within specific criteria ranges, they do not provide

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the necessary importance or ranking information required for users to make their final decisions. This model is designed to help users overcome these challenges when purchasing a vehicle and to assist them in selecting the most suitable option based on their personal preferences and expectations.

The decision-making process is multi-staged and complex. The process involves the evaluation of information obtained from analyses based on alternatives and the criteria necessary for selecting among these alternatives. To effectively manage this structure, it is modeled and analyzed, and relevant data are evaluated using MCDM techniques [1].

The emergence of MCDM applications is driven by the fact that as the number of criteria increases, the task of selecting among alternatives goes beyond human cognitive capabilities. In this study, rating and ranking applications for selecting e-commerce products can be used to assist consumers in choosing products from these platforms and to minimize the time spent in the selection process.

In recent years, there have been numerous studies in the literature where AHP and GRA methods have been used integratively in various fields. Pophali et al. [2] integrated AHP and GRA methods for the optimal selection of tannery wastewater treatment plants. This approach, based on real data and considering economic, technical, and administrative factors, provides significant advantages in identifying areas for further improvement within the existing treatment options. Gülçiçek Tolun and Tümtürk [3] aimed to manage a complex decision-making process for agricultural machinery manufacturing companies by selecting the most suitable machine from various alternatives with differing criteria such as cost, speed, quality, and after-sales service, using AHP. Additionally, the selection of the most appropriate machine from the alternatives identified using the GRA method was supported by considering the diversity of managerial priorities. In a study by Samvedi et al. [4], the integrated use of AHP and GRA methods for selecting the most suitable machine tool for a manufacturing facility was examined. In the study, the priorities of criteria such as cost, flexibility, efficiency, and safety were determined using AHP, and the GRA method was then applied to select the most suitable machine tool. Tayyar et al. [5] aimed to evaluate the financial performance of companies operating in the technology and IT sectors listed on the Istanbul Stock Exchange. In this study, AHP and GRA methods were used to compare the financial performance of companies based on financial criteria such as profitability, and the most successful company in the sector was determined. Wang et al. [6] developed a mathematical model using GRA and AHP theories for optimizing the necessary machinery systems to convert biomass resources, such as straw, into biomass briquette fuel. The optimal approach for selecting a biomass briquette fuel system schema aims to meet multiple objectives, including cleanliness, economy, environmental protection, product quality, production capacity, and production stability. There are also studies in the literature related to vehicle selection and the application of various decision-making techniques. Ballı et al. [7] evaluated seven selected vehicles based on criteria such as price, fuel consumption, performance, and safety. They demonstrated that the PROMETHEE method, which processes linguistic values through fuzzy logic, provides a more flexible evaluation, thereby simplifying the resolution of complex problems. Yavaş et al. [8] scaled a set of primary criteria and twenty sub-criteria using AHP and the Analytic Network Process (ANP) methods. The analysis results prioritized criteria such as interior design, safety equipment, and engine capacity, and ranked alternative car brands, showing that these methods could positively impact customer satisfaction and sales volume. In a study by Ghadikolaei and Esbouei [9], a hybrid approach incorporating accounting and economic value measures was proposed to assess the financial performance of automotive companies listed on the Tehran Stock Exchange. Using fuzzy AHP (FAHP), criteria weights were determined, and companies were ranked using grey-VIKOR, ARAS-F, and grey-COPRAS methods. It was found that economic value measures were more important than accounting measures. Gnanasekaran et al. [10] proposed two models for selecting the best car among five alternatives based on criteria such as safety, performance, economy, exterior design, comfort, dealership services, warranty, and emissions. In the first model, FAHP was integrated with the PROMETHEE technique, and in the second model, FAHP was integrated with the hierarchical GRA technique. In both models, FAHP was used to analyze the structure of the car selection problem and determine the weights of criteria, while hierarchical GRA and PROMETHEE techniques were employed to obtain the final ranking of the cars.

1.1. Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is an approach developed by Thomas L. Saaty in the first half of the 1970s. The method allows for the hierarchical organization of criteria, the evaluation of their weights, and, in this context, the ranking or comparison of alternatives [11].

AHP utilizes expert opinions to conduct pairwise comparisons. This process simplifies decision-making by eliminating complexity and making the selection process more straightforward [12].

AHP is commonly used in various fields, such as planning processes, resource allocation, and conflict management, to select the best alternative among several [13]. In decision-making processes where objective data is insufficient, AHP is frequently applied. This method incorporates subjective data, such as the decision maker's personal opinions, along with objective data in the decision process [14].

This study aims to determine the criteria weights using AHP. After identifying the criteria that will form the basis for selecting alternatives, a pairwise comparison matrix is constructed. The purpose of pairwise comparisons among criteria is to convert non-numerical expressions into a numerical scale. In Table 1, all criteria are evaluated relatively using the comparison scale defined by Saaty [15].

Table 1. AHP comparison scale.

Importance Degree	Definition	Explanation
1	Equal Importance	Two criteria contribute equally to the goal
3	Moderately Important	The decision-maker slightly prioritizes one element over the other.
5	Significantly Important	The decision-maker strongly prefers one element over the other.
7	Highly Important	One criterion is very strongly preferred over the other — in a practically demonstrable way.
9	Critically Important	One criterion is superior to the other in a highly verifiable manner, supported by strong evidence.
2,4,6,8	Transition Values	Can be used to express intermediate values.

As a result of the relative evaluations, the comparison matrix A_{nxn} given in Equation 1 is obtained. Here, n represents the number of criteria.

$$A = [A_{ij}] = \begin{bmatrix} 1 & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & 1 & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & 1 & \dots & a_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & a_{n3} & \dots & 1 \end{bmatrix} \quad (1)$$

Equation 2 normalizes the comparison matrix by dividing each column element by its total. The sum of each column in the normalized matrix must be equal to 1.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (2)$$

The average of the row elements of the normalized matrix is calculated by using Equation 3. The obtained w_i values represent the criteria weights. The eigenvalue calculation used in the consistency ratio calculation is provided in Equation 4.

$$w_i = \frac{\sum_{j=1}^{n} b_{ij}}{n} \quad (3)$$

$$\lambda = \frac{\sum_{i=1}^{n} \frac{a_{ij} w_i}{w_i}}{n} \quad (4)$$

In Equation 5, CR represents the consistency ratio, which is a random index that changes based on the size of the comparison matrix (the value of n). The RI values, created by Saaty [16], are provided in Table 2.

$$CR = \frac{\lambda - n}{RI(n-1)} \quad (5)$$

Table 2. Random index table.

N	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

1.2. Grey Relational Analysis (GRA)

The method we now use as GRA is based on the concept of "grey theory", which was introduced by Julong D. in 1982 [17]. Grey theory offers advantages in solving problems involving limited data and uncertainty, without requiring a statistical distribution.

GRA is a quantitative analysis that shows the similarity and difference between the reference series and the alternative series. The alternative series that shows the closest similarity to the reference series is the best alternative for the given problem.

GRA is more efficient than deterministic methods when analyzing decision-making problems under uncertainty. If the data is sufficient, it allows the use of statistical analyses such as clustering analysis and regression analysis. Additionally, multi-criteria decision-making (MCDM) methods such as AHP, ANP, Data Envelopment Analysis (DEA), TOPSIS, and ELECTRE can also be used [18].

The term "grey" in the method refers to the lack of information within the system. The state of complete information is represented by the color 'white,' while complete lack of information is represented by the color "black". The goal of grey theory is to grey the black data within the system.

The application of the GRA method begins with an mxn decision matrix consisting of m alternatives and n criteria, as shown in Equation 6.

$$X = \begin{bmatrix} x_1(1) & x_1(2) & \cdots & x_1(m) \\ x_2(1) & x_2(2) & \cdots & x_2(m) \\ \vdots & \vdots & \vdots & \vdots \\ x_n(1) & x_n(2) & \cdots & x_n(m) \end{bmatrix} \quad \text{i=1,2,…,n ve j=1,2,…,m} \tag{6}$$

The reference series is derived from the column values of the matrix in Equation 1, based on benefit, cost, or optimal criteria. For example, if the vehicle price is to be minimized, the lowest price of the alternatives is added to the series as the reference value.

In the normalization of the decision matrix, if the data set is in the benefit case, Equation 7 is used, and if it is in the cost case, Equation 8 is used.

$$x'_i(j) = \frac{x_i(j) - min_{i=1}^{n} x_i(j)}{max_{i=1}^{n} x_i(j) - min_{i=1}^{n} x_i(j)} \tag{7}$$

$$x'_i(j) = \frac{max_{i=1}^{n} x_i(j) - x_i(j)}{max_{i=1}^{n} x_i(j) - min_{i=1}^{n} x_i(j)} \tag{8}$$

As a result of normalization, a standardized decision matrix is obtained. The largest values of the columns of the decision matrix constitute the reference series specified in Equation 9. The highest value of the jth criterion among the normalized values is represented by $x'_0(j)$.

$$x'_0 = x'_0(1), x'_0(2), \dots, x'_0(m) \quad \text{i=1,2,…,n ve j=1,2,…,m} \tag{9}$$

The absolute value matrix is created by subtracting the reference series from the standardized decision matrix via Equation 10.

$$\Delta_{0i}(j) = |x'_0(j) - x'_i(j)| \quad \text{i=1,2,…,n ve j=1,2,…,m} \tag{10}$$

The grey relational coefficient is calculated for all values in the difference matrix. The calculation of the grey relational coefficient is shown in Equation 11. The grey relational coefficient is used to determine how close $x_i(j)$ is to $x_0(j)$. The larger the grey relational coefficient, the closer the $x_i(j)$ and $x_0(j)$ series are for criterion j.

$$\gamma_{0i}(j) = \frac{\Delta_{min} + \xi \Delta_{max}}{\Delta_{0i}(j) + \xi \Delta_{max}} \tag{11}$$

The "ξ" (distinguish) coefficient specified in Equation 11 takes values in the range of [0,1], and it is typically set to 0.5 in applications [19]. Δ_{max} and Δ_{min} are selected from all elements in the $\Delta_{0i}(j)$ matrix.

The determination of grey relational degrees can be calculated for cases where the criteria weights are either equal or different. Γ_{0i}, given in Equation 12, represents the grey relational degree of element i.

$$\Gamma_{0i} = \sum_{j=1}^{m} [\text{w(j)} \times \gamma_{oi}(j)] \; , \sum_{j=1}^{m} w(j) = 1 \tag{12}$$

2. Material and Methods

In this study, the AHP and GIA methods are used together to address the vehicle selection problem from online advertisement sites. Considering the necessity of taking personal preferences and expectations into account when purchasing a vehicle, it is believed that weighting the criteria will produce more realistic solutions [20].

Therefore, while the AHP method is used for weighting the criteria, the GIA method is applied for ranking the vehicle listings. For the application, 10 cars published on a widely used advertisement site in Turkey were evaluated based on 13 predefined criteria.

2.1. Determination of criteria

In this study, in addition to the site data, objective data that could influence vehicle selection were used when determining the criteria. The user profile, expectations, and needs are outlined below.

- High security features
- Large trunk space and living area
- High long-distance capability
- Automatic transmission for ease of use
- Fuel-efficient
- Advanced in terms of equipment features
- High performance on hills
- Suitable for generally calm driving
- Low repair, maintenance, and parts costs
- Suitable for use by a family of three

The user has selected ten vehicles from the list based on their own defined criteria, such as price, model, and mileage range. In this way, subjective evaluations such as vehicle design, color, and body type have been left to the individual's personal judgments, while the analysis is primarily based on numerical or quantifiable data. Table 3 presents the site data for the selected alternatives.

Table 3. General information about the alternatives, listing site data.

VEHICLE ID	BODY TYPE	SEGMENT	MODEL YEAR	ENGINE DISPLACEMENT	ENGINE POWER	FUEL TYPE	FUEL CONSUMPTION	TRANSMISSION TYPE	COLOR	MILEAGE	PRICE	ACCELERATION (0-100 km)	MAXIMUM SPEED
A1	SEDAN	C	2017	1.6	125	PETROL	6.7	AUTOMATIC	GREY	122000	800000	11.6	196
A2	HATCHBACK	B	2017	1.4	90	DIESEL	3.5	AUTOMATIC	WHITE	129000	725000	10.9	184
A3	SEDAN	C	2019	1.8	122	HYBRID	3.5	AUTOMATIC	GREY	110600	841000	11.0	180
A4	SUV	B	2020	1.0	115	PETROL	5.2	AUTOMATIC	BLUE	134000	935000	11.8	180
A5	SUV	H	2019	1.6	120	DIESEL	5.0	AUTOMATIC	BLACK	105000	965000	10.2	178
A6	HATCHBACK	C	2017	1.6	116	DIESEL	3.9	AUTOMATIC	WHITE	110000	900000	10.4	202
A7	SEDAN	D	2018	1.5	152	PETROL	5.8	AUTOMATIC	BLACK	108000	1100000	8.60	210
A8	SUV	B	2018	1.4	100	PETROL	6.9	AUTOMATIC	WHITE	77452	840000	13.7	176
A9	SEDAN	C	2018	1.5	120	PETROL	5.0	MANUAL	RED	93000	850000	10.1	195
A10	HATCHBACK	B	2017	1.4	100	PETROL	6.2	AUTOMATIC	WHITE	122250	725000	12.9	170

The following assumptions and quantifications were made when determining the criteria to be included in the decision matrix:

- **Body type and vehicle color criteria:** These criteria are based on individual preferences and are assumed to have no impact on the analysis outcome. Therefore, they are excluded." avoids redundancy.
- **Model year:** Model year values were converted into vehicle age relative to 2024.
- **Fuel consumption:** The fuel consumption criterion, in Turkish Lira (TL), was included in the analysis based on the ceiling prices of the top 8 companies with the highest transaction volume for the period of June 2024, published on the EPDK [21] website.
- **Transmission type:** According to the May bulletin from ODMD [22], automatic transmission vehicles account for 89.6% of total sales, while manual transmission vehicles account for 10.4%. Based on user preferences outlined in the article, the transmission type criterion was weighted as 9 for automatic and 1 for manual transmissions.

- **Engine capacity:** It was directly included in the numerical analysis based on the assumption that engine capacity affects the vehicle's long-distance capability.
- **Engine power:** Given the environmental factors where the vehicle will be used, the engine power criterion, which affects climbing ability, was directly included in the analysis.
- **Acceleration and top speed values:** Due to customer expectations for generally calm usage, the 0-100 km/h acceleration time and maximum speed values were excluded from the analysis.
- **Vehicle safety:** The vehicle safety criterion was included in the analysis based on the Euro NCAP [23] test results, which provide a final rating between 1 and 5 for the model year.
- **Mileage, price, and trunk capacity:** These numerical values were directly included in the analysis.
- **Segment values (B, C, D, and H):** Since the B, C, D, and H segment values are part of a classification system used in the automotive industry to categorize vehicles based on certain features and usage purposes, a suitability scoring scale, as shown in Table 4, was created for their quantification.

Table 4. Suitability scores according to vehicle segments.

Segment	Interior Space	Trunk Space	Comfort	Safety	Fuel Economy	Average Suitability Score
B	5	4	6	7	8	6.0
C	7	7	7	8	7	7.2
D	8	8	9	9	6	8.0
H	9	9	9	9	5	8.2

- **Repair-maintenance costs:** Ten-year total repair-maintenance cost values, published by Consumer Reports [24] in April 2024, were included in the analysis in relation to the user's expectations regarding repair-maintenance and parts costs. The analysis incorporated breakdown rates per 100 vehicles, derived from the 2024 J.D. Power Vehicle Dependability Study [25].
- **Equipment features:** The equipment features criterion varies in terms of brand and model, so it was possible to quantify the selected alternatives based on their level of meeting the technical specifications provided on the site. Each alternative was assigned a numerical value based on the number of equipment features it satisfies, as listed in Table 5.

Table 5. Equipment features matrix of the alternatives.

ABS braking system	Tire pressure monitoring System	Fatigue detection system	Heated front seats	Steering wheel audio controls	LED rear stop lights
Electronic stability control system	Rearview camera	Parking sensors (rear or front/rear)	Electric windows (front and rear)	360-degree bird's-eye view camera	Alloy wheels
Multiple airbags	Lane-keeping assist	Automatic emergency braking system	Electrically foldable side mirrors	Keyless entry and start	Start-stop system
Traction control System	Adaptive cruise control	Parking assistant	Touchscreen multimedia system	Automatic headlights	Panoramic sunroof
Electronic brakeforce distribution	Traffic sign recognition system	Automatic climate control	Bluetooth connection	Rain-sensing wipers	Traction control system
Hill-start assist	Blind spot warning system	Leather steering wheel and gear shift	USB and AUX ports	LED daytime running lights	Eco-driving assistance system

As a result of the assumptions and quantifications explained above, the criteria and data for the alternatives determined are presented in Table 6. The abbreviations for the criteria are as follows: K1: Segment, K2: Vehicle Age, K3: Engine Volume, K4: Engine Power, K5: Fuel Consumption, K6: Ncap Test Result, K7: Transmission Type, K8: Trunk Capasity, K9: Vehicle Mileage, K10: Price, K11: Number of Breakdowns, K12: Repair Cost, K13: Features. Table 6 presents the initial data set consisting of given alternatives and criteria values.

Table 6. Initial data set consisting of alternatives and criteria values.

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13
A1	7.2	7	1.6	125	274.05	4	9	440	122000	800000	206	5835	26
A2	6.0	7	1.4	90	142.34	5	9	280	129000	725000	267	6530	25
A3	7.2	5	1.8	122	143.16	5	9	471	110600	841000	147	4900	27
A4	6.0	4	1.0	115	212.69	5	9	422	134000	935000	199	5700	28
A5	8.2	5	1.6	120	203.35	3	9	351	105000	965000	190	6400	26
A6	7.2	7	1.6	116	158.61	5	9	380	110000	900000	275	9890	26
A7	8.0	6	1.5	152	237.24	5	9	380	108000	1100000	245	9285	29
A8	6.0	6	1.4	100	282.23	3	9	352	77452	840000	187	5850	26
A9	7.2	6	1.5	120	204.51	5	1	419	93000	850000	185	5800	25
A10	6.0	7	1.4	100	253.60	4	9	301	122250	725000	198	5640	9

2.2. Determining criterion weights using AHP

In this study, the AHP method has been applied to determine the weights of the criteria. Evaluating only the upper diagonal matrix requires 78 comparisons. Assuming that the decision maker has sufficient time, it is possible for them to evaluate each criterion relatively using a 78 question survey.

Table 7. Criteria expectations of decision-makers for vehicles and their relative importance levels.

Decision Maker A			Decision Maker B		
HIGH EXPECTATION LEVEL (9)	**MEDIUM EXPECTATION LEVEL (3)**	**LOW EXPECTATION LEVEL (1)**	**HIGH EXPECTATION LEVEL (9)**	**MEDIUM EXPECTATION LEVEL (3)**	**LOW EXPECTATION LEVEL (1)**
Trunk Capasity	Low Mileage	Package Completeness	Safety	Breakdown Rate	Trunk Capasity
Fuel Consumption	Automatic Transmission	Performance	Automatic Trasnsmission	Repair Cost	Fuel Consumption
Engine Volume	Segment			Package Completeness	Engine Volume
Safety	Investment Cost			Segment	Low Mileage
Breakdown Rate	Vehicle Age			Vehicle Age	Performance
Repair Cost					Investment Cost

Ensuring the decision support model is both realistic and applicable to practical scenarios involved tasking two decision-makers with categorizing the criteria into three main groups. Table 7 illustrates the grouping of customer expectations and the corresponding importance levels assigned to these groups. For decision-maker A, pairwise comparisons reveal, for example, that luggage volume is three times more important than the vehicle segment, while vehicle age is considered only one-third as important as fuel consumption.

Table 8. Pairwise comparison matrix.

	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**	**K11**	**K12**	**K13**
	SEGMENT	**VEHICLE AGE**	**ENGINE VOLUME**	**ENGINE POWER**	**FUEL CONSUMPTION**	**NCAP TEST RESULT**	**TRANSMISSION TYPE**	**TRUNK CAPASITY**	**VEHICLE MILEAGE**	**PRICE**	**NUMBER OF BREAKDOWNS**	**REPAIR COST**	**FEATURES**
K1	1.00	1.00	0.33	3.00	0.33	0.33	1.00	0.33	1.00	1.00	0.33	0.33	3.00
K2	1.00	1.00	0.33	3.00	0.33	0.33	1.00	0.33	1.00	1.00	0.33	0.33	3.00
K3	3.00	3.00	1.00	9.00	1.00	1.00	3.00	1.00	3.00	3.00	1.00	1.00	9.00
K4	0.30	0.33	0.11	1.00	0.11	0.11	0.33	0.11	0.33	0.33	0.11	0.11	1.00
K5	3.00	3.00	1.00	9.00	1.00	1.00	3.00	1.00	3.00	3.00	1.00	1.00	9.00
K6	3.00	3.00	1.00	9.00	1.00	1.00	3.00	1.00	3.00	3.00	1.00	1.00	9.00
K7	1.00	1.00	0.33	3.00	0.33	0.33	1.00	0.33	1.00	1.00	0.33	0.33	3.00
K8	3.00	3.00	1.00	9.00	1.00	1.00	3.00	1.00	3.00	3.00	1.00	1.00	9.00
K9	1.00	1.00	0.33	3.00	0.33	0.33	1.00	0.33	1.00	1.00	0.33	0.33	3.00
K10	1.00	1.00	0.33	3.00	0.33	0.33	1.00	0.33	1.00	1.00	1.00	1.00	3.00
K11	3.00	3.00	1.00	9.00	1.00	1.00	3.00	1.00	3.00	1.00	1.00	0.33	9.00
K12	3.00	3.00	1.00	9.00	1.00	1.00	3.00	1.00	3.00	1.00	3.00	1.00	1.00
K13	0.30	0.33	0.11	1.00	0.11	0.11	0.33	0.11	0.33	0.33	0.11	1.00	1.00
Toplam	**23.67**	**23.67**	**7.89**	**71.00**	**7.89**	**7.89**	**23.67**	**7.89**	**23.67**	**19.67**	**10.56**	**8.78**	**63.00**

Since the criteria of luggage volume and fuel consumption belong to the same expectation level group and have equal relative importance, their comparison coefficient is assigned a value of 1. Additionally, Table 7 includes the relative evaluation of the criteria defined by decision-maker B. The analyses presented in the subsequent sections of this study focus on decision-maker A. However, the same methodology can be applied to derive results for decision-maker B.

It should be noted that in cases where there is no time constraint for the decision maker, they may be required to fill in the pairwise comparison matrix provided in Table 8 based on the comparison scale data in Table 1. In this study, the analysis will proceed with the importance degree coefficients (9-3-1) assigned to the expectation levels divided into three groups. Based on the data obtained from the decision maker, the pairwise comparison matrix provided in Table 8 has been created.

The created pairwise comparison table was normalized with the formulas given in Equations 2 and 3. The criterion weights (w) were found and shown in Table 9. Eigenvalues for the consistency ratio calculation were calculated with Equation 4. The consistency ratio was calculated using Equation 5 with the weights obtained from the normalized matrix.

Tablo 9. Normalized matrix and criteria weights (w_i).

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	w	AW	AW/W
K1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.04	0.05	**0.04**	0.58	13.68
K2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.04	0.05	**0.04**	0.58	13.68
K3	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.15	0.09	0.11	0.14	**0.13**	1.73	13.68
K4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	**0.01**	0.19	13.68
K5	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.15	0.09	0.11	0.14	**0.13**	1.73	13.68
K6	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.15	0.09	0.11	0.14	**0.13**	1.73	13.68
K7	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.04	0.05	**0.04**	0.58	13.68
K8	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.15	0.09	0.11	0.14	**0.13**	1.73	13.68
K9	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.04	0.05	**0.04**	0.58	13.68
K10	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.09	0.11	0.05	**0.05**	0.73	13.89
K11	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.05	0.09	0.04	0.14	**0.11**	1.54	13.67
K12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.05	0.28	0.11	0.02	**0.12**	1.68	13.57
K13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.11	0.02	**0.02**	0.30	13.83

As a result of the calculations, $\lambda = 13.69$; CI = 0.058 has been found, and RI for 13 criteria has been selected as 1.56 from Table 1. Since the consistency ratio CR = 0.0371 <0.1, it has been determined that the criteria weights are consistent.

2.3. Alternative Selection with GRA

The problem, for which the criteria weights have been determined using the AHP method, will be resolved through GRA. The dataset, comprising the criteria and alternatives presented in Table 6, serves as the initial matrix for the analysis. The identified criteria are listed in Table 10, where they are categorized according to their nature as either maximization or minimization criteria, depending on whether they represent benefits or costs.

The reference series has been determined by selecting the maximum values for benefit criteria (e.g., a higher NCAP score is preferred) and the minimum values for cost criteria (e.g., a lower vehicle price is preferred).

Table 10. Dataset and reference series.

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13
	MAK	**MİN**	**MAK**	**MAK**	**MİN**	**MAK**	**MAK**	**MAK**	**MİN**	**MİN**	**MİN**	**MİN**	**MAK**
RS	**8.2**	**4**	**1.8**	**152**	142.34	**5**	**9**	**471**	**77452**	**725000**	**147**	**4900**	**29**
A1	7.2	7	1.6	125	274.05	4	9	440	122000	800000	206	5835	26
A2	6.0	7	1.4	90	142.34	5	9	280	129000	725000	267	6530	25
A3	7.2	5	1.8	122	143.16	5	9	471	110600	841000	147	4900	27
A4	6.0	4	1	115	212.69	5	9	422	134000	935000	199	5700	28
A5	8.2	5	1.6	120	203.35	3	9	351	105000	965000	190	6400	26
A6	7.2	7	1.6	116	158.61	5	9	380	110000	900000	275	9890	26
A7	8.0	6	1.5	152	237.24	5	9	380	108000	1100000	245	9285	29
A8	6.0	6	1.4	100	282.23	3	9	352	77452	840000	187	5850	26
A9	7.2	6	1.5	120	204.51	5	1	419	93000	850000	185	5800	25
A10	6.0	7	1.4	100	253.60	4	9	301	122250	725000	198	5640	9

The normalization method based on the ratio was used for benefit criteria according to Equation 7 and for cost criteria according to Equation 8.

By obtaining the data from the normalization matrix, the differences between the values and the reference series were calculated, and the coefficient differences were determined. From the absolute value matrix data, $\Delta_{max} = 1$ and $\Delta_{min} = 0$ were found. The distinguishing coefficient ζ was selected as 0.5. The Grey Relational Grade, indicating the closeness of the alternatives to the reference series, was calculated using Equation 12.

The Grey Relational Coefficients, computed with the weights obtained from AHP, were multiplied, and the weighted Grey Relational Coefficients for each alternative were summed up to obtain the Grey Relational Grade. Table 11 shows the Grey Relational Grades and the ranking based on these grades.

Table 11. Grey relational grades and alternative ranking for decision-maker A.

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	Γ_1	RANK$_1$
	0.04	**0.04**	**0.13**	**0.01**	**0.13**	**0.13**	**0.04**	**0.13**	**0.04**	**0.05**	**0.11**	**0.12**	**0.02**		
A1	0.52	0.33	0.67	0.53	0.35	0.50	1.00	0.75	0.39	0.71	0.52	0.73	0.77	**0.59**	**6**
A2	0.33	0.33	0.50	0.33	1.00	1.00	1.00	0.33	0.35	1.00	0.35	0.60	0.71	**0.63**	**4**
A3	0.52	0.60	1.00	0.51	0.99	1.00	1.00	1.00	0.46	0.62	1.00	1.00	0.83	**0.91**	**1**
A4	0.33	1.00	0.33	0.46	0.50	1.00	1.00	0.66	0.33	0.47	0.55	0.76	0.91	**0.63**	**3**
A5	1.00	0.60	0.67	0.49	0.53	0.33	1.00	0.44	0.51	0.44	0.60	0.62	0.77	**0.57**	**8**
A6	0.52	0.33	0.67	0.46	0.81	1.00	1.00	0.51	0.46	0.52	0.33	0.33	0.77	**0.61**	**5**
A7	0.85	0.43	0.57	1.00	0.42	1.00	1.00	0.51	0.48	0.33	0.40	0.36	1.00	**0.58**	**7**
A8	0.33	0.43	0.50	0.37	0.33	0.33	1.00	0.45	1.00	0.62	0.62	0.72	0.77	**0.53**	**9**
A9	0.52	0.43	0.57	0.49	0.53	1.00	0.33	0.65	0.65	0.60	0.63	0.73	0.71	**0.65**	**2**
A10	0.33	0.33	0.50	0.37	0.39	0.50	1.00	0.36	0.39	1.00	0.56	0.77	0.33	**0.53**	**10**

In cases where the comparison matrix cannot be created due to the decision-maker's time constraints, it is still possible to determine the ranking of alternatives using GRA. In such instances, it is assumed that the criteria weights are equal, and the Grey Relational Grades are calculated accordingly. Table 12 presents not only the ranking obtained with equal criteria weights but also the Grey Relational Grades and alternative rankings for Decision-Maker A and Decision-Maker B.

Table 12. Grey relational grades in all cases.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Γ_{equal}	0.6	0.6	**0.81**	**0.64**	0.62	0.59	**0.64**	0.58	0.6	0.53
RANK$_{eq}$	7	5	**1**	**3**	4	8	**2**	9	6	10
Γ_A	0.59	0.63	**0.91**	0.63	0.57	0.61	0.58	0.53	0.65	0.53
RANK$_A$	6	4	**1**	3	8	5	7	9	2	10
Γ_A	0.64	0.67	**0.77**	0.68	0.67	**0.70**	**0.85**	0.54	0.60	0.55
RANK$_B$	7	6	**2**	4	5	**3**	**1**	10	8	9

3. Conclusion

In this study, a decision support model for classified advertisement websites was examined. Using criteria based on the expectations of decision-makers, the vehicle selection problem was analyzed by evaluating 10 vehicles from a widely used classified ad website in Turkey through the AHP and GRA methods.

As a result of the analysis, for Decision-Maker A, who had expectations suitable for family use, a C-segment hybrid vehicle with a sedan body type, automatic transmission, and a 1.8 engine volume ranked first with a weight of 91%. In cases where the decision-maker faced time constraints and was unable to complete the comparison matrix, assuming equal weights for all criteria, the same alternative still ranked first with a score of 81%.

For Decision-Maker B, who determined criteria for a person new to driving, Alternative 7, a D-segment vehicle with a sedan body type, automatic transmission, and a 1.5 engine volume, ranked first with a score of 85%.

The decision support model developed for classified advertisement websites was evaluated as an innovative approach, as it can generate results solely based on the criteria data available within the website infrastructure, regardless of whether detailed or limited data is provided by the user.

This study presents a unique and adaptable methodology, offering a solution that can be applied to all online sales or classified advertisement websites, even in cases where very limited data is available.

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