Team 10
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Homework 3: Decision Making

Problem Statement: “I'm contemplating a new vehicle to compliment my bike now that my 1991 VW camper needs too much maintenance. I'm only willing to consider the new (2020 model year) all-electric vehicles. Using the AHP methodology, recommend one for me.”

Determining the Selection Criteria

It is specified that the professor is only willing to consider the new, 2020 all-electric vehicles. Then, the considered alternatives will only consider new, all-electric models in order to facilitate a more meaningful comparison and recommendation process. Because these factors are a requirement, they are included in the pre-filter process and the year of release, and whether or not the cars are fully electric will not be considered as weighted criteria. As further expounded below, the included criteria included in this decision-making process are the range, storage capacity, maintenance, safety, price, and acceleration.

Determining the Criteria Weightings

Range - It is assumed that if the professor is commuting by car, he is traveling a distance that is significantly larger than what is reasonable to travel by bicycle. Additionally, electrical vehicles typically offer a much lower range than the more familiar fossil fuel cars. Then, on average, the range is given the highest priority over the other criteria. The range is measured quantitatively in miles per fully charged battery.

Storage - Because the professor would like his new vehicle to compliment his bicycle, it is assumed that the vehicle should have sufficient storage space to lug his bicycle around. Then, storage is given overall moderately high importance compared to the other criterion and is measured in the total cargo capacity of the vehicle as measured in cubic feet.

Maintenance - The professor indicated that one of the motivating factors for considering buying a new vehicle was that his previous vehicle required too much maintenance. However, it is also assumed that any new vehicle will require much less maintenance than the 1991 Volkswagen camper that the professor previously owned. Then, these two considerations give maintenance moderate importance relative to the other criteria. Ease of maintenance is measured quantitatively by the powertrain warranty, which is ubiquitously given in years/mileage. Because the range is listed as our typically most important factor, the mileage is used as the final metric for maintenance in this comparison.

Safety - Safety features, and measures are taken to ensure the driver and passengers are safe on the road or in the event of a crash, this can range from safety belt design to automatic emergency brakes. We are assuming that the professor would pay for safety features proportionately, but less than the range, storage, and maintenance factors. Because the more standard National Highway Traffic Safety Administration ratings are sporadic for newer car models, the safety is instead measured by the braking distance it takes for the vehicle to completely stop from a speed of 70 miles per hour, in feet.

Price - Electrical vehicles are often pricier than their fossil fuel counterparts. However, the electric car industry is an emerging industry, and customers understand that there is an investment cost in order to support this growing industry. The professor presumably has a comfortable budget, which is why the importance of price is moderately low compared to the other considered criteria. The price is measured quantitatively by the starting price of the car in US dollars.

Acceleration - Typically, the demographic of people who are interested in electrical vehicles are not attracted to them for their speed. However, it might be of slight subconscious interest to our professor, so it will still be included here with generally the least importance. Acceleration is measured here is the time in seconds that it takes for the vehicle to accelerate from rest to 60 miles per hour.

Although the general justification of the importance for each criterion is given above, there may be instances in which there are inconsistencies for pairwise comparisons. The pair-wise comparison of the relative importance of each criterion is given below in Table (1), where a score of 1 indicates that the two compared criterion are equal, a score of 3 indicates that the criterion on the corresponding column is moderately more important, 7 indicates that the criterion is strongly more important, and a score of 9 means that the criterion is extremely more important than the corresponding column. A reciprocal score indicates less relative importance.

	Storage	Maintenance	Price	Range	Safety	Acceleration
Storage	1	1	7	1/5	3	9
Maintenance	1	1	5	1/7	1/3	7
Price	1/7	1/5	1	1/7	1	9
Range	5	7	7	1	3	9
Safety	1/3	3	1	1/3	1	9
Acceleration	1/9	1/7	1/9	1/9	1/9	1

Table (1): Pairwise comparison of relative importance for each criterion

	Mean*	Weight**
Storage	1.83	0.204
Maintenance	1.09	0.121
Price	0.55	0.062
Range	4.33	0.483
Safety	1.00	0.111
Acceleration	0.17	0.019

Table (2): Geometric Means and Weights of Each Criterion

Formulae used in Calculations

*Geometric Mean Calculation:

$$Geometric\ Mean\ = \sqrt[n]{\prod_{i=1}^{i=n} x_i}$$

**Weight Calculation:

$$Weight_{row} = \frac{Geometric\ Mean}{\sum_{r=1}^{r=n} Mean_r}$$

Identifying Alternatives

It is essential that all of the pertinent information is available for a valid comparison of each car model. Although there are several new all-electric attractive cars on the market, the safety ratings of many of the models are not yet published.

In the search for viable alternatives, there should be a wide, but still reasonable price range of cars included. The Tesla Model Y and Hyundai are mid-price ranged fully electric cars that had new models released in 2020. Then, the Jaguar I-Pace S acts as the upper price limit in the group of possible alternatives, while the Hyundai Ioniq Electric acts as the lower bound in the price range.

Rating Alternatives Relative to the Criteria

	Storage (ft^3)	Maintenance (years/miles)	Price (US Dollars)	Range (miles)	Safety (feet)	Acceleration (seconds)
Jaguar I-Pace S	51.95	5/60,000	69,850	234	160	4.5
Tesla Model Y	68	8/120,000	49,990	326	161	3.5
Hyundai Ioniq Electric	23	10 /100,000	33,045	170	191	11.4
BMW i3	36.9	4/80,000	44,950	153	180	7.2

Table (3): Quantitative Criterion Comparison of Each Car

Computing the Scores for the Alternatives

Criteria	Weight	Jaguar I-Pace S	Tesla Model Y	Hyundai Ioniq Electric	BMW i3
Storage	0.204	0.29	0.38	0.13	0.21
Maintenance	0.121	0.17	0.33	0.28	0.22
Price	0.062	0.16	0.23	0.35	0.26
Range	0.483	0.27	0.37	0.19	0.17
Safety	0.111	0.27	0.27	0.23	0.24
Acceleration	0.019	0.30	0.39	0.12	0.19
Score		**0.25**	**0.34**	**0.20**	**0.20**

Table (4): Calculated Criterion and Overall Scores for Each Car

Reviewing the Decision

According to the Analytic Hierarchy Process, the most highly recommended vehicle is the Tesla Model Y. This is consistent with the large weight that the range has over the other criterion. The Tesla boasts a considerable range compared to the other models. This, coupled with a long mileage warranty and considerable cargo capacity means that the Tesla Model Y seems to be an excellent compliment to someone that actively commutes locally with a bike, but would like to go journey out at times.