Moody's Mega Math Challenge®

A contest for high school students

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PREVIEW PAPER:
AVERAGE

This team provided a good executive summary, but the summary did not provide clear guidance with respect to the team's conclusions. With respect to the first question the team discussed how they arrived at their cut off values for the different time and mileage levels. They also noted that they assumed that the two aspects, time and distance, were independent. It was clear how they performed their calculations, but the presentation of their results does not compare favorably with other teams.

The team's answers for the second question was incomplete, and they did not provide an answer for the third question. It was not easy to follow what they were trying to do. Additionally, their plots were not clearly annotated nor adequately described.

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Moody's Mega Math Challenge
Share and (Car) Share Alike Modeling
New Approaches to Mobility

Executive Summary

Nowadays, car-sharing has become more and more popular due to its convenience and low-cost with short-term usage compared to owning a car. Why bother to buy a car for a few trips to a mountain every year? Renting a car is $200 to $250 weekly for Uber or Lyft, and the total cost for six weeks is $1200 to $1500. Compared to the low cost of renting a car for six weeks, owning a car costs more than $10,000. It is certainly not worthy to buy a car just for vacations.

As a result, many Americans choose to rent cars instead of owning a car. Renting a car can resolve many problems associated with the massive production of cars in the early 20th century: pollution, energy use, and traffic congestion. Promoting rental car services will decrease the number of cars on the street because one car can be shared by multiple families, improving the heavy traffic.

Activities of automobile are phenomenons that resulted by the keeping up with the speed of economy. Therefore, it is important for us to understand who's driving and how that will relate to the carsharing area. In Part I, we used probability multiplication rule to calculate the percentage of of current U.S. drivers in each category-low, medium, and high-for all combinations of the two specified factors, the amount of time using the car and miles driven per day,according to different age group.

Carsharing is an important strategy for young generations nowaday. It is designed for shorter time and shorter distance as an extension of the transportation network, providing a public service designed to enhance mobility options. Companies that have been offering these carsharing options were Ubers, Car2Go, Getaround, and Zipcar. In Part II, we have been asked to determine whether the company Zipcar's different business options are efficient in it's area. We took consideration of the number of location offered by zipcar and number of average hours people drove to build a model. We ranked the issues in these city: Poughkeepsie, NY; Richmond, VA; Riverside, CA; Knoxville, TN.

Under circumstances of technologies developments, inventions such as self-driving automobile becomes a risk for car sharing companies to expand. In Part III, we have been asked to take consideration of the technology impact on this mainstream. Through readjust of the model in Part II, we will re-rank the four cities identified in part II.

Table of Content

Introduction

Background: The introduction of mass-produced cars in the early twentieth century has caused much controversy over heavy environmental pollution, traffic congestion and and demanding energy use accompanied by the heavy use of automobiles. Currently, car sharing has become an attractive option for consumers who may want to avoid the costs and responsibilities of owning a private car. This new form of car service can lessen the drawbacks that the massive production of automobiles has brought us.

Restatement of the Questions:

1. The percentage of current U.S. drivers who fall into the categories of "small", "medium" , and "high" based on the amount of time using the car and the miles driven per day.
2. Given the following four car-sharing business options: round trip car sharing, one-way car sharing floating model, one-way car sharing station model and fractional ownership, which is the most popular in the each city: Poughkeepsie, NY; Richmond, VA; Riverside, CA; Knoxville, TN. The problem should be solved using a model.
3. Redo part-two taking into account of the self-driving cars and vehicles that run entirely on alternative fuel or renewable energy.

Global Assumption:

The car companies are currently focused on urban environments.

Part I : Who's driving?

In part I ,we have to develop a model that takes into consideration of the two factors amount of the time using the car and the miles driven per day to determine the percentage of people in low, medium, and high usages of car in the combination of those two factors.

Let LH be the drivers who use their vehicles for a low number of hours
Let MH be the drivers who use their vehicles for a medium number of hours
Let HH be the drivers who use the;ir vehicles for a high number of hours
Let LP be the purpose of driving that results in low mileage.
Let MP be the purpose of driving that results in medium mileage.
Let HP be the purpose of driving that results in high mileage.

Average hours of different age group spend on auto rental

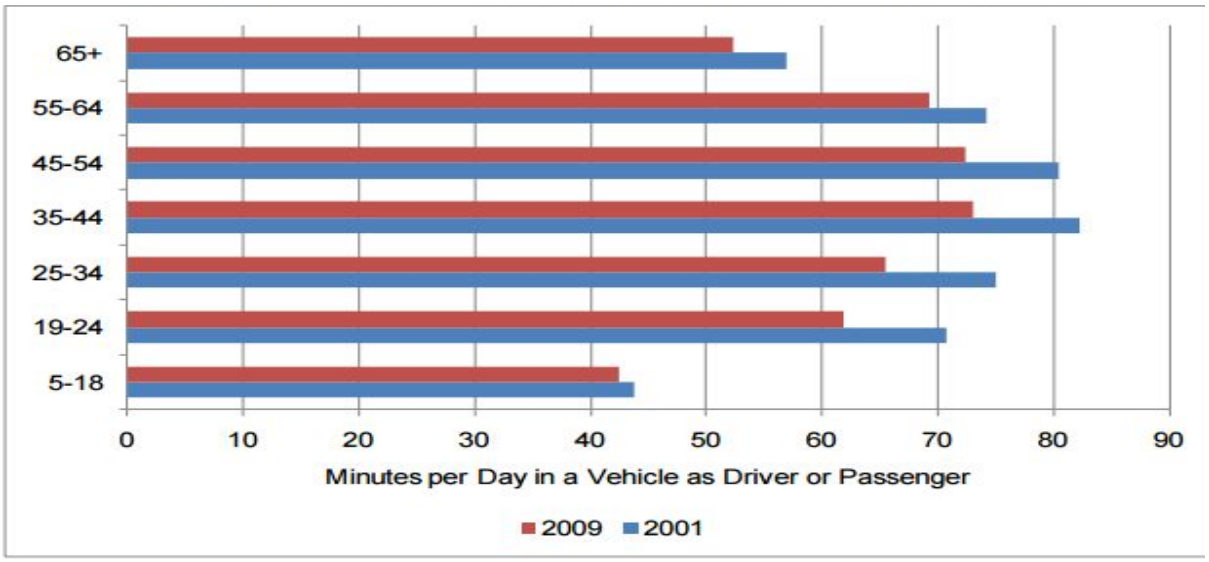


Figure 1

According to the figure 1, 65+ age group can represent drivers that use their vehicle for a "low" number of hours (LH); 20-34age group can represent drivers that use their vehicle for a "medium" number of hours(MH); 34-65 age group can represent drivers that use their vehicle for a "high" number of hours (HH).

Purposes for driving	Average Vehicle Trip Length (mile)
Shopping	6.4
Social and recreational	11.2
To work	12.2

▫ Table 1

Assumption:

Shopping, social and recreational, and to work are the main purposes that make Americans drive for all age groups.

According to the table 1, shopping would be the purpose of driving that results in low mileage(LP); social and recreational would be the purpose of driving that results in medium mileage(MP); to work would be the purpose of driving that results in high mileage (HP).

Age groups	Population	%
65+	38870	17.75
20-34	50844	23.23
34-65	129202	59.02
Total	218916	100

▫ Table 2

The Purpose	Average Annual VMT per Household (Year 2009)	%
Shopping	2979	22.34
Social and recreational	4842	36.31
To work	5513	41.35
Total	13334	100

▫ Table 3 *VMT=vehicle miles of travel

Independence:
It's unlikely that the percentage of certain age group in United States affected the the purpose that makes people drive, so the events seem to be independent. We can use multiplication rule.

Model:

$$P(\text{event 1} \cap \text{event 2}) = P(\text{event 1}) \times P(\text{event2})$$

$P(LH \cap LP) = P(LH) \times P(LP) = 0.1775 \times 0.2234 = 0.03965$
$P(LH \cap MP) = P(LH) \times P(MP) = 0.1775$ mg$\times 0.3631 = 0.06445$
$P(LH \cap HP) = P(LH) \times P(HP) = 0.1775 \times 0.4135 = 0.07340$
$P(MH \cap LP) = P(MH) \times P(LP) = 0.2323 \times 0.2234 = 0.05190$
$P(MH \cap MP) = P(MH) \times P(MP) = 0.2323 \times 0.3631 = 0.08435$
$P(MH \cap HP) = P(MH) \times P(HP) = 0.2323 \times 0.4135 = 0.09606$
$P(HH \cap LP) = P(HH) \times P(LP) = 0.5902 \times 0.2234 = 0.13185$
$P(HH \cap MP) = P(HH) \times P(MP) = 0.5902 \times 0.3631 = 0.21430$
$P(HH \cap HP) = P(HH) \times P(HP) = 0.5902 \times 0.4135 = 0.24405$

<u>Conclusion</u>
The percentage of drivers who are "low" mileage drivers that use their vehicle for a "low" number of hours is 3.965%.
The percentage of drivers who are "medium" mileage drivers that use their vehicle for a "low" number of hours is 6.445%.
The percentage of drivers who are "high" mileage drivers that use their vehicle for a "low" number of hours is 7.340%.
The percentage of drivers who are "low" mileage drivers that use their vehicle for a "medium" number of hours is 5.190%

The percentage of drivers who are “medium” mileage drivers that use their vehicle for a “medium” number of hours is 8.435%
The percentage of drivers who are “high” mileage drivers that use their vehicle for a “medium” number of hours is 9.606%
The percentage of drivers who are “low” mileage drivers that use their vehicle for a “high” number of hours is 13.185%
The percentage of drivers who are “medium” mileage drivers that use their vehicle for a “high” number of hours is 21.430%
The percentage of drivers who are “high” mileage drivers that use their vehicle for a “high” number of hours is 24.405%

Part II : Zippity do or don't?

Why do people choose car-sharing: Carsharing is designed for a short time period for local user to reach community supports and business destinations. Some people cannot afford to buy a car, and even those with the financial ability to buy a car cannot afford the cost of owning a car. A person who owns a car has to pay for the maintenance expenses, licensing expenses, fuel and insurance of up to $10,000 in total for the first year. In addition, the owner has to be responsible for the car's maintenance because once an accident happens, the insurance premium (a regular payment to the insurance company) automatically goes up. In this case, instead of buying a car, renting becomes the best option for city dwellers, suburbanites, and rural residents who either do not want the inconvenience of public transportation or have no access to it.

What is a Zipcar and what are the four ways of carsharing? Zipcar is an car-sharing company which offers reliable automobile reservations to those who needs it. Zipcar has four different business options provided for its members to their best preferences. Round trip car sharing is where vehicles are rented by the day, hour, or mile, or some combination of the three, and are picked from and returned to the same point. One-way car sharing floating model is where cars are rented on demand and are returned to defined areas. One-way car sharing station model is where customers pick up and drop off cars at existing stations. Fractional ownership is where multiple owners jointly purchase a private car.

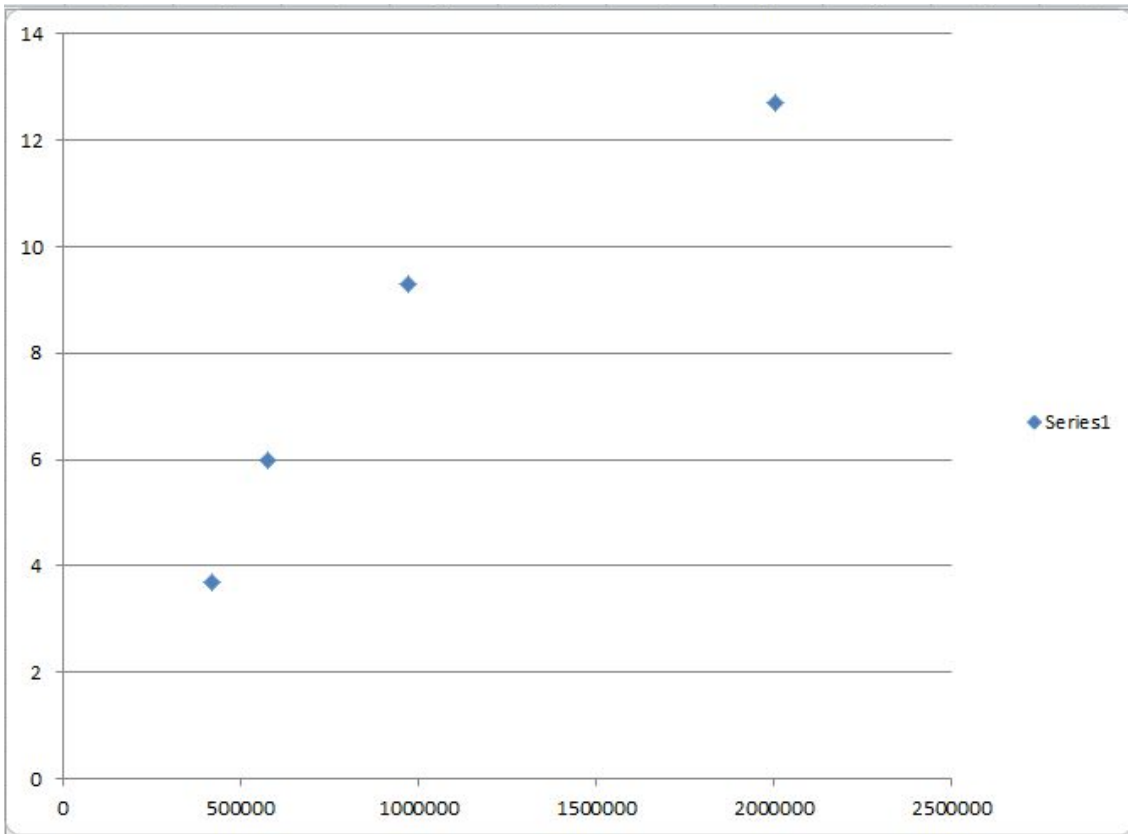
In Part II, we have been asked to create a model to determine which of these car-sharing options would best fit or garner most participation in the following cities: Poughkeepsie, NY; Richmond, VA; Riverside, CA; Knoxville, TN.

Assumptions:

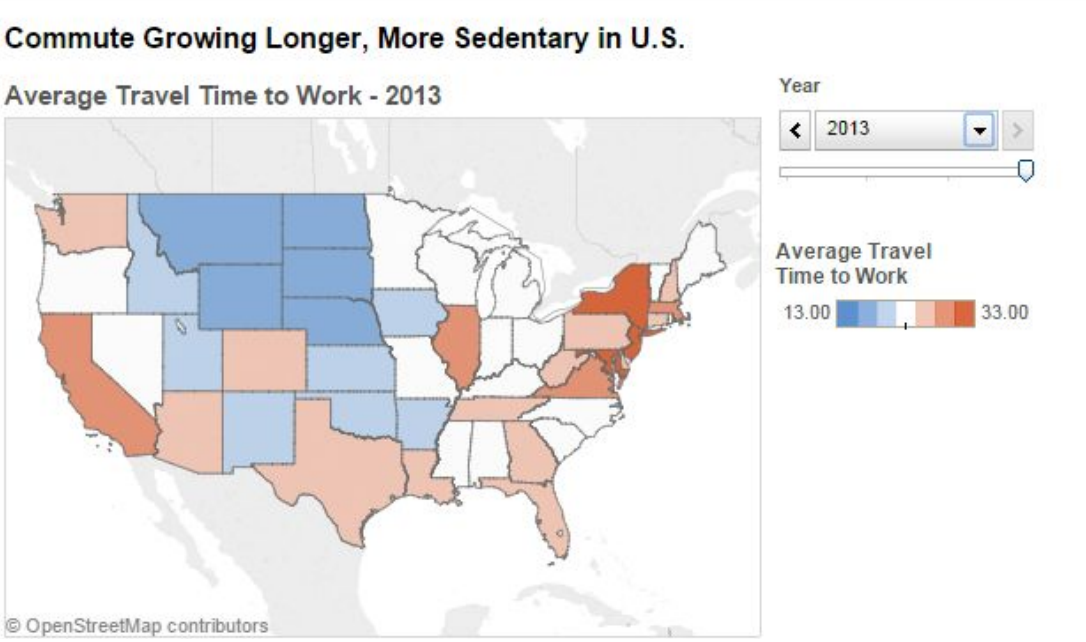
1. All the customers choose a monthly plan for Zipcar.
2. The most participation occurs with the least cost.
3. 7 dollars for the monthly fee
4. 9 dollars for the hourly fee

City	Population	Trips Per Person
Riverside-San Bernardino, CA	2,003,253	12.7
Knoxville, TN	575,185	6.0
Richmond, VA	969,365	9.3
Poughkeepsie-Newburgh, NY-NJ	419,248	3.7

Across cities, the presence of a well-developed transit system is correlated with fewer vehicle miles of travel . Cities with more heavily utilized transit systems have, on average, fewer vehicle miles of travel per person than cities with less heavily utilized transit systems.



Therefore the cities in order of the vehicle miles traveled per person per day from the largest to the smallest are: Poughkeepsie, NY-NJ > Knoxville, TN > Richmond, VA > Riverside, CA



According to the graph, we found the following:
The average number of hours traveled by a New Yorker is 0.535.
The average number of hours traveled by a resident in California is 0.465.
The average number of hours traveled by a resident in Tennessee is 0.408.
The average number of hours traveled by a resident in Virginia is 0.462.

x= number of hours
P = total price
General formula: P = p* t

P for Poughkeepsie, NY = $7+ $9*0.535hrs = $11.815
P for Richmond, VA= $7+$9*0.462hrs = $11.158
P for Riverside, CA= $7+$9*0.465hrs=$11.185
P for Knoxville, TN=$7+$9*0.408hrs=$10.672

Part III : Road map to the future.

With the fast developing of technology, self-driving car becomes one of the efficient and environmentally friendly options for people in the United States. These technologies will push our countries to a different future and will dramatically change the number of people who use the car-sharing system due to less pollution and more convenience.

In Part III, we will readjust the model in Part II in consideration of the self-driving cars and alternative fuel or renewable energy cars suggested in Part III.

Conclusion

Based on what we have concluded from our models, it is certainly useful to have an environmentally friendly car or a self-serving car in the future. However, it takes

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