Share and (Car) ShareAlike

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Contents

5. Summary

In this problem we were asked to classify American drivers by percentage into classes of high, medium, and low as it relates to their average commute time as well as their average numbers of miles driven per day. Also we were asked to asses the viability of 4 different car-sharing methods in 4 different cities in the us. As well, we were asked to predict how new driverless technology would impact the car-sharing industry.

When asked to find the percentages of americans that fell under one of the 9 categories as relating to their average commute time and their average miles driven per day, we created a table with categories based on those variables. We found the average time in the car using statistics we found online for each state. In addition to this, we calculated the standard deviation using this data. In order to calculate the average number of miles traveled in a day, we used the formula d=rt. (distance=rate*time). We categorized each state into the categories of high, medium, and low, in respect to the two variables (Average commute time, and average miles traveled per day). we then found the sum of the population of every state in each category and then divided the number we got in each category by the total U.S. population. (308,602,708 citizens)

In order to calculate the average cost of the 4 given car-sharing methods (round trip car sharing, one-way car sharing floating model, one-way car sharing station model, and fractional ownership), we created a formula to estimate the cost of using their services in the given cities. (Poughkeepsie, NY; Richmond, VA; Knoxville, TN; Riverside, CA) We learned of their rates from phone calls to stores as well as online webpage visits. The formula showed that Zipcar will always be the most cost effective option regardless of the city.

In order to calculate the future price, a field of definite uncertainty, we added a constant to all of the equations except for the equation for the yellow taxi service and the shared car. The equation used for the yellow taxi service didn’t gain the constant because we assumed that the extra price due to the driverless technology would be cancelled out by the amount of money saved by not having to pay for the “jockey”. It wasn't added to the shared car because the car will still be the same car regardless of new technological innovations. The exact price of the car-sharing options in the future is uncertain however with our formulas,however the price of any of the 4 car-sharing options may be determined by replacing the constant (c) with the actual

price difference between the price of the old technology and the increased price of the new technology.

1 Introduction

1.1 Background

We live in a world where carpooling is the most economical and environmentally friendly means of transportation. Car-sharingwill cause less pollution, less traffic, and less oil consumption, which means more money can be saved. Time spent in traffic will decrease, the pollutants given off by cars will decrease since there will be less cars of the roads. That is why more and more people have decided to buy a car together, rather than having a car on their own. The use of car sharing has the given aspects of owning a vehicle, but not the financial burden of maintaining the vehicle. There are about 214 million drivers on the road as of 2014. As technology has increased, the efficiency of cars has increased. With the efficiency of cars increasing, less pollutants are getting put into the air. Technology will always be increasing which means pollutants will be decreasing. This will also be the case if more and more people start to carpool.

1.2 Restatement of Problem

Our team has been asked to do three things. First we were asked to categorize all American drivers under one of 9 categories according to the rank of their average commute time as well as their average miles driven per day. We were asked to rank the drivers as low, medium, or high in respect to their average commute time as well as their average miles driven per day.

Second, we were asked to create a model that will determine which car-sharing option would be most viable in the cities listed (Poughkeepsie, NY; Richmond,VA; Riverside, CA; Knoxville,TN) in order to inform car-sharing companies as to which approach they should take in each city. (Round-trip car sharing, One-way car sharing floating model, One-way car sharing station model, Fractional ownership)

Lastly, we were asked to adjust our model in order to account for how driverless cars will affect the effectiveness of each car-sharing approach.

1. Who will be driving? how much time will be spent driving in relation to how many miles you drive?
2. Zippity do or don’t? Is it worth the carpooling or to drive by yourself? which carpooling methods work best?

3. Road map to the future. how will driverless-car technology effect carpooling? Will this cause a decrease in carpooling?will it cause an increase?

2 Who's Driving?

2.1 Assumptions

- Assumption #1: All individuals considered are employed.
    - Justification of assumption 1: The given problem was concerned with the percentage of U.S. "drivers", individuals taken into consideration must not only choose to use a form of automotive transportation but, would also need a source of income in which to purchase a mode of automotive transportation therefore, they would have to be employed.
- Assumption #2: The only usage of automotive transportation would be in getting to and from their workplace.
    - Justification of assumption 2: As explained in Assumption #1, since only those who are employed were considered to be "drivers" then, it is reasonable to assume that they will only be driving to and from their workplace. This assumption was made because there is no way to account inability for the spontaneous nature of everyday life, I.E. grocery trips, gas refills, etc.
- Assumption #3: We assumed that americans work on an average of five days in a week with a typical "nine to five" work schedule.
    - Justification of assumption 3: we assumed this because most americans only have a five day work week.
- Assumption #4: Because of Assumption #3, we assumed that those who would choose to share transportation would also live and work in a close proximity to one another.
    - justification of assumption #4: We assumed this so that the time and distance between their homes would be negligible in comparison to the overall commute to work.
- Assumption #5: We assumed that traffic within United States cities would be relatively equal.
    - Justification of assumption 5: We made this assumption because of Assumption #3, and therefore, traffic can be considered proportionate to the time of day, not the density of the city's population therefore remaining constant.
- Assumption #6: We assumed that the speed at which the typical person would travel would be equivalent to the average speed limit of American highways. for the purpose of simplification in our calculations.

- Justification of assumption 6: We assumed this for the purpose of simplification in our calculations and because drivers are attempting to minimize their travel time without breaking the law.

2.2 Average Commute & Miles per Day

We needed to determine the the average amount of time that would be spent traveling from the starting point and ending at the desired destination. In this particular case the starting point is the point at which the chosen mode of transportation begins traveling and the desired destination is an individual's workplace. In order to do so, we used the data found on [10] in order to calculate an average commute time across the United States, or Ā.

After our calculations, we discovered that the mean was 23.75 minutes in order to commute to work and the standard deviation was 3.54 minutes. In order to categorize the high, medium, and low we used inequalities, subtracting and adding the standard deviation, going 1 standard deviation away from the mean.With this information, we created our high, medium, and low categories. Low commute times were less than 20.21 minutes. Medium commute times were greater than or equal 20.21 and less than or equal to 27.29 minutes. The high commute times were greater than 27.29 minutes. Each state was then assigned high, medium, or low based on these conditions.

Low	Medium	High
$\bar{A} < 20.21$	$20.21 \leq \bar{A} \leq 27.29$	$\bar{A} > 27.29$

In order to define or categories for miles driven in a single day we used the equation:

$$x=2(65\frac{\bar{A}}{60min/hr}),$$

where x is equal to the miles driven in a single day. 65 miles per hour is equal to the average highway speed limit in the United States of America. The 2 signifies the measurement in both directions. So in creating the categories for x we plugged in one standard deviation above and then one standard deviation below the mean.

Low	Medium	High
$x<43.79$	$43.79 \leq x \leq 59.13$	$x> 59.13$

2.3 Percentages of Drivers

The rows on the Left side of the table are the categories of miles driven in a single day and the columns at the top are the categories of the average commute time. Our margin of error is approximately 3.76% due to rounding and not accounting for unemployment.

Categories of drivers (percent)

	Low	Medium	High
Low	3.24%	49.31%	20.02%
Medium	0.80%	21.69%	0.00%
High	0.18%	0.00%	0.00%

Fig.1
American drivers as it relates to their average commute time as well as their average miles driven per day.

In order to calculate the percentages seen above we used the population information obtained from [12] and added together the populations of each state for the category that the state fell into, then divided by the total population of the United States. This is represented by the equation seen below.

$$\frac{\Sigma P}{308{,}602{,}708}$$

3 Zippity do or don't

3.1 Assumptions

- Assumption #7: All individuals who make use of car-sharing businesses are going to use; Zipcar, Yellow Cab, Hertz, or Ford.
    - Justification of assumption 7: We made this assumption for the simplification of our calculations. This is reasonable because it would be impossible for us to account for all of the price differences between the different companies.
- Assumption #8: All individuals when using a car-sharing business will pay the cheapest price offered by the chosen company.

- Justification of assumption 8: We made this assumption for the simplification of our calculations. This is reasonable to assume because people are always looking to find the most affordable option.

- Assumption #9: A car-sharing company's amount of participants is inversely proportional to the offered price-levels.
  - Justification of assumption 9: We made this assumption because of the law of demand states that when prices increase the demand will decrease.

- Assumption #10: All modes of transportation used are standard four door sedans.
  - Justification of assumption 10: We made this assumption so as to define the possible number of people that can carpool at the same time.
- Assumption #11: There are four people traveling within the same automotive vehicle regardless of the company and therefore each will pay equal portions of the total cost.
  - Justification of assumption 11: We made this justification because the problem is about vehicle sharing and therefore the cost should be equally distributed among a set number of individuals.
- Assumption #12: All four individuals will be present for both the trip to and the return trip from the workplace.
  - Justification of assumption 12: We made this assumption so that the price per individual will be the same both on the commute to work as well as the commute back from work.

3.2 Round Trip

When doing a round trip a person will pay by the day instead of by the hour. The Zipcar rate in Knoxville, TN is $7.50 an hour and $69 for a week. In the other three locations the hourly rate is $8.50 and has the same week rate of $69.

3.3 One-way car floating

We assumed that a taxi service would be the company will be rented on demand of the person who is renting it. Taxi services charge by the mile at a going rate of three dollars for initial payment and $2.00 per mile after that. The initial payment of the taxi co $3.00 when they show up. In order to set the variable for the taxi service to hours, we plugged in our equation from part one into the variable that was equal to miles. That turns the equation into 2.7(2)(65h) $= y \rightarrow 5.4(65h) = y$

3.4 One-way car station

Hertz is the rental company that we went with for our consumer pick up and drop off at a certain location. All the locations will offer unlimited free miles. The going rate for a four door sedan at Knoxville, TN is $170.00 for a week. At Riverside, Ca is $149.00 for a week. For Richmond, Va the going rate is $230.00 a week. At Poughkeepsie, NY it will be $171.00 for a week.

3.5 Fractional Ownership

For fractional ownership, a group of people will go out and buy a 2011 Ford Focus at $11000. They will then divide it by four, since four of them will be buying the car. It will come to be $2750 that each person will pay for the car.

3.6 The Model

Prices in locations (Dollars/Hours)

Knoxville,TN	Richmond,VA	Riverside, CA	Poughkeepsie, NY		
(7.5Ā+70)/2	(8.5Ā+70)/2	(8.5Ā+70)/2	(8.5Ā+70)/2	Zipcar (Round trip)	Ā=hours
(5.4(65+Ā3))/2	(5.4(65+Ā3))/2	(5.4(65+Ā3))/2	(5.4(65+Ā3))/2	Yellow Cab (floating one-way)	Ā=hours
(170)/2	(230)/2	(149)/2	(171)/2	Hertz (station one-way)	
2750	2750	2750	2750	2011 Ford Focus (fractional Ownership)	Price divided by 4

Fig.2

All equations below are set to y=, the Āwill be used for the average commute time in the given city. Each equation is divide by 2 due to the fact that it is a round trip and when you multiply the whole equation then divide it by 4 will be the same as dividing the whole equation by 2.

$$x=2(65\frac{\bar{A}}{60min/hr})$$

This equation rate here is used to calculate the number of miles traveled at a given speed (65 mph) the 2 represents the round trip which will be multiplied by 2. Where x is the number of miles that will be traveled and Āis the number of hours that has been traveled in that day.

Cost of commuting in each city

Knoxville,TN	**Richmond,VA**	**Riverside, CA**	**Poughkeepsie, NY**	
36.09	**36.54**	**36.96**	**36.58**	**Zipcar**

52.69	**65.27**	**82.23**	**67.02**	**Yellow Cab**
85	**115**	**74.5**	**85.5**	**Hertz**

Fig.3

The table above shows the price per person for a round trip in order to commute to work. The numbers we used to calculate this number was the average commute time to work. This allows us to reach our conclusion that for all cities that in the short run, Zipcar is the cheapest option, meaning that Zipcar is the one that should continue to implement and research the legalities and issues regarding it. However, buying a car and sharing it with other people in order to commute will ultimately end up being cheaper in the long run.

The X-axis will be the average commuting time spent on a given day. The symbol we used for the time spent driving is Ā. The A represents the commute between the person's house and the drive to work. The line about the A represents the average of the commute time between the house and work. That is how our team got the hours spent driving. On the Y-axis it is the amount spent on renting/buying/taxing. The amounts we got are the amounts for Zipcar, Yellow Cab, Hertz, and a 2011 Ford Focus. All of the pricing except the 2011 Ford Focus are in an hourly rate.

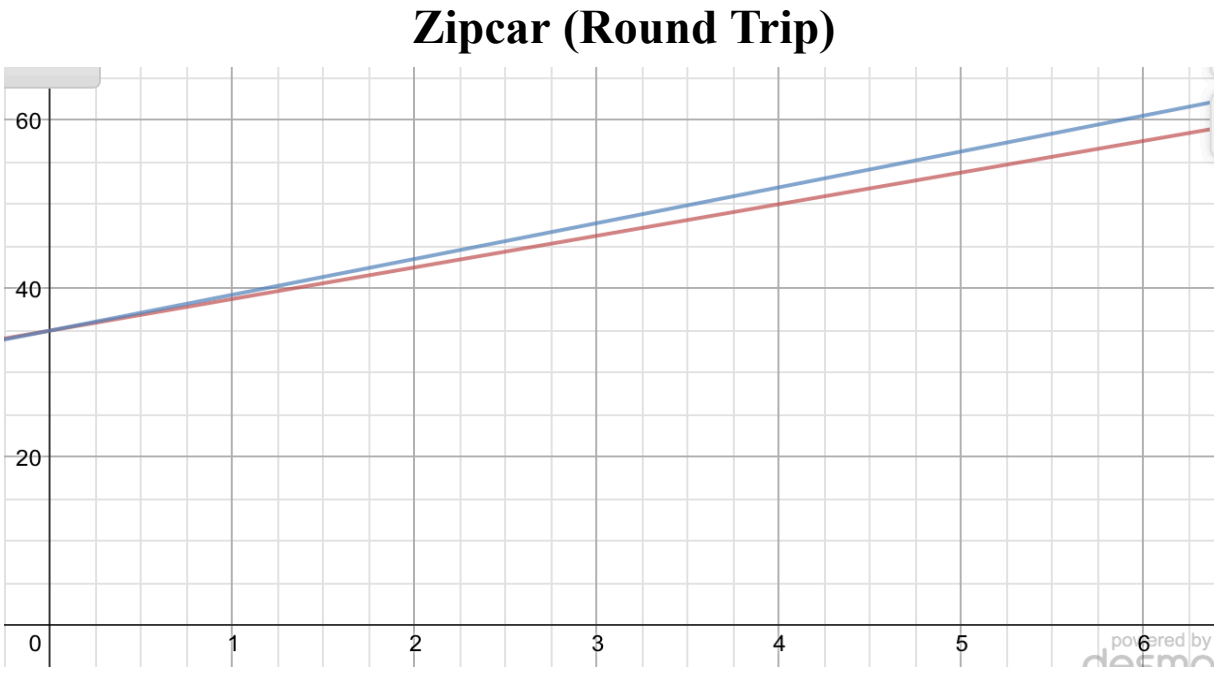

Fig.4

The blue line represents the cities of Richmond, VA: Riverside, CA: Poughkeepsie, NY. The red line represents Knoxville, TN. The reason why Richmond, Riverside, and Poughkeepsie lie on the same graph is due to the function of y= (8.5Ā+70)/2 since the three of them are the same price per hour. Whereas, Knoxville is $7.50 per hour, so Knoxville's function is y=(7.5Ā +70)/2.

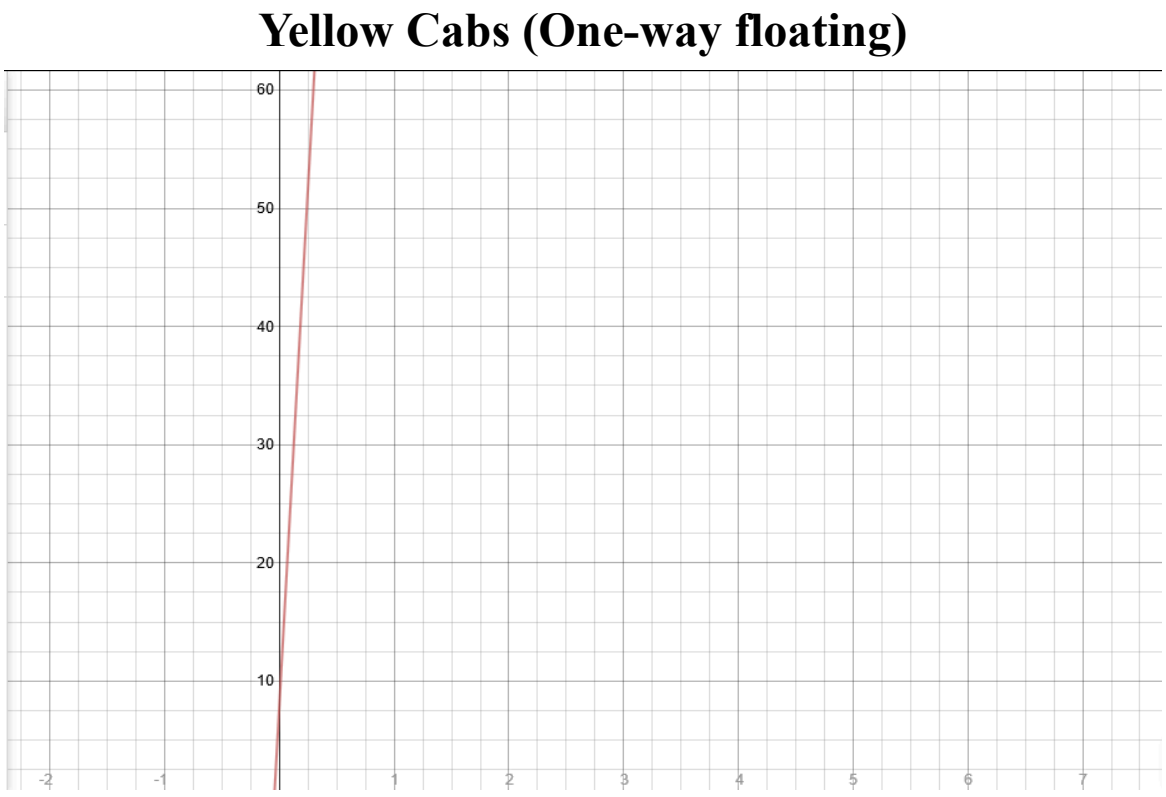

Fig.5

The price of the Taxi service is constant for all states at $2.00 per mile and for an initial rate of $3.00.

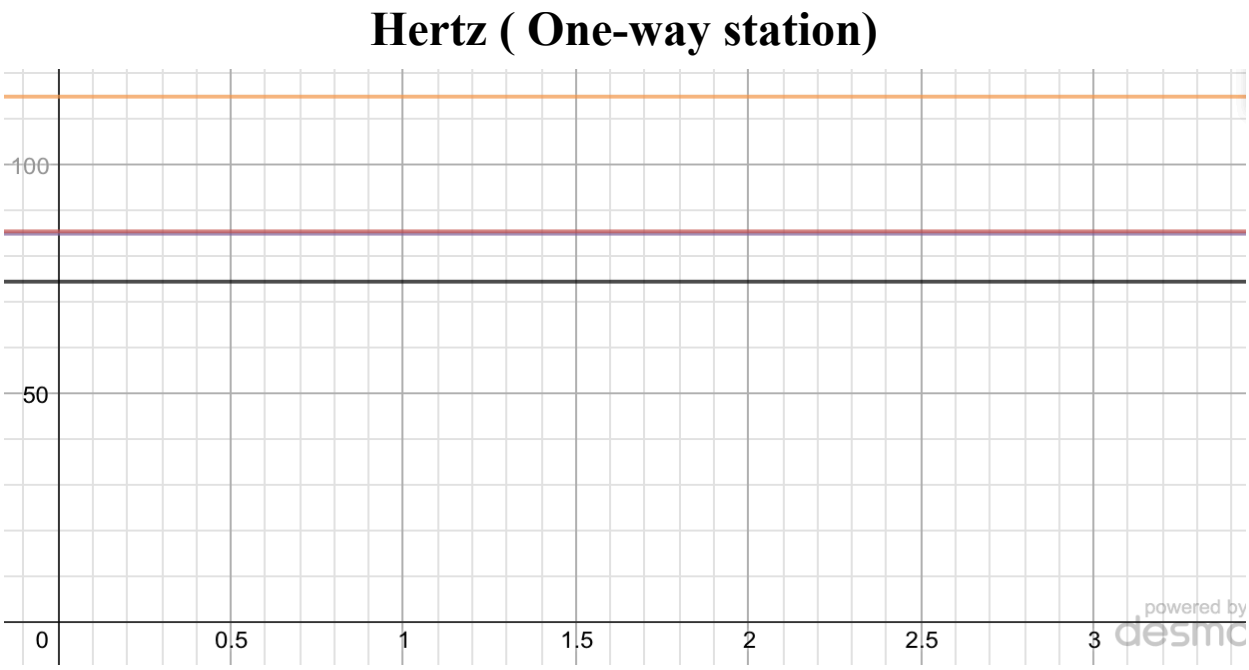

Fig.6

These lines represent the amount you have to pay at Hertz when you rent one of their cars. The orange line represents the cost in Richmond,Va. The purple line represents Knoxville, TN and Poughkeepsie, NY; since they are only a dollar apart they can be graphed on the same line. The black line is the cost of Riverside, CA which is the smallest price in the renting from Hertz.

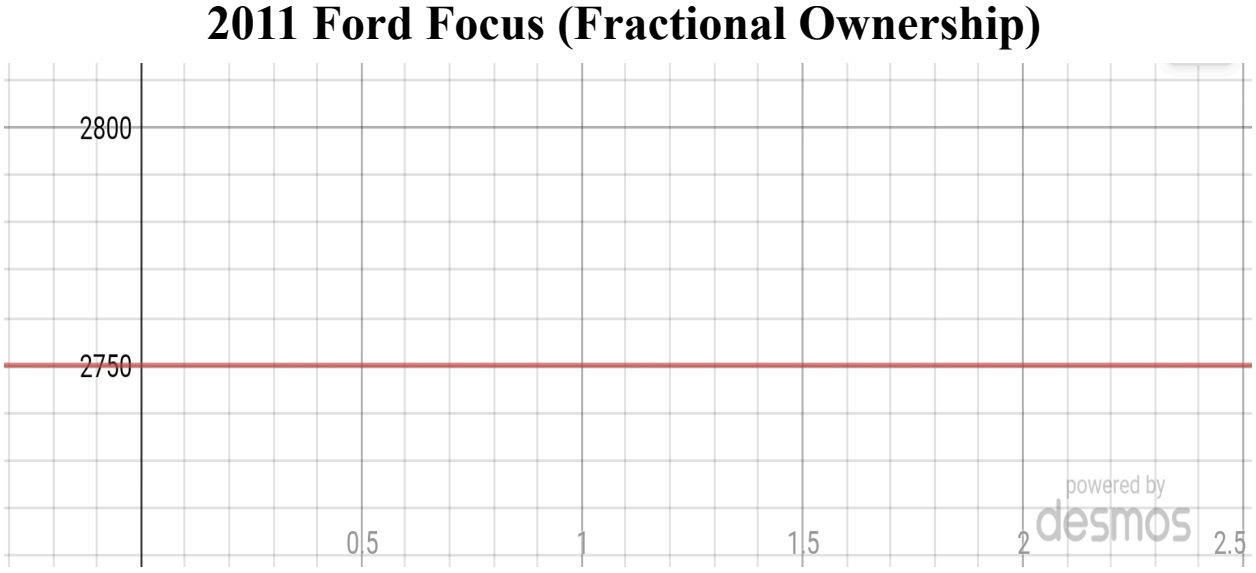

Fig.7This graph shows owning a car will be at a constant rate and will not change over time, it will continue to stay at 2750. This is the case due to the fact that the price of a vehicle doesn't change in different states.

4 Road map to the future

4.1 Assumptions

- Assumption #13: People will be more willing to pay for a car that drives itself.
    - Justification of Assumption 13: There will be no human error which will cause the rates of accidents to decrease.
- Assumption #14: The price of having a driver will be gone completely because the car will be autonomous.
    - Justification of Assumption 14: No one will have to be payed to drive the car because a computer will.
- Assumption #15: People will no longer be sharing cars.
    - Justification of Assumption 15: It's much more convenient and practical to have a car delivered to your house and go directly to point B than it is to share an autonomous car with other people in your peer group.
- Assumption #16: The rates of vehicle sharing companies will increase.
    - Justification of Assumption 16: New technology costs more to produce and therefore, it will cost the companies more to supply the newer service.
- Assumption #17: The price of the innovations made by the company are proportional to the cost of the driver.the company's car innovations are proportional to the pay that the "jockey" would receive.
    - Justification of Assumption 17: If a business were to lose money then it wouldn't have made economical-sense for it to have replaced the vehicle's "Jockey" in the first place. Therefore, it is safe to say that the value of both the "Jockey" and the computer used to perform the same function have either an equal or greater value.
- Assumption #18: We are unable to predict the companies decision making process on how to deal with the price of their newer technology.
    - Justification of assumption 18: Since we are incapable of predicting the future we are safe to assume that based on assumptions 16 and 17 there must be some form of increase for companies that have no way of funding the cost of producing the newer technology.
- Assumption #19: The cost increase would be added to the cost per hour rather than any membership fees.
    - Justification of assumption 19: It is reasonable because,to assume that a business would increase the portion of the overall price that would have the greatest positive impact on the profitability.

4.2 Cost of Future Cars

Being that we assumed that the cost of having a "Jockey" is the determinate factor as to whether or not the prices of car-sharing businesses will increase or remain the same, the additional cost is capable of being represented by the constant "C". So we used the same equations we used in Figure 2 (which are with respect to the average commute times of the four specified cities, that were obtained from [5,4,3,2] , and then modified those that would be affected by the presence and or absence of a "Jockey", as demonstrated in Figure 8. We are justified in adding the constant "C" because of assumption 18.

Change of cost of cars

Richmond	Knoxville	Riverside	Poughkeepsie	
36.06+(0.292C/2)	36.09+(0.2916C/2)	36.96+(0.46C/2)	36.58+(0.373C/2)	Zipcar
(230+C)/2	(170+C)/2	(149+C)/2	(171+C)	Hertz

Fig.8

For example, when calculating the new price for Zipcar in the city of Knoxville, TN:

$$\frac{((7.5+c)(\bar{A}))+70}{2} \rightarrow add\ c\ to\ cost\ per\ hour$$

$$\frac{(7.5\bar{A}+\bar{A}c)+70}{2} \rightarrow distribute$$

$$\frac{(7.5(0.2916)+(0.2916c)+70)}{2} \rightarrow insert\ average\ commute\ time$$

$$\frac{(2.1875+(0.2916c)+70)}{2} \rightarrow simplify$$

$$\frac{(72.1875+0.2916c)}{2} \rightarrow simplify$$

$$36.09+\frac{(0.2916c)}{2} \rightarrow simplify$$

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