Car Sharing in America: What Works Best?

Team #6898

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Executive Summary

As the United States has become more and more urbanized, the need for every person to have his or her own car has lessened. Alternative solutions to car ownership such as public transportation and bike riding have grown in popularity in recent years, yet another new and exciting option for Americans has arrisen- car-sharing programs.

In order to analyze need for car-sharing programs, we looked at car usage (distance driven and amount of time spent driving) among Americans. The need for alternative methods of transportation depends largely on current driving habits. Determinations were made as to what determines a “low”, “medium”, and “high” amount of time spent driving per day and what determines a “low”, “medium”, and “high” distance driven per day. It was determined that 32.5% of Americans fall into the “Low Time” range, 35.7% fall into the “Medium Time” range, and 31.8% fall into the “High Time” range. We also found that 26.9% of Americans fall into the “Low Distance” range, 45.6% fall into the “Medium Distance” range, and 27.5% fall into the “High Distance” range.

Next, we looked at the four main systems for car sharing. These are: round-trip car sharing, in which people rent out a car for a period of time and then return it to the place they got it, station-based one-way car sharing, which is the same as round-trip except the car can be left at any approved car station after use, floating one-way car sharing, in which the car can be parked in any parking space after use, and fractional car ownership, in which multiple people purchase a car together and decide amongst themselves how to divide up allowed usage of the shared vehicle. Then, using four model cities: Richmond, VA, Knoxville, TN, Riverside, CA, and Poughkeepsie, NY, we determined which of these car sharing systems would work best for each city. For Richmond, the optimal system was determined to be round-trip; for Knoxville, the optimal system was determined to also be round-trip; for Riverside, the optimal system was determined to be one-way floating; and for Poughkeepsie the optimal system was determined to be fractured ownership.

Finally, we looked to future technologies in alternative fuels/renewable energy and self-driving cars. These technologies are promising, but they present unique challenges. One of such challenges is public opinion of self-driving cars, as many Americans feel uneasy about the safety of such vehicles. An advantage of using alternative fuels and renewable energy sources is that many states offer cash rebates for purchasing vehicles which utilize these technologies. After adjusting our model for these new parameters, the optimal system for Richmond was determined to be round-trip, for Knoxville, the optimal system was determined to be round-trip, for Riverside the optimal system was determined to be floating, and for Poughkeepsie the optimal system was determined to be fractional ownership.

Introduction

In today's fast-paced world, readily-available transportation services are in high demand, and new businesses that offer personal transportation are continuously emerging around the United States. In particular, automobile sharing businesses allow for people to access cars at a significantly lower cost than those associated with owning a private automobile. Car sharing businesses are most essential in locations with high levels of households without cars, high population densities, high populations of college students, as well as locations that are at close proximities to major cities. Shared cars are often used by tourists traveling to hot spots within a given metropolitan area, college students and their visiting parents, members of one-car households that regularly require access to an additional automobile, residents of towns without efficient public transit, and others for miscellaneous uses. Shared cars also have a positive impact on the environment, as they discourage excessive automobile usage. In many cases, car sharing services are more cost effective than full car ownership. In order to create a business that provides the required services, we analyzed a myriad of variables and conditions.

1.1) Problem Restatemen

Our goal for Part 1 was to design a mathematical model that generates the percentages of American drivers who fall into each of nine combinations of the following categories: high, medium, and low distance driven per day, and high, medium and low time spent driving per day. These two sets of categories are related by speed driven, which depends on whether driving was conducted on highways, busy streets, densely populated communities, and town roads. Another major factor in the relationship between distance travelled and the time spent doing so is weather conditions of the location, such as heavy snow impeding traffic speed.

Our goal for Part 2 was to design a mathematical model that outputs the ideal business model for a car-sharing service in four particular cities (Poughkeepsie, NY; Richmond, VA; Riverside, CA; Knoxville, TN). The four business models considered were: 1) a round trip car sharing service, 2) one-way car sharing floating model, 3) a one-way car sharing station model, and 4) fractional ownership. The output is based on population demographics that indicate needs of a given city.

Our goal for Part 3 was to update our model from Part 2 in order to account for energy-efficient and self-driving automobiles. These two new factors radically change how the car-sharing program can operate, and what programs will work best where. Factors considered were state laws and rebates available as well as public opinion.

2. Calculations for Part 1

Analysis of the Problem

The purpose of Part 1 is to calculate the percentage of United States drivers who fall into each of the nine combinations of daily driving time (high, medium, and low) and daily driving distance (high, medium, and low). In order to generate values for each combination, we used data from the National Household Travel Survey to plot the number of minutes traveled vs. the number of miles traveled for a sample distribution of 262,933 subjects.

Assumptions:

1. We determined that in a given day, travel distances of 0-5 miles to be "low," 6-30 miles to be "medium," and 31+ miles to be "high."
2. Additionally, we determined that in a given day, travel times of 0-19 minutes to be "low," 20-59 minutes to be "medium," and 60+ minutes to be "high." We chose these values because on usa.com, in the "Travel Time to Work Distribution" graphs, the bottom two categories comprised 0-19 minute travel time, the middle three categories comprised 20-59 minute travel time, and the two highest categories comprised 60+ minutes travel time.
3. The NHTS data is representative of the United States population as a whole, considering the very large sample size consisting of random households across the nation.

These data were obtained from a sample of 150,147 households from around the United States that were interviewed over the phone. The calls were made to randomly chosen telephone numbers. The data were then weighted to provide numerical proportionality of the statistics based on the population of the home states of the interviewed subjects. Because our sample size is less than 10% of total United States households, the sample obeys the 10% Condition of Statistics and can therefore yield statistically significant conclusions. Thus, the National Household Travel Survey data is representative of the United States population as a whole, and can be used to model the behavior of its citizens.

Design of the Model (Questions/Diagrams)

We created a model that generates the percentage distribution of driving times and distances for United States households. The percentage distribution matrix was calculated using data from the National Household Travel Survey (NHTS).

Using Python code to scrape this database hosted by the United States Federal we could determine the total time spent driving, as well as the total mileage driven for each respondent to the National Household Travel Survey. In this survey, each and every trip by any means of transportation taken by a subject of the survey is reported. In our analysis we filtered out all trips not by car, and then were able to determine the total time and car milage for 262,933 subjects.

Thus we have a set $S = \{(t,d)\ \varepsilon\ R^2 | \ (t,\ d) = (time\ traveled\ in\ car, distance\ traveled)\}$ where S is of length 262,933.

Due to the fact that this survey is representative of the United States' travel habits as a whole, we were able to determine the proportion of Americans who fall into each of category. Additionally, in accordance with assumptions 1.1 and 1.2 the time cutoffs determining the ranges for low, medium, and high are $tc_1 = 20$, $tc_2 = 60$ and the distance cutoffs determining the ranges for low, medium and high are $dc_1 = 5$, $dc_2 = 20$ such that an arbitrary $(t,d)\ \varepsilon\ S$ is grouped into each category by the heuristic classification defined below

Level	Time	Distance
Low	$t < tc_1$ (Set T_l)	$d < dc_1$ (Set D_l)
Medium	$tc_1 \le t < tc_2\,(T_m)$	$dc_1 \le d < dc_2\,(D_m)$
High	$tc_2 \le t\,(T_h)$	$dc_2 \le t\,(D_h)$

Thus, the proportion of Americans that fall into each of nine groupings of the three possible categorizations of time and distance travelled can be calculated using the following equation [1] $P(n,k) = size(S_{n,k})/size(S)$ where $S_{n,k} \subseteq S$ such that $S_{n,k} = \{(t,d) \mid t\ \varepsilon\ T_n, d\ \varepsilon\ D_k\}$ where $n,k\ \varepsilon\ \{l,m,h\}$

Justification/Testing Model (Tables/Graphs)

Commutes By Time and Distance

Low Time	85352	32.5%
Medium Time	93978	35.7%
High Time	83603	31.8%
Low Distance	70763	26.9%
Medium Distance	119872	45.6%
High Distance	72298	27.5%

	Low Time	Medium Time	High Time
Low Miles	66348	18949	55
Medium Miles	4274	80324	9380
High Miles	141	20599	62863

	Low Time	Medium Time	High Time
Low Miles	25.23%	7.21%	0.02%

Medium Miles	1.63%	30.55%	3.57%
High Miles	0.05%	7.83%	23.91%

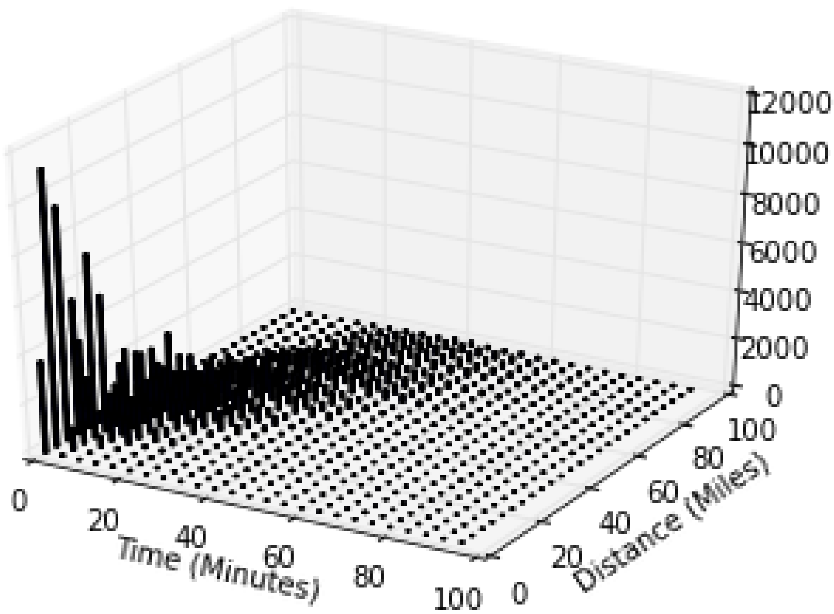


Figure [1] - 3D Histogram: Frequency as a function of time and distance driven per day

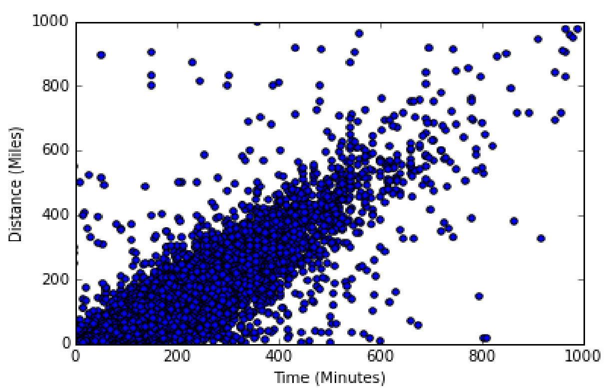


Figure [2a] - Scatter Plot: Distance driven vs time driven

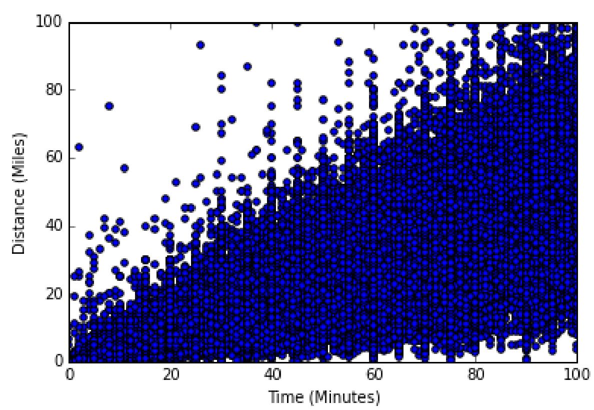


Figure [2b] - Zoomed-in plot of Figure [2a]

NOTE: <0.5 cars excludes zero cars

We assumed that the majority of shared car users would be citizens with less than 0.5 cars per adult in a given household.

3. Calculations for Part 2 (four cities+four methods)

Analysis of the Problem:

The purpose of part 2 is to determine which of the four following business methods is optimal for a given city: 1) round trip sharing, 2) one-way sharing floating, 3) sharing with stations, and 4) partial ownership. In order to determine the recommended method for a given city, our model takes into account demographic factors that impact the transportation needs of the population.

Assumptions:

1. Competing businesses are negligible. The use of other similar companies will not affect the success of the company.
2. The company is funded such that a sufficient number of cars can be purchased.
3. The population densities of cities are homogeneous within the city boundaries.
4. Only data on United States cities are relevant to the model.
5. If people who do not currently have a car were to subscribe to the car-sharing company, they would drive an equivalent amount to those who own a private car.
6. Zipcar provides parallel services to our model company, therefore the hourly price of using a Zipcar is the same as our hourly price.

The average cost of owning a sedan (the lowest-cost model) is $6729/ year [4], or $18.44/ day. The average cost for using a Zipcar, and therefore for using a car from our model company, is $8.77/hour. (Zipcar Website)

$8.77[dollars/hour] * x\ [hours] = 18.44\ [dollars/hour] \Rightarrow x = 2.10\ hours$

Once a trip exceeds 2.10 hours, it is more economically sound to own a car than to use a car-sharing service.

7. Users will not utilize the car sharing company for trips with a duration greater than 2.1 hours per day.
8. Users who live in a household with fewer than .5 cars per adult will use a ride-share service at half the rate of their fellow citizens with 0 cars.

Ranking Cities

In order to rank cities in terms of their amenability to a carsharing program we determined a value in dollars for the maximum revenue per day per square mile if the car sharing program was used by 100% of people with 0 cars, and 50% of people with .5 cars in their household. The calculated number of customers was then multiplied by the predicted hours per day a ride-share car would be used by these customers, as well as the price per hour, which was determined to be $8.77 an hour based on competitive pricing (see assumption 6).

To determine the number of customers for the ride sharing program we averaged the expected value determined by the population density of the city and its income distribution. To determine these expected values we created polynomial regressions to data mined from the National Household Travel Survey. Using Python code, we scraped the database for the proportions of adults in America who live in households with either fewer than .5 cars per adult, or zero cars, as described by population density and household income. The plots are shown below, and each have associated functions.

Figure [3a] - Proportion of Population with No Cars vs. Population Density (noCarPop(p))[2]

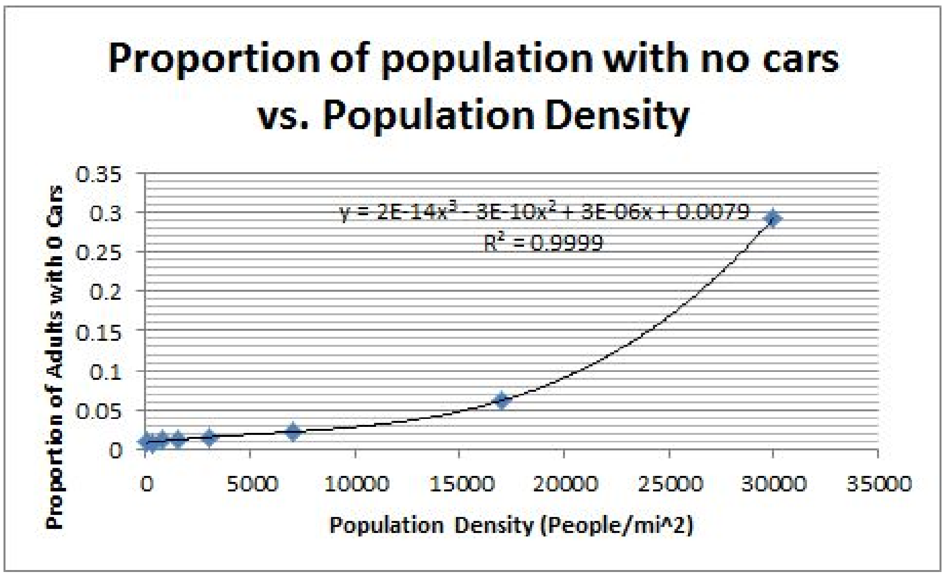


Figure [3b] - Proportion of Population with No Cars vs. Household Income (noCarIncome(i))[3]

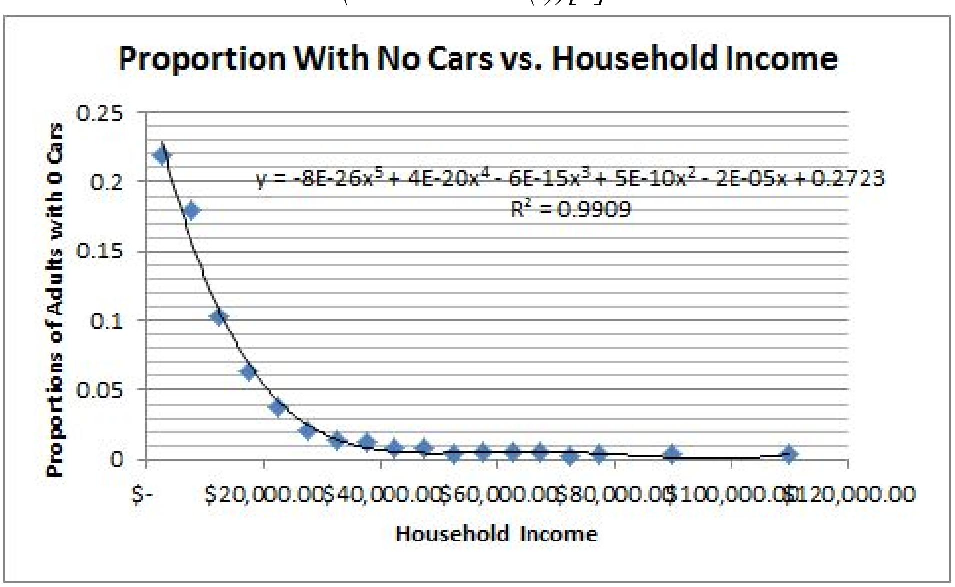
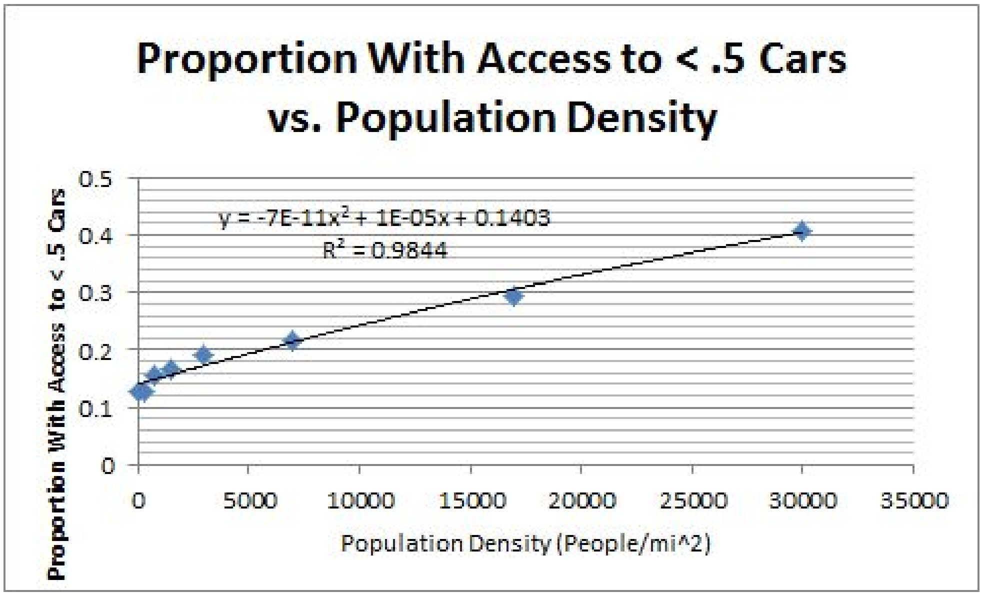
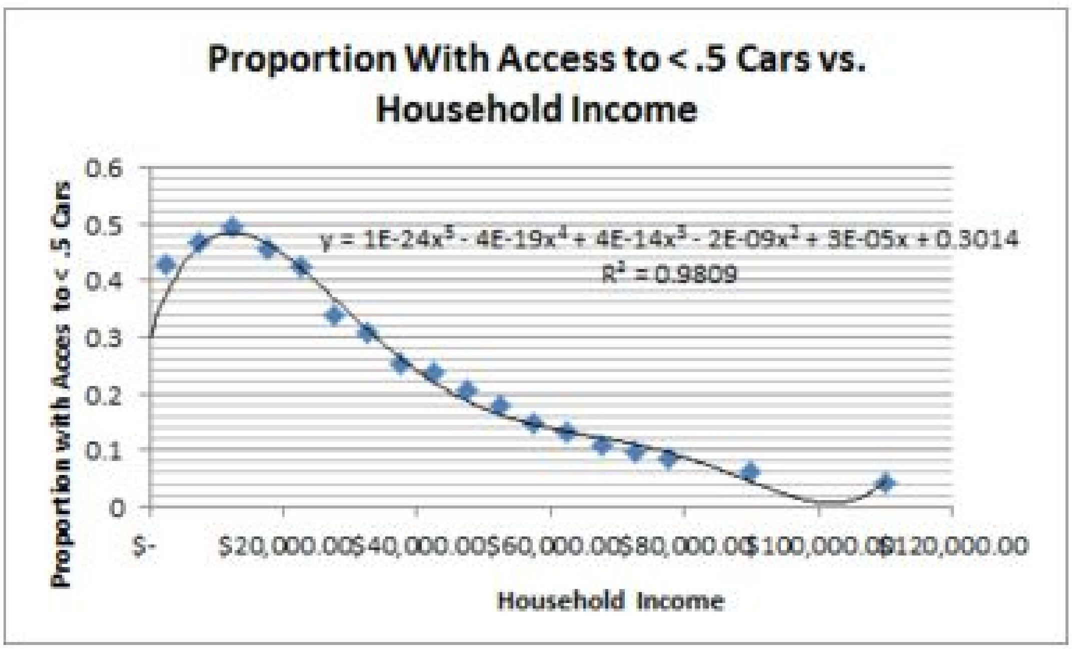


Figure [4b] - Proportion with Access to <.5 Cars vs. Population Density (halfCarPop(p))[4]



Figure[5b] - Hours per Day in Trips < 2 Hours vs. Income (halfCarIncome(i))[5]

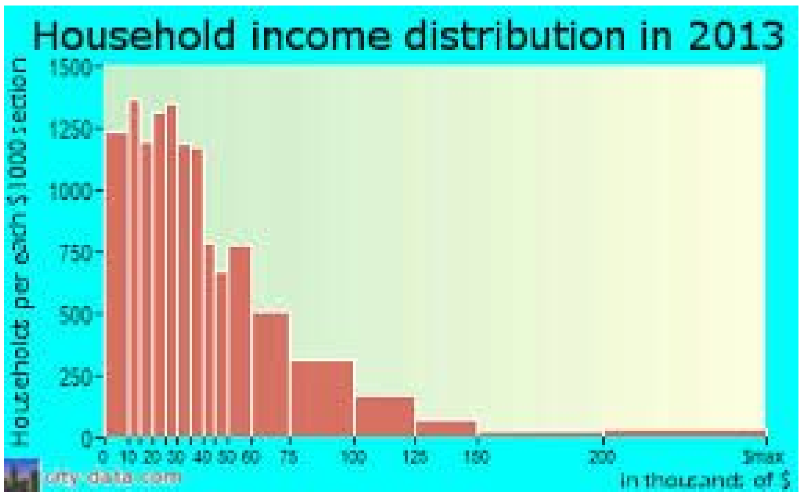


In this case, it is appropriate to use a high degree polynomial in order to approximate values because all calculations are interpolations. However, if we were to attempt to use this model to approximate values outside of this range, it would not be appropriate.

Equations 2, 3, 4, and 5 can be used to approximate the proportion of adults in any city who could be customers if the market was fully saturated in accordance with assumptions 5 and 8. In order to prevent this value from being too sensitive to fluctuations in either income distribution or population density, the expected values for each equation are averaged.

In order to find the value calculated using income distributions (using equations [3] and [5]) must take a weighted average of the proportion of people without cars weighted by the proportion of the population that is in this income bracket. This can be described analytically as for some set $S = \{x_i| x_i = \textit{median income of each income range}\}$ and
$T = \{p_i|p_i = \textit{proportion of of people in the city at that income range}\}$ each of size n.
These sets were defined by analyzing income distributions such as the one in *Figure [6].*

Figure [6] -Example of household income distribution (Knoxville).



For any city the total number of customers expected by that model, which can be called $Customers_{income}$.

$$[6]\ \ Customers_{income} = \sum_{k=1}^{n} p_k * I(x_k)$$

Where I is either equation [3] if calculating for no cars or [5] if for < .5 cars. Additionally $Customers_{population}$ can be calculated as

$$[7]\ Customers_{population} = P(pop)$$

Where P is either equation [2] if calculating for no cars or [4] if for <.5 cars. Thus, the calculated number of customers for each group will be [8] and the total will be [9]:

$$[8]\ \ Customers_{\ car\ no.} = 1/2 * Customers_{population} + Customers_{income}$$

$$[9]\ Customers_{total} = Customers_{zero} + ½ * Customers_{<.5}$$

Thus, we can then determine the estimated number of hours that a driver will spend in trips under 2.1 hours per day in accordance with assumption 6 in a very similar manner. Using Python code to scrape the National Household Travel Survey it was possible to find the average number of hours of these sorts of trips as described by population density as well as household income. These plots and their associated equations are available in Figures [7a] and [7b].

Figure [7a] - Hours per Day in Short Trips vs. Income (hourIncome(i)) [10]

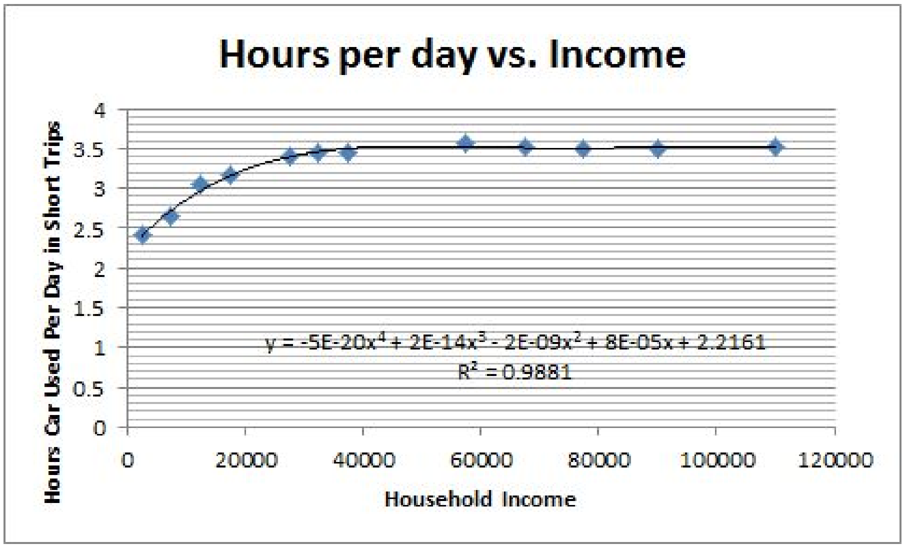
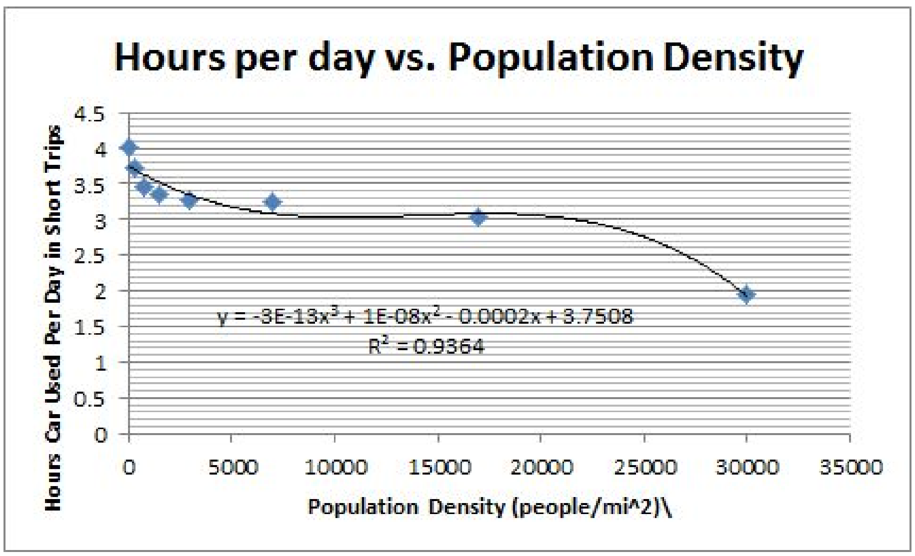


Figure [7b] - Hours per Day in Short Trips vs. Population Density (hourPop(p)) [11]



Thus in accordance with Assumption [5] we can estimate the number of hours that each customer would use the car by averaging the values from [10] and [11]. Using a similar methodology as was used for the number of customers and the same sets *S* and *T*:

$$[12]\ Hours = 1/2 * hourPop(pop) + 1/2 * = \sum_{k=1}^{n} p_k * hourIncome(x_k).$$

By multiplying equations [12] and [9] together by the population density and the price per hour ($8.77) we can determine the maximum possible revenue per day per square mile in each city. This relationship can be described as equation [13]

$$[13]\ Revenue = Hours * Customers * pop * 8.77$$

Thus, we get the following table.

	Poughkeepsie	Richmond	River	Knoxville

potential users	2242	1240	1200	652
estimated hours	3.18	3.28	3.40	3.51
revenue per day per square mile	$62,461.79	$35,708.38	$35,825.20	$20,072.22

Types of Ride-Sharing

1. Round-trip sharing
    a. Primary use: Running errands (such as grocery shopping)
    b. Car stations will be placed evenly throughout municipal regions
2. One-way floating sharing
    a. Primary use: Commuting to work
    b. Includes additional cost to cover the employment of "jockeys", who deliver cars to requested locations
    c. Because of aforestated cost augmentation, this method will be used by wealthier populations
3. One-trip station sharing
    a. Primary use: Commuting to work
    b. Cheaper alternative to floating sharing, therefore used by less wealthy populations; however, not as cheap as round-trip sharing
4. Fractional sharing
    a. Primary use: Private miscellaneous errands and activities
    b. Appeals to populations wherein people travel from nearby starting points to nearby destinations

For car-sharing services, there are four possible systems: round-trip, one way station, one-way floating, and fractional ownership. Each of these systems have unique benefits and drawbacks. These are as follows:

Round-Trip Car Sharing

Benefits

- Simple system
- Minimal work/cost for car supply service
- Well-suited for long trips

Drawbacks

- Requires the creation of reserved parking "bases"
- Somewhat infrastructure-intensive
- Not very flexible (in terms of pickup and dropoff) for consumers
- Consumers must find transportation to and from car bases

One-Way Floating Car Sharing

Benefits

- Most flexible pickup and drop-off for consumer
- Largest radius of travel possible
- No hassle of finding acceptable parking spots

Drawbacks

- Requires hiring "jockeys" who are paid employees
- Coordination/transportation system to get jockeys to cars is needed
- Car tracking system is needed

One-Way Station-Based Car Sharing

Benefits

- Flexible pickup and drop-off for consumer
- Car location (when parked) controlled
- Easy to establish stations in areas where commerce is concentrated

Drawbacks

- Most infrastructure-intensive
- Has tendency to create vehicle-stock imbalances
- Distribution of cars may become non-uniform; may require hiring individuals for redistribution

Fractional Car Ownership

Benefits

- Simple payment model
- Car type can be chosen for needs
- More expensive car models can be purchased
- More "clean" than alternatives- sharing among trusted people
- Good for people who use cars most often

Drawbacks

- Payment not based on actual usage
- Conflicts in which multiple parties need car at same time difficult to resolve
- Problematic in emergency situations
- Blocking time with other people can be very difficult

The model we create must take into account the following about the cities/towns we observe:

- residential population
- population density
- presence of college/university
- age distribution
- median household income
- availability/efficiency of public transport

- family size distribution
- proximity to large city

We first created a model to determine the proportion of each city's population that was likely to use a car sharing service. We wanted our model to take into account population density, income distribution, and likelihood of owning zero cars or <0.5 cars per adult in a given household (see graph). We formulated this function:

For people not owning a car: $0.5d + 0.5\sum_{k=1}^{n}(p_n * P(0|n))$

For people owning <0.5 a car: $0.5d + 0.5\sum_{k=1}^{n}(p_n * P(0|n))$

d = population density
p_n = proportion of town's citizens per income level n
$P(0|n)$ = probability of owning zero cars per income level n

We considered round-trip services to be most useful to residents conducting personal errands, and concluded that parental units of children ages 18 and younger would be most likely to partake in this type of driving trip. The mean age of parents of a newborn is 26 (according to Business Insider), so citizens of ages 25-44 would be most likely to partake in errands.

$p_a * k_1$ *= score for round-trip*
p_a *= Proportion of residents ages 25-44*

City	*Proportion of Residents ages 25-44*
Poughkeepsie, NY	*0.2920*
Richmond, VA	*0.3171*
Riverside, CA	*0.2997*
Knoxville, TN	*0.2955*
National Avg (U.S. 2010 Census)	*0.2660*

Bureau of Labor Statistics
One-way floating would be the most expensive option, because it requires the car company to pay a jockey. Therefore, high income levels correlate with this type of car sharing service. Those earning $75,000 or more are considered high-income (U.S. Census Bureau of Labor Statistics)

due to current income tax levels. Also, one-way floating is usually done by commuting workers, so employment rate will also increase the benefits of this type of car sharing.

$k_2(r_e + p_h)$ = *score for one-way floating*
r_e = *Employment rate of town*
p_h = *Proportion of high-income residents*

City	*Proportion of High-Income Residents*	*Employment Rate*
Poughkeepsie	*0.0600*	*94.2%*
Richmond	*0.0610*	*95.8%*
Riverside	*0.0983*	*94.1%*
Knoxville	*0.0452*	*95.2%*
National Average	*0.2868*	*94.5%*

We predict that low-income commuters will be less likely to use the floater system due to its higher price, and will therefore be more likely to use the one-way station system. Thus, we concluded that cities with a higher proportion of citizens making $40,000 to $75,000 (medium income) would be more likely to use the one-way station system. We will factor in employment rate because users of this system will be working commuters.

$k_3(r_e + p_m)$ = *score for one-way station*
r_e = *Employment rate of town*
p_m = *Proportion of medium-income residents*

City	*Proportion of Medium-Income Residents*	*Employment Rate*
Poughkeepsie	*0.2207*	*94.2%*
Richmond	*0.2448*	*95.8%*
Riverside	*0.3068*	*94.1%*
Knoxville	*0.2237*	*95.2%*

National Average	*0.2646*	*94.5%*

We deduced that college students would be most likely to use the fractional ownership system, because they are most likely to share a car. We therefore used college enrollment data from each city for the scoring of the fractional ownership system.

$k_4 * p_c$ = *score for fractional ownership system*
p_c = *Proportion of high-income residents*

City	*Ratio of college students to residents*
Poughkeepsie	*0.2674*
Richmond	*0.1792*
Riverside	*0.0975*
Knoxville	*0.1602*
National Average	*0.0555*

For the national averages, we will scale each equation for each system to make the function equal to 0.5, and solve for k.

$k_1 = 1.8797$
$k_2 = 0.4059$
$k_3 = 0.4134$
$k_4 = 9.009$

Note: Comparable between cities, not comparable between systems

City	*Round-Trip*	*One-Way Floating*	*One-Way Station*	*Fractional Ownership*
Poughkeepsie	*0.5489*	*0.4067*	*0.4807*	*2.4090*

Richmond	*0.5961*	*0.4136*	*0.4972*	*1.6144*
Riverside	*0.4318*	*0.4219*	*0.5158*	*0.8784*
Knoxville	*0.5555*	*0.4048*	*0.4860*	*1.4432*

Cities with the highest scores in a given system category would be most ideal for that category.
For example, out of the four cities, Richmond would be best for round-trip.
For another example, out of the four cities, Riverside would be best for floating.

Now, each entry was divided by the sum of all the entries in its row.

City	*Round-Trip*	*One-Way Floater*	*One-Way Station*	*Fractional Ownership*
Poughkeepsie	*0.1427*	*0.1057*	*0.1250*	*0.6265*
Richmond	*0.1910*	*0.1325*	*0.1593*	*0.5172*
Riverside				
Knoxville	*0.1922*	*0.1401*	*0.1681*	*0.4995*

For fractional ownership, we realize the national average unfairly skewed how ideal it was. We therefore made greater conclusions about the first three systems. (Poughkeepsie would be best for fractional ownership, though.

4. Planning/Execution of service

Analysis of the Problem (our interpretation of how to execute)

For the third part of the problem, we incorporated information on self-driving cars, and cars running on alternative (non-gasoline) energy. In order to do this, we looked at local laws and regulations regarding such vehicles along with government incentives for the purchase of electric vehicles.

Assumptions

1. In states that offer cash rebates for vehicles which run on renewable energy, programs that involve renewable energy vehicles will be less expensive and easier to implement than in states where rebates do not exist.
2. The savings associated with such rebates carry over to the customer; lower prices for car-sharing would result from such savings for the company.
3. Characteristics and public opinion of a state can be assumed to be characteristic of the entire state.

4. In states where people polled were more comfortable with self-driving cars, the implementation of programs involving self-driving cars will be more practical than in states in which public opinion of self-driving cars is negative.
5. Self-driving cars can be operated without any human present in the vehicle, and these vehicles will be lawful by the time of implementation. Laws are already being rolled out permitting self-driving cars, including in the relevant state of California.
6. Self-driving cars will be equally as safe as human-operated vehicles, and insurance prices do not differ. Technological errors on behalf of self-driving vehicles are readily compensated by the lack of human error as a concern.

A list of the 24 electric vehicles currently on the market was obtained, for which the average cost was determined; the number obtained was then subtracted by $7,500, which is the federal rebate for electric vehicles. This method produced $45,200 as the initial price of an electric vehicle, which would be originally purchased by the car-sharing company. This number is then to be divided by the respective state rebate subtracted from 45,200; for the four cities analyzed, only Knoxville and Riverside are in states which offer such an incentive, that being $2,500 in both cases. This is then multiplied by the decimal that represents the level of confidence that each state's residents have in self-driving cars, with 1 being full confidence. Tennessee is the lowest at 0.4; Virginia is 0.5, and California and New York are both 0.6.

$S = original\ score,\ R = state\ rebate,\ C = confidence\ level$

$$S * \frac{45{,}200C}{45{,}200-R} = adjusted\ score$$

City/Town	Original Score	Adjusted Score
Poughkeepsie	62461.79	37477.10
Richmond	35708.38	17854.20
Riverside	35825.20	22753.60
Knoxville	20072.22	8498.96

Coincidentally, the order for the cities remain the same, despite changing drastically. A crucial point to note, however, is that if a car is entirely capable of driving itself, this eliminates the need for a "jockey" to bring the it to a specific location, leaving only three options (round-trip, fractional ownership and floating). Round-trip would be the best for Richmond, floater would be the best for Riverside, fractional ownership is the best for Poughkeepsie, and round-trip is also the best for Knoxville. For any city for which sharing station is calculated to be the best model, floating point is the best model with self-driving cars being a reality.

5. Strengths and Weaknesses

This model accounts for a variety of factors that may differ between US cities, including average age, income distribution of residents, number of parents as a percentage of the total population, well-defined boundaries for what constitutes short, medium and long commutes for both distance and time, and thoughtful analysis of how futuristic technologies could be realistically implemented. However, there are weaknesses that were not very feasible to avoid. For example, factors such as climate could cause considerable changes to vehicle usage, and sporadic events such as crime could lead to serious problems for any car-sharing business attempting to enter a new market. In terms of the third part of this model, it is impossible to do more than educated guessing on how laws, technological innovations and public perceptions will affect the usage of cars that implement new technology. For example, while self-driving cars do exist and have already proven themselves to be competent, they have not achieved mainstream success and it is impossible to know how long it will take for them to do so.

6. Conclusion

Part 1:

	Low Time	Medium Time	High Time
Low Miles	66348	18949	55
Medium Miles	4274	80324	9380
High Miles	141	20599	62863

Part 2:

For Richmond, the optimal system was determined to be round-trip; for Knoxville, the optimal system was determined to also be round-trip; for Riverside, the optimal system was determined to be one-way floating; and for Poughkeepsie the optimal system was determined to be fractured ownership

Part 3:

If we had more time, we would have liked to analyze many more factors for what makes a car-sharing system optimal for any given city. Tourism rates, population distribution, amount of businesses in the area and public transportation availability were all considered, but in the short period of time allotted to us, we were unable to account for everything. Additionally, we would have liked to look at different types of alternative fuel which cars can run on, and the environmental impacts of these fuels in comparison to traditional gasoline. As global climate change becomes an ever-increasing issue, finding and utilizing alternative fuels matters more and more.

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