Share and (Car) Share Alike

Team #6996

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Dear Car-Sharing Services,

People are making practical innovations in our society everyday. One of the most prominent and revolutionary ideas was Henry Ford's development of the production line. This allowed for rapid production of cars, which inevitably made them more affordable for the common person. This has lead to the car becoming one of the most commonly used forms of transportation. However, now people are looking for car-sharing services, causing us to come full circle as a society. People want the enjoyment of driving a car without the responsibilities and costs of owning one. And as always, where the people go, the investors will follow. This has lead to a dramatic spike in the car-sharing industry and has given us a glimpse into a more efficient future. High usage of car-sharing industry has the potential for less pollution, less traffic, and a greener Earth.

Our job was to first develop a mathematical model that solved for the percentage of people who travel a low, medium, and high distance or time. We did this by researching the number of miles and the time spent traveling and taking an average for the low, medium, and high categories. We found that regardless of the distance that one has to travel, most people take a long time to travel, most likely due to the amount of traffic we experience in our everyday lives.

Then, we sought to develop a mathematical model that calculates the most effective car-sharing business option for a city or location based on several different factors. The four factors we used were: population, travel time, public transportation availability, and wealth. We developed an arbitrary number system to decide which of the four car-sharing options is best for each of the given cities or locations. We used research and common sense to assign point values to each of the options for each of the factors. We observed that the more urban areas tended towards one way methods such as floating and station, while more suburban areas tended towards the round-trip options.

Finally, we devised a model to determine the most useful method of car-sharing for a city where everyone has an electric self-driving car. We evaluated the same four factors as our previous model, but this time we discovered that each city would benefit the most by using one-way floating car-sharing. This makes sense because one-way floating car-sharing is the most convenient mode of transportation for almost any situation because it takes you where you need to go, doesn't require you to drive, and is the same price as other car-sharing methods.

The world we live in is rapidly changing. As the times change, so do people's preferences. And right now it seems society is shifting towards the car-sharing business. As we found in our data, this could be a very real outcome with the creation of electric and self-driving cars.

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1 Introduction

1.1 Background

We live in a world run by technology, where hundreds of millions of cars are used each day around the world. Due to the controversy of the heavy usage of automotives, car sharing has become an attractive option for both saving resources and decreasing pollution. Companies such as General Motors are investing money to institute car-sharing and rental programs such as Lyft [9]. There are several different options for car-sharing such as round-trip car-sharing, one-way floating or station car-sharing, and fractional ownership, each method having its own benefits depending on the location and population [14].

Another factor of car sharing programs is the use of alternative fuel in cars and self driving automotives. The use of electric cars will further increase the amount of users and providers in car sharing programs because it will be cheaper to run, easier to afford, and better for the environment.

1.2 Restatement of the Problem

With the emergence of car-sharing as an alternative option for consumers, we were asked to consider and develop models for the following situations:

1. Determine the percentage of current U.S. drivers in varying degrees of amount of time spent using the car and miles driven per day, which will aid in finding how willing consumers are to using car-sharing services.
2. Determine which of four current car-sharing options (round trip, one-way floating, one-war station, and fractional ownership) would be best suited for a given city, ultimately deciding if a car-sharing company should further investment in certain cities.
3. Determine adjustments for our model from part two given the usage of self-driving cars and environmentally friendly vehicles, then reevaluating which model is best for the given cities.

2 Too Much Driving

2.1 Preface

Consumers consider many factors when deciding whether to purchase a vehicle or use car-sharing services. Opposite from the consumer end, as the car-sharing industry grows from a collaboration of nonprofits and co-ops to a for-profit industry [1], companies must consider a variety of factors before investing in car-sharing services, with the chief amongst these being amount of time consumers use their cars and miles driven per day. We used data from the National Household Travel Survey (NHTS) to compile percentages of drivers in varying levels of the main deciding factors.

2.2 Assumptions and Justification

To extend our model to encompass all drivers in the United States and therefore obtain the widest range of information to be considered in our model, we made the following assumptions, with provided justification:

- **Assumption:** The weather doesn't affect the data.
  Justification: This is a safe assumption because while weather conditions can lead to a significant increase in travel time, it'll affect all of the different categories, so the overall effect to one category is minimal.

- **Assumption:** Gender, age, and ethnicity don't influence driving habits heavily.
  Justification: All people, regardless of age, gender, or ethnicity, own a car (if they can afford it) and drive to different places.

- **Assumption:** Data obtained from the NHTS is an appropriate representation of the general population.
  Justification: The NHTS uses a random digit dialing service to conduct their survey, and the random nature of this sampling type balances many factors that may contribute to skewing the results. While random digit dialing may exclude those without access to a phone, it is reasonable to infer that those who drive have sufficient resources to have access to a phone.

2.3 Obtaining Data from the NHTS

The 2009 National Household Travel Survey (NHTS) provides information to assist transportation planners and policy makers who need comprehensive data on travel and transportation patterns [2]. We were able to find statistics on the average miles driven per day per person and the average time spent traveling per day per person, and compile these two statistics together to come up with the general percentages for drivers in categories such as low time, low mileage; low time, medium mileage; low time, high mileage; and so on.

Figure 2.1-Statistics Obtained from the NHTS

2009 NHTS
Avg. Miles Driven per Day per Driver, All Drivers

Derived total HH income	Avg Miles Driven	
	Sample Size	Mean
Refused	13,096	30.46
Don't know	3,918	17.01
Not ascertained	52	17.21
< $5,000	2,535	15.43
$5,000 - $9,999	5,295	17.09
$10,000 - $14,999	8,307	22.28
$15,000 - $19,999	10,300	19.01
$20,000 - $24,999	9,286	22.85
$25,000 - $29,999	14,272	23.43
$30,000 - $34,999	8,666	28.79
$35,000 - $39,999	14,867	24.83
$40,000 - $44,999	7,450	29.80
$45,000 - $49,999	14,975	29.12
$50,000 - $54,999	6,906	30.67
$55,000 - $59,999	14,128	30.39
$60,000 - $64,999	5,550	30.41
$65,000 - $69,999	12,332	30.76
$70,000 - $74,999	5,727	31.63
$75,000 - $79,999	12,179	33.56
$80,000 - $99,999	24,520	33.84
> = $100,000	55,521	34.59
All	249,882	28.97

2009 NHTS
Avg. Time Spent Traveling per Day - All Persons (Minutes)

Derived total HH income	Avg Minutes Traveling	
	Sample Size	Mean
Refused	15,075	74.32
Don't know	5,419	55.72
Not ascertained	64	52.52
< $5,000	4,346	69.14
$5,000 - $9,999	7,997	65.19
$10,000 - $14,999	11,444	69.21
$15,000 - $19,999	13,539	64.04
$20,000 - $24,999	11,827	66.39
$25,000 - $29,999	17,464	69.26
$30,000 - $34,999	10,571	75.82
$35,000 - $39,999	17,804	68.95
$40,000 - $44,999	9,035	75.56
$45,000 - $49,999	17,746	73.03
$50,000 - $54,999	8,338	70.91
$55,000 - $59,999	16,854	76.20
$60,000 - $64,999	6,743	72.75
$65,000 - $69,999	14,820	73.85
$70,000 - $74,999	6,966	79.00
$75,000 - $79,999	14,714	80.31
$80,000 - $99,999	30,175	79.82
> = $100,000	67,960	84.68
All	308,901	74.71

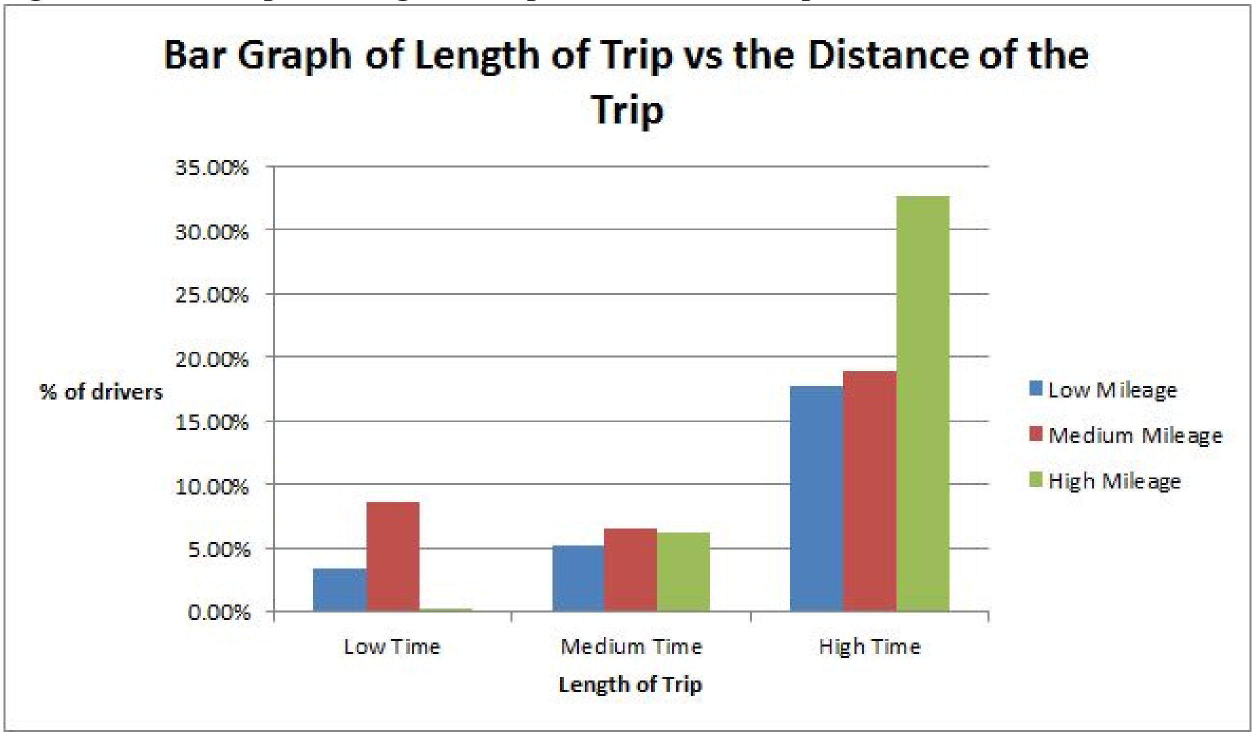
Source: Federal Highway Administration, 2009 National Household Travel Survey (NHTS)
Tabulation created on the NHTS website at http://nhts.ornl.gov

Using this information, we took data from the highs and lows to arrive at a percentage and then averaged them to get our final percentage. For example, we took the data point at $5000-$9999 for low mileage and at $5000-$9999 for low time and found the averages.

Model 2.1-Percentage of U.S. Drivers in Car-Sharing Consideration Factors

Amount of Time Using Car vs. Miles Driven Per Day		Amount of Time Using Car		
		Low	Medium	High
Miles Driven Per Day	Low	3.4%	5.2%	17.8%
	Medium	8.6%	6.5%	18.9%
	High	0.3%	6.3%	32.7%

Figure 2.2-Bar Graph of Length of Trip vs. Distance of Trip



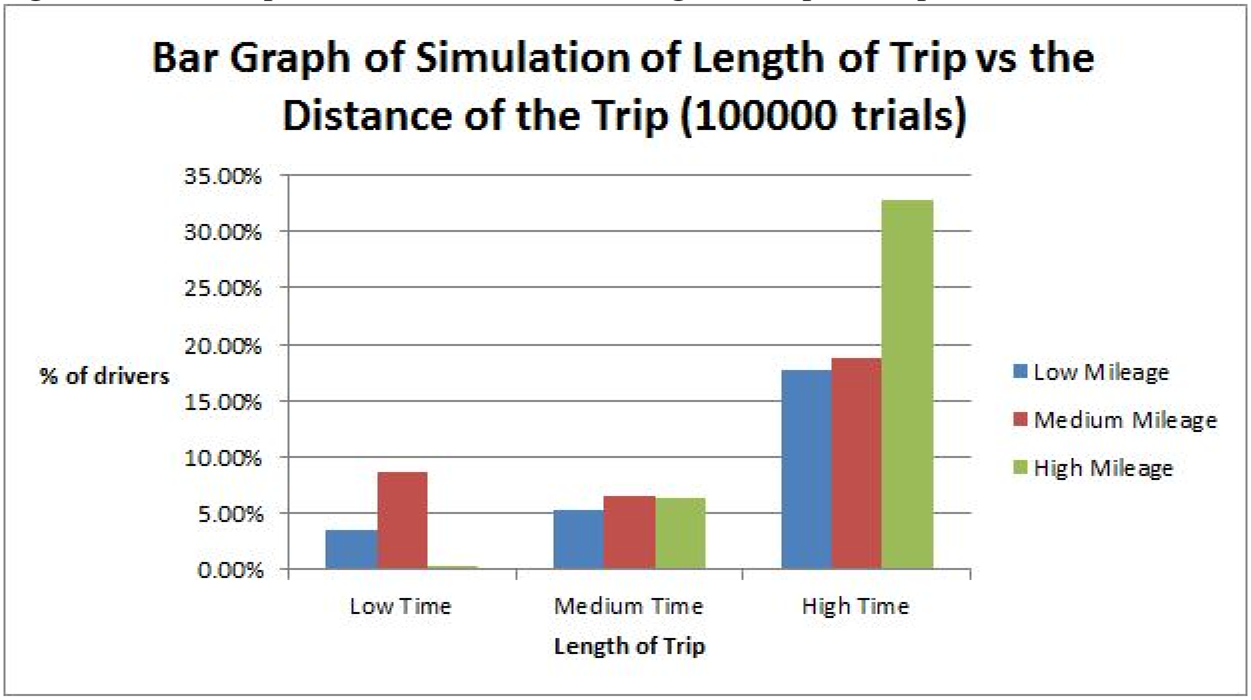
2.4 Sensitivity Analysis

Here we used a simple Java program we created to run a simulation to check the accuracy of the data for our above model:

Model 2.2-Simulation: Amount of Time Using Car vs. Miles Driven Per Day (100000 trials)

<u>Simulation Results:</u>		Amount of Time Using Car		
		Low	Medium	High
Miles Driven Per Day	Low	3.45%	5.24%	17.7%
	Medium	8.63%	6.49%	18.72%
	High	0.295%	6.32%	32.8%

Figure 2.3-Bar Graph of Simulation Results: Length of Trip vs. Trip Distance



The simulation helps to confirm that our data and model are correct. All percentages are within 0.2% difference from the data to the simulation, and the number of trials (100,000) is less than the number of people interviewed for the data (about 250,000). This shows that the number of people interviewed should be a sufficient sample size of the entire target population of the U.S.

2.5 Strengths and Weaknesses

2.5.1 Strengths

- The model shows and compares the relationship between Distance to Travel and Amount of Travel Time.
- The data collected from the sample can be treated as an effective representation of the population because the samples were obtained randomly and the sample size is sufficiently large.

2.5.2 Weaknesses

- The model doesn't define a specific range for low, medium, and high distances or times. This creates a vague defining point for how far someone travels. This is the same with time spent driving.

2.6 Investigation 1 Wrap-Up

The data shows that regardless of the distance people drive, for the most part it takes a high amount time. This is probably mostly due to the high traffic people see on the roads today. With the growing technology and production, the new generation of kids are becoming more accustomed to the developing technology and cars are becoming easier and easier to afford. This higher rate of affordability leads to more and more cars out and the road, which inevitably causes more traffic on the roads.

3 Zippity Definitely Do It

3.1 Preface

Even though a car-sharing company may determine that it is generally a profitable idea to implement their services in a city, the next step in the process is to decide on what the best business option is, amongst round trip car sharing, one-way car sharing floating model, one-way car sharing station models, and fractional ownership. Each method offers different costs and benefits, and we considered different factors in a city to determine the optimal model for a company to implement [13,15,17].

3.2 Assumptions and Justifications

To diminish the number of egregious factors we would have to consider and reach concision in our modeling process, we made the following assumptions:

- **Assumption:** We assume that a large portion of the driving people will do is to their place of work.
  Justification: Though people will occasionally take trips to locations such as shopping centers and appointments, the most constant need for transportation is to a place of employment. This assumption helped us to judge the value of the different options in car-sharing services.
- **Assumption:** The factors that go into deciding which car-sharing service to use do not greatly influence one another.
  Justification: While a city may be urban which leads to greater public transportation, we can make the assumption that the factors do not highly impact each other because every combination of factors should be possible, even though one may be more likely than another.
- **Assumption:** Fractional ownership is a very similar arrangement to carpooling.
  Justification: Whereas fractional ownership is many owners jointly purchasing a private car, carpooling is similar because though each person may have a vehicle and you are transporting multiple people, the costs would show that it is effectively the same as many people owning and using one vehicle, due to the fact you are transporting many people at one time.
- **Assumption:** If people have the capability of using public transportation, they will most likely choose that (or some other mean that isn't driving) over a car-sharing service.
  Justification: As is with economics, people make rational decisions and will choose the cheaper option to save money. Public transportation also means that people have the capacity to multitask while traveling, instead of having to focus on the driving with a car-sharing service, so that public transportation becomes a more attractive option.
- **Assumption:** The cost for the round trip service will be based on the mileage.
  Justification: One of the standard models for pricing in the round trip car-sharing service is by the mile or by gas usage, therefore we will adopt this pricing model when considering the weights of our factors.

3.3 Creation of the Model

To garner the most participation for a specific option of a car-sharing service, we realized that many factors would have to be considered in the decision making process. Cities across the United States vary in many aspects, and each of these aspects have a potential to impact the success of a car-sharing service. Based on discussion from various sources and logic amongst the group, we collectively determined the most influential factors when implementing a car-sharing service to be [8]:

- Population
- Established public transportation
- Average travel time to work
- General wealth of city

Though there are a countless number of potential other factors, we concluded that these would have the greatest direct impact on car-sharing services as they relate most clearly to business' considerations like potential users, benefits over public transportation and more. With these four key factors, we were able to create a model that looks at important factors, though these factors may differ greatly between cities.

Taking the four key factors and breaking them down into categories, such as rural, suburban, and urban for population, we then subjectively assigned weights to each of the four car-sharing services based on how desirable they would be in that category of population, or category of established transportation, or etc. For the wealth category, we looked at the GDP per capitas of many different locations, and determined that the best divisions to obtain a reasonable number of cities in each division were $0-20,000, $20-25,000, and >$25,000. The model we came up with looks like:

Model 3.1 - Scoring Criteria for Car-Sharing Options Divided by Influencing Factors

4 - Highest **1 - Lowest**		**Round Trip**	**Floating**	**Station**	**Fractional Ownership**
Population	**Rural**	**3**	**2**	**1**	**4**
	Suburban	**3**	**4**	**1**	**2**
	Urban	**2**	**3**	**4**	**1**
Established Public Transportation	**Low**	**4**	**2**	**3**	**1**
	Medium	**2**	**3**	**4**	**1**
	High	**2**	**4**	**3**	**1**
Average Time to Work (minutes)	**<20**	**4**	**1**	**3**	**2**
	20-40	**4**	**1**	**2**	**3**
	>40	**3**	**1**	**2**	**4**

Wealth (GDP per Capita in dollars)	**0-20,000**	**2**	**1**	**3**	**4**
	20-25,000	**1**	**2**	**4**	**3**
	>25,000	**3**	**4**	**2**	**1**

As demonstrated above, we judged how viable each option would be using common sense and more research to determine an arbitrary weight, one to four, for the option in a given situation.

For insight into the process we used, we can look at the four options in a rural setting. We judged that fractional ownership would be most desirable because inhabitants are not constantly driving. Therefore, they would not have a large need for constantly available services like one-way station or one-way floating car-sharing. Rather, a "communal" vehicle would be effective in meeting the needs of the people while still keeping costs low for the people, so that the service would see a lot of participation.

As another example, in an area with a high amount of established public transportation, we found a one-way floating car-sharing service to be the most desirable [18]. This decision was made based on the idea that people will preferably take the public transportation they have available, as it will be a quick and relatively cheap option. However, if a car-sharing service were to be implemented, then people would take to the quick availability of a floating service that can be demanded if they decided not to use public transportation someday, while a roundtrip or fractional ownership service would not be desirable because they are longer-term options, and do not meet the instant demand that those used to public transportation need.

After weights for every category have been determined, the total score for a car-sharing option can then be evaluated with the function:

$$S = P + Tr + T + W$$

where S is the score for one given car-sharing option, and P represents the scores obtained from the population category, Tr from the transportation category, T from the average time to work category, and W from the wealth category. The best car-sharing option for a city can then easily be determined using $Max|S_R, S_F, S_S, S_{Fr}|$

3.4 Evaluation of the Model

In order to use our model to evaluate the best car-sharing option for the given cities, we first needed to determine the characteristics of the given cities. Once the characteristics of a city are determined, the model gives a fairly clear reading on the best choice for car-sharing implementation in the city. The model will also effectively rank the four options, so that not only do we obtain the option that should have the most effective implementation, but we learn how comparatively effective the other options would be.

The statistics we obtained for Richmond, Virginia indicated that it is an urban, high transportation, high wealth area, with average travel times to work in the 20 to 40 minute range

[4,8]. Plugging these conditions into our table model, we found the following rankings for how the four options of car-sharing would work in Richmond:

Table 3.1 - Scores evaluated for Richmond, Virginia

Richmond, VA	Round Trip	Floating	Station	Fractional Ownership
Urban	2	3	4	1
High Transportation	2	4	3	1
20-40 min	4	1	2	3
High Wealth	3	4	2	1
Totals	11	12	11	6

As can be seen from the totals, our model indicates that a one way floating car-sharing service would garner the most participation in an urban location like Richmond. The model is useful for more than just the top choice, because we can see that fractional ownership, with a score of only 6, would prove to have a very weak implementation in Richmond, and also that a round trip or one-way station service could be a very close alternative to the one-way floating service.

We then went with the same procedure for the other three cities, obtaining information about the four factors and evaluating the effectiveness of the four options with our established model. Sources showed that Poughkeepsie was a suburban, low public transportation, and medium wealth location, with an average travel time of 20 to 40 minutes [7,8]. Thus the rankings came out as follows:

Table 3.2-Scores Evaluated for Poughkeepsie, New York

Poughkeepsie, NY	Round Trip	Floating	Station	Fractional Ownership
Suburban	3	4	1	2
Low Transportation	4	2	3	1
20-40 min	4	1	2	3
Medium Wealth	1	2	4	3
Totals	12	9	10	9

For Poughkeepsie, our model indicates that the round trip option is the optimal implementation, followed by a one-way station implementation, and finally a tie with one-way floating and fractional implementation.

Carrying on, we found out Knoxville, TN, is an urban, high public transportation, medium wealth area, with an average travel time of less than twenty minutes [5,8]. Using the standard model, we determined the following scoring:

Table 3.3-Scores Evaluated for Knoxville, Tennessee

Knoxville, TN	**Round Trip**	**Floating**	**Station**	**Fractional Ownership**
Urban	**2**	**3**	**4**	**1**
High Transportation	**2**	**4**	**3**	**1**
< 20 min	**4**	**1**	**3**	**2**
Medium Wealth	**1**	**2**	**4**	**3**
Totals	**9**	**10**	**14**	**7**

In Knoxville, our model indicates that the one-way station implementation would be the best for a car-sharing company. This result makes sense because in an urban area with high public transportation, a one-way station system would act a lot like public transportation so people would take to it quickly, and with the medium wealth and short travel times, people wouldn't need the floating service, which is more geared towards slightly longer travel times and will probably cost more.

Last but not least, we took a look at Riverside, California, a beautiful, urban, high public transportation, medium wealth city, where the average travel time to work is 20 to 40 minutes [6,8]. Plugging these characteristics into model results in the following scores:

Table 3.4-Scores Evaluated for Riverside, California

Riverside, CA	**Round Trip**	**Floating**	**Station**	**Fractional Ownership**
Urban	**2**	**3**	**4**	**1**
High Transportation	**2**	**4**	**3**	**1**
20-40 min	**4**	**1**	**2**	**3**
Medium Wealth	**1**	**2**	**4**	**3**

Totals	**9**	**10**	**13**	**8**

From these scores, we can deduce that the one-way station implementation is the best option for long term success in Riverside. The one-way station car sharing obtained a score of 13, which was three points higher than any other service, and the other three services scored closely to each other, so the one-way station service stands out as the clear choice according to our model.

3.5 Strengths and Weaknesses

3.5.1 Strengths

- The model is vague and therefore it can be applied to many different cities with varying factors.
- Our model not only determines the business option that will theoretically garner the greatest participation, but the scoring nature of the model reports the next best options, which can also be considered if a certain service is not implementable for some reason.

3.5.2 Weaknesses

- The model is vague and general in the ranges for our categories and might not be completely accurate in determining the specific needs of a given city or location.

3.6 Investigation 2 Wrap-Up

Our model can be used for many cities. We found that fractional ownership cannot be used every time because it involves more complications. Generally with urban cities, stations are easier and provides a cheaper option. This might be because cities will most likely include many stations where the cars can be dropped off. Cities also include high amounts of public transportation such as buses, which can then be used to return home after returning cars to the station.

4 Road Map to the Future

4.1 Preface

Transportation will be revolutionized by the introduction self driving cars and the more common use of the electric cars [11,12]. Many sources say that this revolution is in the very near future as companies such as Ford and General Motors invest billions of dollars to help advance the research into both electric and self driving automotives [9]. In fact, Ford predicts that 40 percent of its users will be driving electric cars by 2020 [10]. To determine the method of car sharing best suited for a city in the future, where everyone has electric, self driving cars, we used our model from the previous part while changing some strengths to better represent the circumstance.

4.2 Assumptions and Justifications

Since the use of self-driving cars and clean vehicles is still a very new and experimental process, we need to make a few assumptions to be able to model for the best car-sharing service. All assumptions from part 3.2 stand for this section in addition to:

- **Assumption:** All cars used by car-sharing companies will be self driving and run on alternative fuel.

Justification: As we progress into the future, self-driving and clean cars will become more and more mainstream as they provide both convenience for the user and are economical for the company. Given enough time and these potential benefits, car-sharing companies will almost definitely choose to use the cars of the future.

4.3 Alterations to the Model

Working off the foundation of the second question, the model we generated for the car-sharing industry after the introduction of self-driving and clean cars takes a very similar format to our model from the previous section, however we altered the weights of categories accordingly in response to how both we and sources felt that the use of self-driving cars would affect the desirability of each service.

Our group observed most notably that the one-way car-sharing floating model would be immensely more desirable, as the "jockey" component would be almost completely unnecessary. The self-driving car could be requested, it would show up at your location, one would drive or be driven to their destination, instead of a specific defined area, and then the self-driving component would be used again to fulfill another request. Not needing a jockey means that many wages can be eliminated to theoretically reduce the overall cost of the service, and thus why it is so much more rational. Self-driving cars also reduce the need for the one-way car-sharing station option. If the self-driving cars are picked up and dropped off in dedicated stations, the potential of the self-driving aspect is almost entirely wasted. Keeping these facts in mind, our new model for deciding which of the four car-sharing options to use is as follows:

Model 4.1-Scoring Criteria for Car-Sharing Options Divided by Influencing Factors after Implementation of Self-Driving Cars

4 - Highest 1 - Lowest		**Round Trip**	**Floating**	**Station**	**Fractional Ownership**
Population	**Rural**	**2**	**3**	**1**	**4**
	Suburban	**3**	**4**	**1**	**2**
	Urban	**2**	**4**	**3**	**1**
Established Public Transportation	**Low**	**4**	**3**	**2**	**1**
	Medium	**2**	**4**	**3**	**1**
	High	**2**	**4**	**3**	**1**
Average Time to Work (minutes)	**<20**	**4**	**3**	**2**	**1**
	20-40	**3**	**4**	**2**	**1**
	>40	**3**	**2**	**1**	**4**

Wealth (GDP per capita in dollars)	**0-20,000**	**3**	**2**	**1**	**4**
	20-25,000	**2**	**4**	**1**	**3**
	>25,000	**3**	**4**	**2**	**1**

A notable difference, as discussed above, is that the floating method takes higher or similar values in every category. Also noteworthy is that in the average time to work category, the fractional ownership category takes much lower values, as a result of the fact that floating cars now dominate the table and that having self-driving and clean cars available to rent instead of buy (since they may be expensive), makes actually owning a vehicle much less desirable.

4.4 Evaluation of the Model
Much like the process we used before, we were able to obtain characteristics of the cities in question, plug them into the model with updated weights, and therefore obtain the relative rankings of the four car-sharing services.

The new scores for Richmond, Virginia were as follows:
Table 4.1-Updated Scores for Richmond, Virginia

Richmond, VA	Round Trip	Floating	Station	Fractional Ownership
Urban	**2**	**4**	**3**	**1**
High Transportation	**2**	**4**	**3**	**1**
20-40 min	**3**	**4**	**2**	**1**
High Wealth	**3**	**4**	**2**	**1**
Totals	**10**	**16**	**10**	**4**

Here, we can observe that one-way floating car-sharing is the clear winner, taking an almost perfect score, while fractional ownership is far on the bottom, and both round-trip and stations take a middle ranking.

New model scores for Poughkeepsie were:
Table 4.2-Updated Scores for Poughkeepsie, New York

Poughkeepsie, NY	Round Trip	Floating	Station	Fractional Ownership
Suburban	**3**	**4**	**1**	**2**
Low Trans.	**4**	**3**	**2**	**1**

20-40 min	**3**	**4**	**2**	**1**
Medium Wealth	**2**	**4**	**1**	**3**
Totals	**12**	**15**	**6**	**7**

One-way floating was still the winner, but round-trip was not as far behind, and both one-way station and fractional ownership nearly tied for last. This makes sense based on our sources and though process because Poughkeepsie is the closest to rural of the four given cities, therefore inhabitants will most likely be taking round trips from residence to a workplace or similar location, though they will not be traveling the short one-way distances that the floating service tends to.

Updated scores obtained from our new model for Knoxville were:

Table 4.3-Updated Scores for Knoxville, Tennessee

Knoxville, TN	**Round Trip**	**Floating**	**Station**	**Fractional Ownership**
Urban	**2**	**4**	**3**	**1**
High Transportation	**2**	**4**	**3**	**1**
< 20 min	**4**	**3**	**2**	**1**
Medium Wealth	**2**	**4**	**1**	**3**
Totals	**10**	**15**	**9**	**6**

Yet again, our model predicts that the one-way floating service would garner the most participation in a location like Knoxville, Tennessee. Results for Knoxville were generally very similar to results from Richmond, Virginia.

Lastly, we looked at Riverside with the updated model to obtain the following scores:

Table 4.4-Updated Scores for Riverside, California

Riverside, CA	**Round Trip**	**Floating**	**Station**	**Fractional Ownership**
Urban	**2**	**4**	**3**	**1**
High Transportation	**2**	**4**	**3**	**1**
20-40 min	**3**	**4**	**2**	**1**

Medium Wealth	**2**	**4**	**1**	**3**
Totals	**9**	**16**	**9**	**6**

Somewhat unsurprisingly, the one-way floating car-sharing model scores the highest in this city as well. Compiling the results from all four cities shows that the one-way floating service proves the most advantageous in nearly every situation once self-driving cars are implemented.

4.5 Strengths and Weaknesses

4.51 Strengths

- The model accurately addresses the likely future and the outcomes of having electric and self-run cars.
- We can easily observe that a one-way floating system would be the most useful in any kind of community.
- Our model again works for any city and incorporates 4 vital factors to choosing a method of car-sharing.

4.5.2 Weaknesses

- The model is vague in its categories for each factor and may not accurately represent a city's specific needs.

4.6 Investigation 3 Wrap-Up

Our updated model reflects the impact that the introduction of self-driving, clean cars into the mainstream would have on the relative value of each of the four car-sharing options. We saw that the one-way floating model dominated each location as a result of our assigned weights. While this may reflect the reality and importance of self-driving cars, in a reiteration of the model, we may want to address these results by altering the heavy weight on one-way floating model.

5 Conclusion

In our solution, we modeled the factors that we thought contributed to the four car-sharing options: Round Trip, Floating, Station, and Fractional Ownership. First, we created a model that represents the percentage of drivers who fall into certain categories of trip length and trip distance. We used a simulation of 100,000 drivers created in a Java program to see how well it fit our data. This simulation gave us insight into the average driver and his or her behavior.

Then we weighed a few factors - population, public transportation, average time to work, and average wealth of the city - to determine which car-sharing option was the best choice. We applied these factors to four cities - Richmond, VA; Riverside, CA; Knoxville, TN; and Poughkeepsie, NY - and believe our model could represent other cities in the US.

Finally, we factored in the information that self-driving cars and vehicles that run entirely on alternative fuel or renewable energy are close to entering the mainstream [9,10]. These technologies have the potential to dramatically change participation in car sharing as individuals could have environmentally friendly vehicles delivered to their doorstep on demand. With this, we determined that one-way floating model has much more relevance because people would not have to worry about returning the car, as it can drive itself back. After re-weighing our factors with the four cities, we found that the floating model is the most efficient for those cities. Therefore, we believe the floating model will become more and more popular with the addition of self-driving cars.

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