

Travel Reimbursement Cost Analysis

Liam Davies, Anthony Thoel and Connor White

The Overview

Kicking off the start of the year, spring of 2017 a handful of students here at McKendree University were tasked with a project to help the Girl Scouts of America: Southern Illinois Chapters. The Chapters of Glen Carbon IL, and Mount Vernon IL, approached McKendree University for a solution to a real world problem that needed to be solved within their organization. Under the Guidance of Dr. Heather Dye – A Professor of Mathematics here at McKendree University, and with support from PIC Math, the Society for Industrial and Applied Mathematics, as well as the National Science Foundation (NFS Grant DMS-1345499), a driven group of problem solvers decided to take on the challenge and tackle this problem. This would be a first experience for the students to take on and provide a solution to a true real world logistical problem.

Over a recording time of 2 fiscal years, the Girl Scouts of Southern IL recorded some several thousand travel entries that varied in category, magnitude, destination, as well as many other factors. These recordings were logged in an Excel Spreadsheet where each volunteer was tasked with recording their own travel from a central document where they would append their new travel event information to the end of the existing master document. This system was set in place for obvious logistical reasons that would be beneficial to the organization for later review, in a similar matter that any other everyday organization might also record different logistical statistics about their business, club, or organization.

This project entailed examining the raw data recorded by the Girl Scouts of Southern Illinois' two Chapters of Glen Carbon IL, as well as Mount Vernon IL in order to determine if the current method of travel that the Girl Scout organization had been following was in fact the most efficient method. As opposed to a new method that would require the organization to purchase, one, or more cars that would remain strictly tasked with Girl Scout Company Travel, in order to truly become more efficient in their travel expenses. These travel expenses stated above come from the travel required between the two organizations in order to make sure volunteers could make meetings, summits, or other organizational events. The travel data also entailed trips where troop members, cookies, or other supplies were being transported to a long list of possible destinations and events. These travel events required two methods of compensation. The first method of compensation was directly debiting the volunteer who would drive their personal vehicle for the trip, and was thus reimbursed based on mileage costs established by the organization. The second method of compensation was directly debited to Enterprise Rental Services where a certain trip required a longer distance of travel, that per the organizations established rules, warranted Enterprise Car rental. Combined, these expenses logged both separately and differently across the two offices in Glen Carbon, and Mount Vernon would sum to the Girl Scouts of Southern Illinois' total travel expenses per year, over the two years in study which became our baseline of expense history to begin analysis on. Our goal from the beginning of the project was to recommend a number of cars to the organization for purchase or lease that was not only affordable, but also beneficial and efficient specifically to each member of the chapter. This garnered a need for analysis of their travel data, in order to extract specific statistics to show that the existing travel policy was in fact the most efficient. If our studies would prove otherwise we would then recommend a different policy to the Girl Scouts in order to help them save organizational funds long term.

Upon beginning the project, one thing became evidently clear from the first glance over of the data by all the students of the class. The data was recorded imperfectly, much like data is commonly recorded imperfectly in the real world. The group noticed immediately that multiple data types that would prove later on to be extremely valuable, were condensed into one single column within the Excel document where sorting and sifting for said values would not be possible. This simple fact is part of our everyday lives as future students of Data Science and we must continue to be flexible with the people we work with in order to give those results no matter how good or bad the data might be. It is extremely important today to be flexible in our field of work being that data is fueling the markets of tomorrow and that data is, and will always be recorded and shared imperfectly.

With respect to this group of students, it was extremely beneficial to not only take on a problem and provide a solution to it, but also extremely beneficial to see exactly what the real world will look like outside of school. This project directly exemplified the real world type of problem solving teams that would be formed where students of Mathematics, Computer Science, and Education would join together to combine their expertise in order to solve a larger problem that without each other they might not have been able to solve. In the following sections the project will be broken down into a synopsis of exactly what steps were taken from the beginning, being the cleansing of the raw data given, all the way through our findings specific to the Girl Scouts current policy, as well as our own recommendation for the organizations travel policy.

The Data Analysis

From the start of the project, it was evidently clear that due to the large amount of data entries in the raw data, automation was going to be required. The data originally consisted of some several thousand lines of manually entered travel dates to where each entry consisted of several columns. These columns varied from Codes representative of separate Girl Scout functions, volunteer names, dates traveled, description of travel, Date of transaction, transaction debits, as well as transaction debits and credits. This pattern was represented across the multiple data sheets we were given ranging from two separate offices over 2 years. These sheets while organized to an extent had one major flaw typically found in the data recording process when people are not aware of exactly how data is sorted or manipulated. More specifically this flaw came from Column D of each sheet having combined multiple separate yet sortable data values, which happened to be key important values for later use. This very typical mistake in the data

	A	B	C	D	E	F	G	H
1	GL Code	Dept Code	Effect Date	Transaction Description	Debit	Credit	Name	Document Number
1490	8710	350	1/30/2015	01/30/15 - MV - U - Krogers	42.50		employee 1	VW Exp Reim, Jan 2015
1491	8710	350	1/30/2015	01/31/15 - Benton/Kristen-SIU - Recruitment	14.00		employee 2	VW Exp Reim, Jan 2015
1492	8710	350	10/31/2014	10/02/14 - Eldorado - Galatia - ST & SU Mtg	50.00		employee 3	VW Exp Reim, Oct 2014
1493	8710	350	10/31/2014	10/20/14 - East Marion - ST & Su Mtg	41.00		employee 4	VW Exp Reim, Oct 2014
1494	8710	350	10/31/2014	10/30/14 - Perry County - TeamMtg	17.00		employee 5	VW Exp Reim, Oct 2014
1495	8710	350	11/30/2014	11/04/14 - W Williamson - ST mtg/SU Mtg w/Kristen	39.00		employee 6	VW Exp Reim, Nov 2014
1496	8710	350	11/30/2014	11/05/14 - Pinckneyville - Team Mtg	20.00		employee 7	VW Exp Reim, Nov 2014
1497	8710	350	11/30/2014	11/08/14 - Kaskaskia College - Cookie Trng	43.50		employee 8	VW Exp Reim, Nov 2014
1498	8710	350	11/30/2014	11/13/14 - Pinckneyville - ST mtg/SU mtg w/Kristen	17.00		employee 9	VW Exp Reim, Nov 2014
1499	8710	350	11/30/2014	11/17/14 - E Marion - ST mtg/ SU mtg w/Kristen	41.00		employee 10	VW Exp Reim, Nov 2014
1500	8710	350	11/30/2014	11/18/14 - E Marion - Odin Recruitment	50.00		employee 11	VW Exp Reim, Nov 2014
1501	8710	350	11/30/2014	11/19/14 - Eldorado - ST Mtg/Parent Mtg	50.00		employee 12	VW Exp Reim, Nov 2014
1502	8710	350	12/22/2014	12/03/14 - Salem - Mtg w/team members	41.00		employee 13	VW Exp Reim, Dec 2014
1503	8710	350	12/22/2014	12/04/14 - Eldorado - SU team mtg/Su mtg	50.00		employee 14	VW Exp Reim, Dec 2014
1504	8710	350	12/22/2014	12/06/14 - Perry & Jeff Co - Craft fair/office/recruitment	42.50		employee 15	VW Exp Reim, Dec 2014
1505	8710	350	12/22/2014	12/08/14 - Salem - SU Mtg	41.00		employee 16	VW Exp Reim, Dec 2014
1506	8710	350	12/22/2014	12/11/14 - Pinckneyville - SU Mtg	26.00		employee 17	VW Exp Reim, Dec 2014
1507	8710	350	3/1/2015	02/03/15 - Eldorado - ST mtg/SU Mtg	50.00		employee 18	VW Exp Reim, Feb 2015
1508	8710	350	3/1/2015	02/12/15 - Pinckneyville - SU Mtg	26.00		employee 19	VW Exp Reim, Feb 2015
1509	8710	350	3/1/2015	02/23/15 - Centralia - Mtg SU director from E Marion	41.00		employee 20	VW Exp Reim, Feb 2015
1510	8710	350	3/1/2015	03/03/15 - Eldorado - SU mtg/ST mtg	50.00		employee 21	VW Exp Reim, March 2015

recording process leads to hours spent on the analysis side of sifting and cleansing the data in order to extract sortable meaningful data.

As easily noticed from the table above, column D was extremely difficult to handle, as it was a compilation of multiple important values. This problem was overcome by implementing a basic sift through the data where a layer of values was initially removed from consideration. As the first step of the sifting process, the data was sorted in alphabetical order in order to create groups of valuable and like data. This grouping by alphabetical order was extremely important due to the fact that it separated the good data values as determined by the group, from the bad. All valuable, correctly logged data was cleanly and easily sorted in to tidy groups where other data that was less desirable was forced naturally to either blatantly stand out amid other valuable entries for future copy and paste organization, or was conveniently sorted down to the bottom of the sheet due to alphabetical sorting algorithms built into Excel.

	A	B	C	D	E	F	G	H	I
	GL Cod	Dept Code	Name	Effect Date	Travel Date	Destination	Trip Info	Debit	Credit
2	8710	360	Amanda Kaemmerer	3/1/2015	01/13/15	O'Fallon	Trng at SU Mtg	19.50	
3	8710	360	Amanda Kaemmerer	3/1/2015	03/27/15	Plend Lake Resorts	Ann Mtg Setup	50.00	
4	8710	360	Amanda Kaemmerer	3/1/2015	03/28/15	Plend Lake Resort	AnnMtg	50.00	

At this point, the data was much more useful to us as we had clean valuable information with all of the less desirables sifted out. You'll notice Travel Date, Destination, and Trip Info were handily sifted out from the original congested D column exemplified in the table snippet above. From this point, the final step in the data cleanse was to present the desirable data into a clean new sheet in the most beneficial way possible for analysis.

After the data cleanse, the first consideration we had to make, was how do we take our data and extract valuable information from it. While pondering what move to make next, glancing over thousands of lines of excel data containing travel dates, volunteer names, destination descriptions, as well as debits and credits. It was obvious that the first thing we needed to do was to find the **Unique Travel Dates** associated with all of the travel data we had left after the cleanse. These Unique Travel Dates would prove later to be extremely useful to us. The goal of this section of the analysis was to get an understanding of how many days of the year the Girl Scouts were paying out reimbursements. With an understanding of how many days out of the year travels were occurring, we could already get an idea of how necessary a proposition of purchasing a car, or multiple cars was going to be.

Once we had an understanding of the **Unique Travel Dates**, the next step was determining the **Daily Load** at each one of those unique days. This load, would give us an even further understanding of the benefits of purchasing a Girl Scout Car, or multiple cars based on the distribution of travel loads across those unique days. Our findings initially were dismal. We noticed that once sorted the list of Unique Travel Dates with Daily Loads was very heavily averaging multiple trip days.

Unique Travel Date	Unique Travel Dates Expenses	Travel Load	Weeks Of Travel	Week Travel Expenses	Unique Weeks Of Travel	Unique Weeks Expenses
01/05/15	\$99.28	5	2	\$99.28	2	\$579.18
01/06/15	\$118.10	4	2	\$118.10	3	\$698.30
01/07/15	\$83.80	3	2	\$83.80	4	\$394.00
01/08/15	\$116.00	7	2	\$116.00	5	\$961.60

Upon analyzing the loads, our first understanding of what a solution was going to look like immediately changed. It was no longer a solution with the goal of eliminating reimbursement altogether but rather became a solution focused on lightening the reimbursement load on the organization by purchasing one car, or even two cars that over time would eliminate some travel as well as save club funds. We planned to lighten the organizations travel expenses by a simple cost reduction concept outlined in the following table. Based on the purchase of each new car per office, travel loads per unique day of the year would be reduced by one trip. This will present a savings amount per year summed up by not having reimbursed personal travel, or enterprise. With this savings amount, a car to be purchased by the Girl Scouts would have to cost less than the amount of savings made from the reduction concept in order to save them money on travel each year.

Sample of Rental Data Breakdown							
Unique Travel Day	Date #1	Date #2	Date #3	Date #4	Date #5	Date #6	Date #7
Travel Load Per Unique Day	4	4	3	2	1	1	1
One Car Purchased							
New Travel Load Per Unique Day	3	3	2	1	0	0	0
Two Cars Purchased							
New Travel Load Per Unique Day	2	2	1	0	0	0	0
Three Cars Purchased							
New Travel Load Per Unique Day	1	1	0	0	0	0	0

- With an Average Trip Cost Found to be \$46.50 we see that
 - \$46.50 x 16 Trips in the First Row = \$744
 - \$46.50 x 9 Trips in the Second Row = \$418.50
- The difference between these values represents savings through the purchase of one car a reduction of travel cost
- This process can be repeated to show the savings made through each additional purchase

With an understanding of the Sample Data Breakdown Listed above, the following table relates similarly as follows.

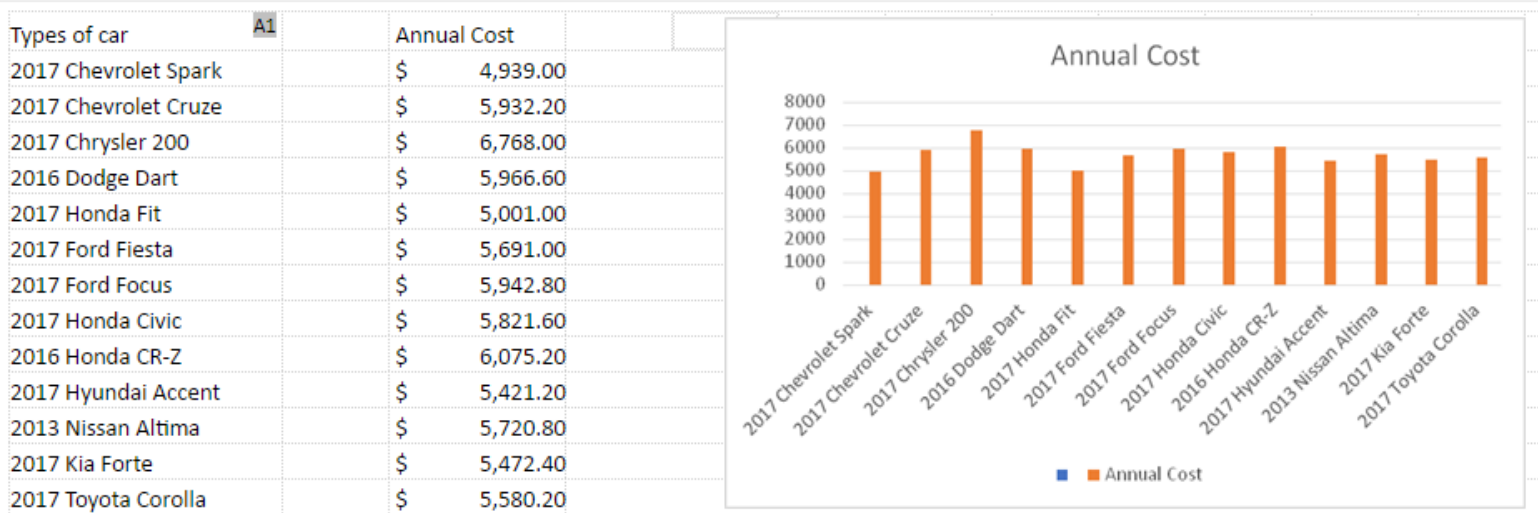
Car	2014	2015	Use_Rent						Use_Personal						Cost	
			Car	14	14Cost	15	15Cost	Car	14	14Cost	15	15Cost	Car	2014	2015	
1	287	287	1	34	1122	50	1650	1	253	5778.52	237	6453.51	1	6900.52	8103.51	
2	226	224	2	4	132	22	726	2	222	5070.48	202	5500.46	2	5202.48	6226.46	
3	169	166	3	1	33	14	462	3	168	3837.12	152	4138.96	3	3870.12	4600.96	
4	124	117	4	1	33	6	198	4	123	2809.32	111	3022.53	4	2842.32	3220.53	
5	86	61	5	0	0	3	99	5	86	1964.24	58	1579.34	5	1964.24	1678.34	
6	62	34	6	0	0	0	0	6	62	1416.08	34	925.82	6	1416.08	925.82	
7	28	18	7	0	0	0	0	7	28	639.52	18	490.14	7	639.52	490.14	
8	14	5	8	0	0	0	0	8	14	319.76	5	136.15	8	319.76	136.15	
9	7	3	9	0	0	0	0	9	7	159.88	3	81.69	9	159.88	81.69	
10	4	3	10	0	0	0	0	10	4	91.36	3	81.69	10	91.36	81.69	
11	3	1	11	0	0	0	0	11	3	68.52	1	27.23	11	68.52	27.23	
12	1	1	12	0	0	0	0	12	1	22.84	1	27.23	12	22.84	27.23	
13	0	1	13	0	0	0	0	13	0	0	1	27.23	13	0	27.23	
14	0	1	14	0	0	0	0	14	0	0	1	27.23	14	0	27.23	
15	0	0	15	0	0	0	0	15	0	0	0	0	15	0	0	

- Left-most column represents the trips each purchased car will take per year wherein reducing the number of reimbursement / rental trips that year by that much
- Use_Rent columns represent the rental car cost reduction by each new car purchased

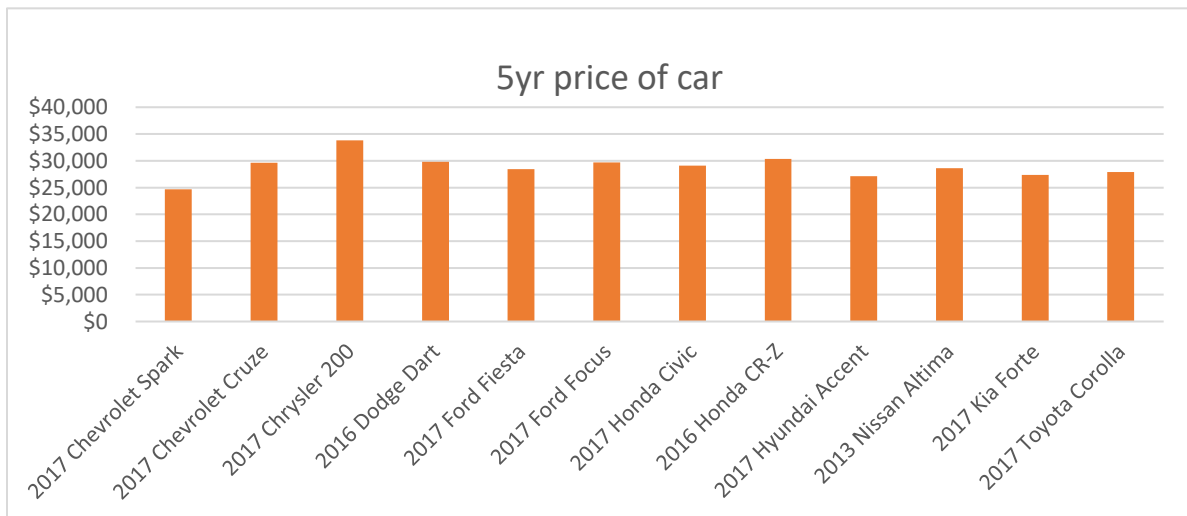
- Use_Personal columns represent the personal travel cost reduction by each new car purchased
- The right-most column represents an acceptable annual cost for each respective amount of cars purchased in order found by summing the Use_Rent & Use_Personal expenses per car purchased

This reduction shows us that for each car purchased we are reducing the Travel Costs by the listed amounts on the rightmost column, yielding the annual cost the girl scouts would be limited to spending when purchasing the car of their choice. If they would spend less annually on the car of their choice than seen above according to our table, this would represent savings.

Listed below is a comprehensive table showing selected car candidates for purchase that would allow for the lowest annual costs.



From this table of Annual Costs, the Girl Scouts are to make their own selection as to which car better suits their needs economically. Each car listed with its associated cost per year represents a value listed by Edmunds True Cost to Own. Edmunds True cost to own accounts for, vehicle depreciation, interest financing the vehicle, taxes and fees, insuring the vehicle, fuel costs, maintenance, repairs, as well as federal tax credits for driving economically efficient cars. This value determined by Edmunds True Cost to own represents a rough average cost of a car per year in current markets.



From our selected cars and their respective cost analysis we were able to put together a savings plan for the Girl Scouts based on the following tables.

Types of car	Savings
2017 Chevrolet Spark	\$ 7,250.00
2017 Chevrolet Cruze	\$ 4,500.00
2017 Chrysler 200	\$ 3,000.00
2016 Dodge Dart	\$ 4,500.00
2017 Honda Fit	\$ 6,500.00
2017 Ford Fiesta	\$ 5,000.00
2017 Ford Focus	\$ 4,500.00
2017 Honda Civic	\$ 4,750.00
2016 Honda CR-Z	\$ 4,250.00
2017 Hyundai Accent	\$ 6,000.00
2013 Nissan Altima	\$ 5,000.00
2017 Kia Forte	\$ 5,750.00
2017 Toyota Corolla	\$ 5,500.00



Types of car	Annual Cost	Syr price of car	MTV	GC	COSTS H1			Approx org.	Savings
2017 Chevrolet Spark	\$4,939	\$24,695	1	2	\$4,939	\$9,878	\$14,817	22200	\$7,250
2017 Chevrolet Cruze	\$5,932	\$29,661	1	1	\$5,932	\$5,932	\$11,864	16500	\$4,500
2017 Chrysler 200	\$6,768	\$33,840	1	1	\$6,768	\$6,768	\$13,536	16500	\$3,000
2016 Dodge Dart	\$5,967	\$29,833	1	1	\$5,967	\$5,967	\$11,933	16500	\$4,500
2017 Honda Fit	\$5,001	\$25,009	1	1	\$5,001	\$5,001	\$10,002	16500	\$6,500
2017 Ford Fiesta	\$5,691	\$28,455	1	2	\$5,691	\$11,382	\$17,073	22200	\$5,000
2017 Ford Focus	\$5,943	\$29,714	1	1	\$5,943	\$5,943	\$11,886	16500	\$4,500
2017 Honda Civic	\$5,822	\$29,108	1	1	\$5,822	\$5,822	\$11,643	16500	\$4,750
2016 Honda CR-Z	\$6,075	\$30,376	1	1	\$6,075	\$6,075	\$12,150	16500	\$4,250
2017 Hyundai Accent	\$5,421	\$27,106	1	2	\$5,421	\$10,842	\$16,264	22200	\$6,000
2013 Nissan Altima	\$5,721	\$28,604	1	2	\$5,721	\$11,442	\$17,162	22200	\$5,000
2017 Kia Forte	\$5,472	\$27,362	1	2	\$5,472	\$10,945	\$16,417	22200	\$5,750
2017 Toyota Corolla	\$5,580	\$27,901	1	2	\$5,580	\$11,160	\$16,741	22200	\$5,500
					MTV	GC	total		

The following savings plan is to be implemented at the discretion of the Girls Scouts of Southern IL based off of our recommendations.

Based on these calculations, we can begin searching for car options that fit within the necessary price ranges. The easier way of doing this is to find suitable cars, find their annual cost, and then determine how many can be bought.

Recommended Vehicles:

Chevrolets:

1. The 2017 Spark has an annual cost of 4939 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 14817 USD. This replaces approximately 22200 USD of reimbursement costs on an annual basis, a savings of 7250 USD.

2. The 2017 Cruze has an annual cost of 5932 USD. At this cost, 1 would be purchased for the Mount Vernon office and 1 for Glen Carbon, at a total annual cost of 11864 USD. This replaces approximately 16500 USD, an annual savings of 4500 USD. 3.2.

Fords:

1. The 2017 Fiesta has an annual cost of 5691 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 17073 USD. This replaces approximately 22200 USD of reimbursement costs on an annual basis, a savings of 5000 USD.
2. The 2017 Focus has an annual cost of 5943 USD. At this cost, 1 would be purchased for the Mount Vernon office and 1 for Glen Carbon, at a total annual cost of 11886 USD. This replaces approximately 16500 USD, an annual savings of 4500 USD. 3.3.

Hondas:

1. The 2017 Civic has an annual cost of 5882 USD. At this cost, 1 would be purchased for the Mount Vernon office and 1 for Glen Carbon, at a total annual cost of 11643 USD. This replaces approximately 16500 USD of reimbursement costs on an annual basis, a savings of 4750 USD.
2. The 2017 CR-Z has an annual cost of 6075 USD. At this cost, 1 would be purchased for the Mount Vernon office and 1 for Glen Carbon, at a total annual cost of 12150 USD. This replaces approximately 16500 USD, an annual savings of 4250 USD.
3. The 2017 Fit has an annual cost of 5001 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 15003 USD. This replaces approximately 22200 USD, an annual savings of 7000 USD.

Others:

1. The 2017 Chrysler 200 has an annual cost of 6768 USD. At this cost, 1 would be purchased for the Mount Vernon office and 1 for Glen Carbon, at a total annual cost of 13536 USD. This replaces approximately 16500 USD of reimbursement costs on an annual basis, a savings of 3000 USD.
2. The 2016 Dodge Dart has an annual cost of 5967 USD. At this cost, 1 would be purchased for the Mount Vernon office and 1 for Glen Carbon, at a total annual cost of 11943 USD. This replaces approximately 16500 USD, an annual savings of 4500 USD. The 2017 Hyundai Accent has an annual cost of 5421 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 16264 USD. This replaces approximately 22200 USD, an annual savings of 6000 USD.
3. The 2013 Nissan Altima has an annual cost of 5721 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 17162 USD. This replaces approximately 22200 USD, an annual savings of 5000 USD.
4. The 2017 Kia Forte has an annual cost of 5472 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 16417 USD. This replaces approximately 22200 USD, an annual savings of 5750 USD.
5. The 2017 Toyota Corolla has an annual cost of 5580 USD. At this cost, 1 would be purchased for the Mount Vernon office and 2 for Glen Carbon, at a total annual cost of 16741 USD. This replaces approximately 22200 USD, an annual savings of 5500 USD.

As a general rule when selecting a car for purchase, it should be ensured that the annual cost of the car is less than the annual expenditure on the travel this car is used for. We suggest the following policies for the cars in order to benefit the most from our study.

Recommended Travel Policy Adjustments

1. Purchased vehicles must be used for the longest trip per day, unless otherwise prioritized for storage capability or any other alternative use.
2. Vehicles will not sit idle unused for more than 30 days.
3. If multiple vehicles are purchased each vehicle will alternate longest trips made, in attempt to keep mileage on each car within the same relative range.
4. Vehicles will be maintained according to manufacturer’s manuals and specifications in order to maintain the highest quality vehicle for the longest possible duration.
5. Vehicles are to be returned with a full tank of gas which will either be charged to the girl scouts, or reimbursed to the employee’s upon processing of a receipt.

Recommended Book Keeping Adjustments

	A	B	C	D	E	F	G	H	I	J	K
1	GL Code	Dept Code	Volunteer	Destination	Mileage	Date of Travel	Debit	Credit	Payee	Effect Date	Comments
2	8710	350	Amy Sample	Alton, IL	25	1/1/2017	54	0	Amy Sample	4/20/2017	STEM
3	8720	150	Amy Sample	Grafton, IL	50	1/5/2017	68	0	EAN Services, LLC	4/20/2017	Monthly Meeting
4	8710	250	Carol Ann Hering	Alton, IL - Grafton, IL - Mt. Vernon, IL - Nashville, IL	125	1/5/2017	100	0	Carol Ann Hering	4/20/2017	Cookie Pick Up

1. Volunteer Names should be identical to office phone lists
2. Destination MUST be in form City, State followed by “-” “if multiple destinations are reached per trip.
3. Mileage MUST be recorded for daily trips using built in trip odometers standard to all vehicles, or GPS. Each Employee should record this reading upon parking the car at the end of the trip.
4. Dates should all be recorded in the same format
5. Take advantage of the Comments column to record pertinent information
6. Consistency in the data recording process is critical. Try to minimize typos, abbreviations, and irregularities.

References

- Girl Scouts Of Southern Illinois- <http://www.gsofsi.org/>
- Edmunds True Cost To Own- <https://www.edmunds.com/tco.html>
- Analyst Cave – Geocoding- <http://analystcave.com/excel-get-geolocation-coordinates-of-an-address/>