ECONOMIC EVALUATION OF LEASE VS BUY OPTION FOR ELECTRIC VEHICLES (EV)

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EXECUTIVE SUMMARY

The skyrocketing gas prices, environmental impact, and reducing long term dependence on oil are some of the few issues which have really pushed both the consumers and the vehicle makers to consider vehicles powered with alternate sources of energy such Hydrogen Gas, Fuel cell, Hybrid Battery and Gasoline powered, and finally Battery only powered or also known as Electric vehicle. Of the above mentioned options Electric Vehicles are widely popular (trending) in the current vehicle purchase market. In this report an attempt has been made to explore both lease and buy options and make a recommendation as to which one would be a better alternative for the consumer in said vehicle. The results of economic analysis show that, it is generally better to lease the vehicle at lower APR and when the lease period is shorter. On the other hand, it is better to buy the vehicle at a higher APR than to lease it, since leasing will make one pay almost as high in interest as the one buying the vehicle. It was also shown that since the market fluctuation for used vehicles is uncertain, it is more risky to buy the vehicle if one intends to use it for a shorter period, since vehicles generally depreciate quicker in the first few years - being able to sell it for an anticipated market value might be difficult.

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1 INTRODUCTION

In an effort to reduce greenhouse gases and to conserve a healthy environment, countries are putting various energy efficiency programs in place. In some countries, there are interventions to limit the use of certain inefficient fuels and also do away with vehicles that are too old for the same reason. In the US, there have been several government policies to encourage green and sustainable use of energy. One of such interventions is the endorsement of the development and adoption of electric vehicles (EV's). EV's, unlike many other vehicles, utilize batteries in both ignition and complete operation and does not require a fuel combustion engine. The batteries are charged by electricity and makes it fully operational without the need of an engine. A variation of EV's, called hybrid vehicles have both this functionality and a fuel combustion engine for obvious reasons. It is estimated by [1], that if all vehicles in the US were electric vehicles and use electricity generated by fossil fuels carbon emission could be reduced by 42%, among other benefits.

Public records show that in the US the adoption of EV's although slow is encouraging and has probably been enhanced by federal and state incentives. In many states, the infrastructure for EV's are being expanded to encourage many users who have concerns of not being to drive long distances due to few charging spots. As of 2015, charging outlets have increased to over 24,000 from 20,000 in 2013 [4][5]

The business model for most auto dealers has being to either sell the vehicle to a customer or to lease it for a specified number of years. There are pros and cons to each of these models which would be discussed further. Leasing of the vehicle allows a user to be a temporary owner of the vehicle and returns it after the agreed period. Dealers of automobiles have continued to allow customers to either buy or to lease an EV as has been the case for other types of vehicles.

This project does an economic analysis of the two arrangements of acquiring an EV from the perspective of the customer. In other words, assuming a customer has already validated the benefits of EV and has chosen to go for it, is it better to buy or lease? This project uses economic analysis tools for both arrangements and points out what the key differences and how they play in a potential customer's decision to lease the vehicle or to buy it. Another thing the project tries to achieve is to determine which factors are sensitive and have the potential of changing a customer's mind to lease instead of buy and vice versa. In the following sections, a detail discussion is done about the pros and cons of both arrangements and the factors for the economic analysis are extracted and analyzed.

2 LITERATURE REVIEW

What is the technology evolution of EV, how it is affecting the adoption of EV

The reason behind evolution of Electric vehicles are reduce greenhouse gases and to conserve a healthy environment. In some countries, there are interventions to limit the use of certain inefficient fuels and also do away with vehicles that are too old for the same reason. One possible innovation to address the environmental concerns such as climate change, greenhouse gases that can attitudes serious threat to physical and economical livelihoods. In 1960's and 70's the soaring oil prices and official ban on foreign oil, which lead the Electric and Hybrid Vehicle Research, Development, and Act of 1976, authorizing the Energy Department to support research and development in electric and hybrid vehicles [27]. At the same time many big and small automakers started focusing on alternative fuel vehicles, 1990 Clean Air Act Amendment and the 1992 Energy Policy Act are the major reasons for electric vehicles [27]

In many developed nations, there is widespread concern about sustainability and green energy. These concern has further being a motivation to encourage the adoption of Electric vehicles. Specifically, there are government rebates to technology innovation in the development of electric vehicles. As of 2008, various governments have invested over $8.5 billion in R&D and tax credits [25]. Records show that from 2011 to 2012 global sales of EV has doubled [25].

Since EV innovation is still in its infancy, there is uncertainty in the how better newer models are going to be and that will impact the cost of acquisition [25]. This widespread concern about the uncertainty could affect the adoption of EV [16] and which mode of acquisition people will choose, when a user finally decides to go for an EV.

Why EV now?

More and more car manufacturers are offering electric vehicles, as a result electric vehicles are on the rise. This is also greatly due to the tax/rebate incentives [13] offered by the federal and some state governments to support not just alternative fuels but to reduce foreign dependency on oil and reduce ground-level ozone as well as greenhouse gases [12]. The relative maintenance and service costs are low compared to a traditional gas or gas/hybrid cars [11]. The total operating costs are lower as well, as the cost of charging the battery is less compared to the purchase of the gas in the regular vehicles and hybrids.

A Word of caution…

Depreciation in electric cars is relatively higher due to the technology in the battery [8]. So, buying an electric car wouldn't be economically advisable until it is for a long run and it's better not to buy an "old version [14][15]

An average life of a battery in the electric vehicles today can be estimated at 8 years, but it can be lower depending on the amount of use for replacement would dominate operating costs [16].

Lastly current electric vehicle batteries have a range limit, as estimated by EPA, depending on whether the commute is either on the highway or internal/local roads the battery may need a full charge before it can used again [17].

Why Lease the electric vehicle?

Leasing an electric vehicle allows one to use an electric vehicle for a fixed period of time at an agreed amount of money for the lease. The two types of leases are closed-end leases and open-end leases. Close-end leases allows one to walk away from the vehicle at the end of the lease term. However one needs to pay for any extra miles driven or damage to the vehicle. In an open-end lease one has to purchase the vehicle at the end of the lease term for a predetermined amount [20]. Leasing an electric vehicle is advantageous for people who know that they will not need the vehicle for more than a few years. And keep the monthly payments lower than that for buying a car [9]. Thus it provides greater flexibility and avoids long-term commitment [10].

Why Buy the electric vehicle?

Buying an electric vehicle gives the buyer the ownership of the vehicle for the usable life of the vehicle. The vehicle can be bought two different ways, one paying cash upfront which makes the buyer the owner of the vehicle which he/she may take home debt free. The other way is via loan through a financial institution. In this scenario, the finance company actually owns the car till the last loan amount is paid off and in the meantime, the person who actually borrows the loan is just using the finance company's car (financial company keeps the title of the car up until the loan is paid off).

3 FACTORS IMPACTING THE BUY/LEASE DECISION

The factors that affect the decision of lease and buy are discussed as follows [6][7]:

MSRP (Manufacturers Suggested Retail Price) The price of the vehicle which typically includes the base price of the vehicle and any additional option/package costs that the vehicle is currently outfitted with at the time of purchase/lease or prior

Cap Cost (Capital Cost): Adjusted sale price or negotiated lease price of the vehicle that the buyer has agreed to acquire the lease or loan on the vehicle and the amount that is used to calculate the monthly payments.

Down Payment (Cap Cost Reduction): A payment made towards the initial capital cost at the time of leasing the vehicle. This reduces the cap cost which reduces the monthly payments that need to be paid by the borrower.

Acquisition Fee: Also known as inception fee or origination fee, which is paid by the borrower at the time of signing the lease contract.

Security Deposit: A security deposit may be required by the leasing company to be paid by the borrower at the time of signing the lease contract to cover any excess wear and tear up front or at the inception of the lease. The true damage from the wear and tear is analyzed at the end of lease term and additional amount may be recovered from the borrower.

Money Factor: Money factor is a decimal number, which is an approximation of the interest rate, used by the leasing company to determine the monthly payments. The approximate interest rate can be back calculated by multiplying the money factor with 2400. If the money factor is 0.00160, then the interest rate can be calculated as 0.00160 x 2400 = 3.84%.

Lease Term: Lease term is the length of the lease agreement. Typical lease agreements are 24, 36 and 48 months. The term of the lease factors into determining the residual value of vehicle at the end of lease term. The longer the lease term, the lower the residual value, higher the monthly payments.

Lease Miles (Allowable Miles): The number of miles the borrower is allowed to drive over the term of the lease. The lease miles factor into how the leasing company determines the residual value of the vehicle at the end of lease term. The more the number of lease miles, the lower the residual value, higher the monthly payments.

Actual Miles: The number of miles the borrower actually drives during the lease term. If the borrower drives less than the lease miles there is no credit but if the borrower exceeds there is heavy penalty of up to $0.40 per mile. This penalty will need to be paid at the end of the lease term.

Residual Value: The value (worth) of the vehicle at the end of the lease term as determined by the leasing company. This value is dependent on the lease term, and lease miles that was agreed upon between borrower and leasing company. If the borrower exceed the lease miles or causes excess wear and tear to the vehicle, then the leasing company will penalize the borrower with a charge based on what the leasing company determines the additional depreciation would be that determines the new residual value.

Disposition Fee: A fee paid by the borrower if the person decides not to purchase the vehicle at the end of the lease term, i.e., for terminating the contract. This fee can vary from several hundred dollars to a rather large value depending on the leasing company and kind of vehicle that was leased, which in most cases can be more than the monthly payments.

The other expenses that were looked into that potentially could impact the financial analysis were:

Maintenance Cost: Maintenance for a lease arrangement is an annual or bi-annual depending on the time of leasing agreement or number of miles driven. The leasing company stipulates that the vehicle be brought in for a regular update where it maybe a tire rotation & wheel balance adjustment. There is not much historic data available for the electric vehicles have been on the road for just a few years.

Service Cost: The manufacturer mandated service for a typical vehicle is set to occur at set years of ownership of the vehicle or number of miles driven. Example Fiat 500e first service is set at 2 years or 20,000 miles, whichever occurs first, and every 10,000 miles after that.

Insurance Cost: The state mandates a minimum requirement for what insurance should cover and protect in the event of an accident, damage, or loss to the vehicle. The leasing company or the bank providing the loan could potentially require the borrower get additional coverage, which can bring up the insurance costs. It is assumed that this cost can be constant between the two alternatives.

Gap Insurance: GAP insurance or Guaranteed Auto Protection insurance covers or pays the difference between the current book value of the vehicle and the what the borrower owes, either the leasing company or the bank from which the loan was received, in the event of a major accident leading to total damage of the vehicle, or lost/stolen [6].

Cost of Charging the Battery: The average EV needs about 30 kWh of electricity to power the vehicle for 100 miles. For instance, the EPA rating [26] for the BMW i3 is exactly 27 kWh per 100 miles, Tesla Model

S 70 is rated at a combined 33 kWh per 100 miles and uses a little more energy since it's heavier and more powerful than a BMW i3 and Fiat 500e EV has a combined consumption rating of 27 kWh per 100 miles. The average cost of electricity in the US is $0.12 per kWh. Therefore the average person driving an average EV 15,000 miles per year pays about $540.00 per year to charge it. It's important to remember that charging times will depend greatly on what the current state of charge your battery is at. In addition, how often you need to charge will invariably come down to how far you drive and what your vehicle's electric range is. Electric cars will be able to travel further due to their large batteries and need to be plugged in more often in order to recharge [3].

4 FINANCIAL MODEL AND ASSUMPTIONS

The total cost of ownership of a vehicle for either a leasing or buying arrangement is the logical way of conducting economic analysis to determine which arrangement is good [3]. In the present analysis, a key assumption is that an individual is either paying a monthly uniform fee to lease an electric vehicle or buying and paying on monthly installment through the entire duration of the study. The study also takes into account any other cost other than the monthly installment, such as periodic maintenance cost, insurance, cost per extra miles driven in the case of the lease agreement, and other factors (which are discussed in detail). The analysis uses all such associated cost in each of the arrangements and a discount rate to compute the present worth of owning a given electric vehicle under each of the arrangements. In [2][3], the authors highlight why it is important to use the total cost of ownership approach to determine all the actual cost components which might not be clearly evident during the acquisition of a property. In this paper, a variation of the TCO is created, called Total Differential Cost (TDC). TDC in this project refers to the cost components which could differ for the alternatives being investigated.

Once the components of the cost in both arrangement have been determined, the paper represents them on a cash flow - a representation of how the decision maker's cost is incurred over the study period. An equivalent worth methodology such as the present worth comes handy to determine which of the options will cost more in the future or is worth less if the analysis is being done with respect to the present. According to [18], present worth of future cash flows generally looks less due to the effects of time value of money which typically shows the opportunity forfeited by an investor if they were to make a given decision. To compensate for the time value of money, a discounted rate is often introduced into equivalent worth analysis [18], which shows an investor's opportunity cost of not using the money in another venture which could yield profit. In this project, the discount rate used is assumed to be the minimum annual rate of return (MARR) of state of Oregon.

Present Worth for Buying on Loan

This arrangement is one of the options being considered in the analysis. For this option, dealers allow an individual to finance the vehicle through a financing company and the entire cost and initial purchase fees are spread toward a future annuity payment at an interest rate that compensate toward the finance company, until the payment period elapse. Figure 1 shows the cash flow diagram.

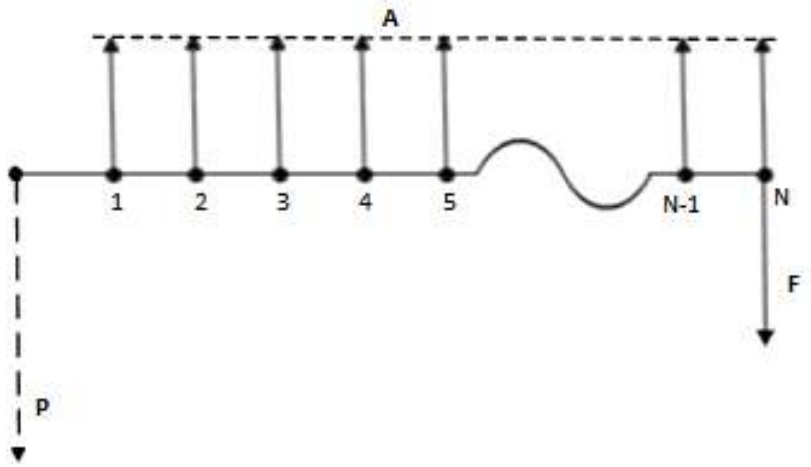

Figure 1: Buy with Loan – Cash flow diagram

Given that the that the sales price is denoted by *P, and T* is the sales tax and *N* is the number of years used for the analysis, a monthly loan amount is an annuity *A* created from the sales price and the sales tax *(P+T)* with a loan interest rate *i (compounded per period)*considered in the analysis. The loan payment can be calculated as follows:

$$A = (P+T)\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right]$$

In a state where sales tax is not charged, *T = 0.* The monthly loan is then spread out for the entire study period such as 36 months, 48 months or 60 months (these are typical periods for paying a vehicle loan). At the end of the payment period, the buyer totally owns the vehicle and has the choice of selling it at a market value, which is a future amount of say ***F.***

The present worth of buying the vehicle on loan installment can be determined by bringing all payments to the present at a discount rate *r;* where *r* is an interest rate representing the opportunity cost of buying the electric vehicle instead of investing the monthly loan payments in an investment [18]. Hence the present worth to be used in the analysis can be stated as:

$$PW(r\%) = A\left[\frac{(1+r)^N - 1}{r(1+r)^N}\right] - \frac{F}{(1+r)^N}$$

The first part is the monthly recurring payment brought to the present, while the second part is the future value of the vehicle at the end of the study period, which is considered as an equity. It is assumed that this is the amount the buyer of the vehicle can sell it for.

Present Worth of the Leasing

The lease arrangement allows an individual to rent the vehicle for a predetermined period of time of say *N* months. In this project, *N* is chosen to be equal with the number of periods for buying the EV on loan as discussed above; this will allow for an equivalent analysis of the two arrangements. For this arrangement, equal payments are made each period through the entire duration of the rent. The vehicle is then returned to the auto dealer at the end of the period to conclude the agreement. Here too, an interest rate of *i* is assumed cost of money at which Lease Company acquired the vehicle. The monthly payment for this arrangement is only based on the depreciated value of the vehicle within the study period and the interest charged by the lease company for the cost of money they used to purchase the vehicle that being leased out. The cash flow for this arrangement is shown in Figure 2.

That is, given that actual price of the vehicle is *P* and the residual value at the end of the lease period is *R,* the Monthly lease payment is an annuity *A*, which also accounts for a sales tax *T* (based on the depreciated value of the vehicle):

$$A = ((P - R) + T)\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right]$$

Where *i* is the interest rate resulting from a lease money factor, covering the financing cost transferred to the person leasing the vehicle. In a state where sales tax is not charged *T= 0.*

Therefore the present worth at a discount rate *r (covering opportunity cost of leasing the vehicle instead of investing the money)*, can be estimated as:

$$PW(r\%) = P_0 + A\left[\frac{(1+r)^N - 1}{r(1+r)^N}\right] + \frac{D}{(1+r)^N}$$

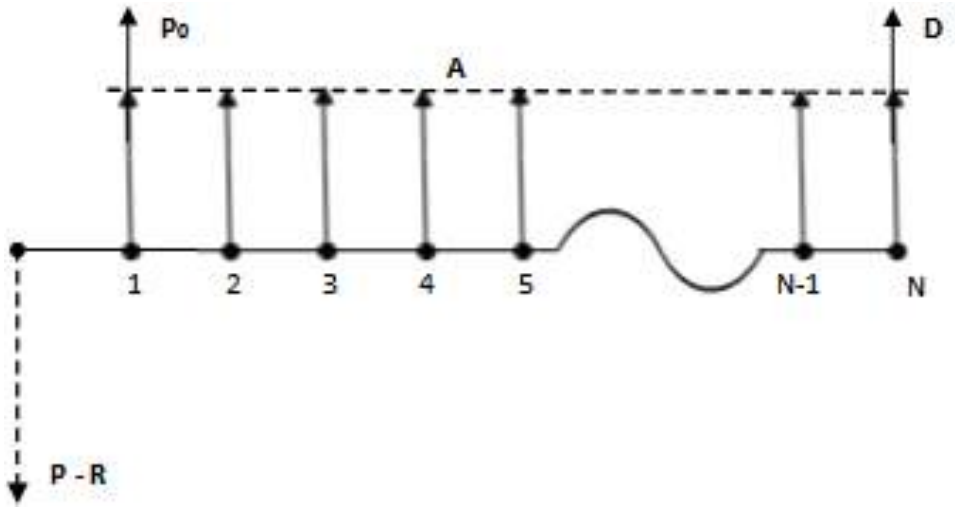

Figure 2: Lease – Cash flow diagram

The first part (P_0) represents the first payment made at the beginning of the lease agreement which is usually larger than the monthly lease payment as result of acquisition fees or other upfront charges. The second part shows the present worth of the monthly lease annuity payments and the third part is the present worth of a future amount *D,* where *D* is the disposition fee charged at the end of the period by the lease company when the vehicle is returned. Using sample figures and based on certain assumptions, analysis of the present worth of both arrangements will be conducted in upcoming sections. Sensitivity analysis is also performed off some of the factors in the PW formulations discussed in this model.

Assumptions:

The financial analysis performed here was done taking into account some of the factors that truly impact the analysis and some assumptions were made to manage the scope of the project better. The analysis performed herein considers that the lease and buy options are being compared for a single vehicle at one time. And under such an assumption some of the factors affect both the lease and the buy option equally. Such factors are removed from the analysis. Each of the vehicles' lease and buy alternatives present worth are compared. Since these are both cost alternative, the lower PW is considered as the better alternative, under the given circumstances. The following factors are not considered for the economic analysis, as the costs are not differential costs (apply to both alternatives):

- Maintenance and service Cost,

- Tax rebates/incentives
- Money Down (cash down/capital cost reduction)
- Cost of Charging the battery per 100mi,
- Insurance,
- GAP insurance,
- Title/Registration

Modified Accelerated Cost Recovery System (MACRS) General Depreciation System (GDS) was used in determining the book value of the vehicle at the end of the lease term. It was determined that a vehicle for personal use is depreciated as a GDS-5 personal property class.

It is assumed that payments for each of the arrangement is done monthly instead of one-time payment, in which case the analysis could be different, such as interest will not accrue if payment is made to purchase in an outright manner, since time value of money is considered in loan payments [18]. It is therefore assumed that the buying arrangement is a loan financing which is paid per period (monthly).

The financial analysis is performed only for the State of Oregon, hence making the sales tax to be zero. Security fee is also set to zero, which applies if the borrower has bad driving history or a history that is less than 2 years.

To help have a better analysis, it is also assumed that the loan financing option and the lease both would end at the same time. This creates an equity in the buy, representing the market value of the vehicle at the end of the study period which is represented in the Loan cash flow (Figure 1). The analysis then looks at this value as though the decision maker will sell the vehicle at that market value.

5 EVALUATION & RESULTS

One vehicle within three different bands were selected; that's one each from the low cost (economy), medium size and luxury (full size) brand. Two models were created; one for each leasing and one for buying with loan modelling (See Appendix). The study periods used for both models is the same for the analysis and only varied for both, in order to see the impact of the time on the decision alternative. The formulae shown in the model above is used to evaluate the present worth (PW) at a minimum acceptable rate return of 10%. To have a consistent analysis, the APR is also maintained and only varied for a given alternative while holding the APR in the other constant. The result of the model using for an APR of 5% annually and 36 months study period is shown in Table 1 for Lease and Table 2 for Buy.

TABLE 1: FINANCIAL MODEL RESULTS: LEASE, APR 5%, 36 MO

	Lease		
	Fiat 500e	**BMW i3 BEV**	**Tesla**
Adjusted Sale Price =	$32,700	$44,000	$75,000
Total Differential Cost =	($23,199.58)	($30,652.70)	($51,297.21)
Total Interest Cost =	($4,872.93)	($5,992.98)	($9,263.61)
PW (10%) =	($20,044.22)	($26,450.26)	($44,215.98)

TABLE 2: FINANCIAL MODEL RESULTS: BUY, APR 5%, 36 MO

	Buy		
	Fiat 500e	**BMW i3 BEV**	**Tesla**
Adjusted Sale Price =	$32,700	$44,000	$75,000
Total Differential Cost =	($20,908.39)	($28,133.61)	($47,955.02)
Total Interest Cost =	($2,581.74)	($3,473.90)	($5,921.42)
PW (10%) =	($19,711.62)	($26,523.29)	($45,210.15)

1. It can be seen that the PW for the lease option is lower in the low value band (-$20,044.22 versus -$19711.62 smaller is the better). This means that the buy arrangement is more suitable in that band. This shows that for the lower cost vehicles, the (P-R) is still close to P. That is, the residual value is

usually not that huge and hence lease payments are closer to loan payments. This is probably showing that it might be better to buy a low value vehicle than to lease it for the study period.

2. On Medium and luxury bands, the lease shows to be the better option as the PW values show less cost, compared to the buy. This is interesting and at the same time makes sense. For instance, in the case of the luxury brand (Tesla), a cost of $75,000 shows that the manufacturer still expects the residual value of the vehicle at the end of the study period to be quite huge. This means, the larger the expected residual value, the lower the (P-R) and the less monthly payment of the lease option. For the buy, it means the buyer has to incur the entire cost of, say $75,000 all within period. This shows that lease will be a very attractive decision if one wants to drive a luxury brand but can't afford huge monthly loan financing.

6 SENSITIVITY ANALYSIS

Sensitivity analysis was performed to better understand the what-if situations.
It is very obvious from the financial model that the annuities computed and PW(10%) calculated are very dependent on the APR% and the residual value of the vehicle at the end of the study period. Hence the following what-if situations were further studied:

1. For what APR% would the lease be considered a better alternative than buy, given the buy APR%.

   For this case, the Buy APR% was varied and a goal-seek option was used in Excel to find for what the maximum allowable lease APR% that would cause lease PW(10%) better than buy PW(10%). All other data was kept constant. The study was performed on all three vehicles for 24mo, 36mo and 48mo. The table shows the results for the analysis for economy class vehicle Fiat 500e. For additional data please see Appendix A

TABLE 3: : SENSITIVITY ANALYSIS RESULTS: FIAT

Fiat 500e	**Max Lease APR%**			
Buy Loan %	**24MO**	**36MO**	**48MO**	**STD%**
5%	4.0009%	4.4683%	4.7157%	0.30%
8%	6.0628%	6.6734%	7.0072%	0.39%
11%	8.1540%	8.9194%	9.3499%	0.49%
15%	10.9866%	11.9754%	12.5483%	0.65%
21%	15.3283%	16.6838%	17.4938%	0.89%

2. For what % reduction in residual value (market value) of the vehicle at the end of the study period would keep the buy as an economical alternative.

   For this analysis, both the buy and lease APR% were assigned the same value. By varying the APR% over a rang, the goal-seek option in Excel was used to resolve a % drop in market value of the vehicle to determine for the buy alternative for which the PW(10%) would still be lower than lease PW(10%). The study was performed on all three vehicles for 24mo, 36mo and 48mo. The table shows data for Luxury vehicle Tesla Model S 70D. For additional data please see Appendix A

TABLE 4: SENSITIVITY ANALYSIS RESULTS: TESLA

Tesla	% Change in MV			
APR%	**24MO**	**36MO**	**48MO**	**STD%**
5%	2.19%	4.07%	6.19%	1.63%
8%	-0.83%	-0.67%	-0.36%	0.19%
11%	-3.79%	-5.26%	-6.63%	1.16%
15%	-7.64%	-11.14%	-14.55%	2.82%
21%	-13.19%	-19.45%	-25.50%	5.02%

7 CONCLUSIONS AND RECOMMENDATIONS

The data used and the financial analysis performed was based on some theoretical and readily available data from various sources online. Some of the key factors such as money factor (used to compute lease APR% and residual value computations used by the leasing company are very difficult to find. Total differential cost, PW(10%) was as indicated by the differences that the answer to the question to lease or to buy is 'depends'. But based on the sensitivity analysis performed the following conclusions were drawn and recommendations were made.

TABLE 5: CONCLUSIONS AND RECOMMENDATIONS

Conclusion	Recommendation
Leasing a vehicle for more than 36mo is the not economical (irrespective of the APR) as longer the term more the interest you will have to pay over the lease term	If Leasing for more than 36mo, at the end of the lease term the borrower may consider buying the vehicle.
Buying a vehicle and owning for less than 36mo is highly risky, as the smallest fluctuation in Market Value will cause a loss (not economical)	If buying, it is recommended that the vehicle be owned for more than 36mo, to minimize the impact of the fluctuations. Or consider leasing the vehicle.
At relative low APRs (less than 8%), higher the Adjusted Sale Price/Cap Cost more economical is the lease as compared to buy	Consider leasing a luxury vehicle than buy if the APR is low (below 8%)
For high APR (>8%), the amount paid towards the interest is relative large as compared to the rest of the leasing period [19].	Consider GAP insurance, if the APR is high
For high Cap Cost/Adjusted Sale Price, the amount paid towards the interest is relative large as compared to the rest of the leasing	Consider GAP insurance, for luxury vehicles

period, even for relatively low APR (5%) [19].	
Interest paid for the lease alternative is higher than the buy option	There is a degree to which the Money factor, residual value, acquisition fee can be negotiated. The borrower should try his best to bring those down. Use online research tools such as [19][21][22][23] The same applies to the APR% the borrower is able to get for the loan. There are banks that will compete to gain your business and match rates, if necessary. Use online research tools such as [23][24].

8 LIMITATIONS AND FUTURE WORK

The financial model that was used to perform the analysis was able to provide conclusive results with the number factors that were considered in the model. There is further work that can be done to improve upon the model and analysis.

The financial model did not take into account tax implications as the analysis was done for the state of Oregon. The analysis could be impacted by sales tax in a significant way. Because the lease option does not pay tax based on the entire cost of the vehicle but on just the expected depreciation of the vehicle, whereas the sales tax for the buy option is paid against the adjusted sale price of the vehicle, which would be more than the lease option.

Due to the lack of availability of information/data for the maintenance/service cost the costs were omitted from the financial analysis. This can added to the model to understand how these contact impact the study.

The financial model can be improved so the lease vs buy comparison can be used to help any vehicle type and not just EV to help the decision making process.

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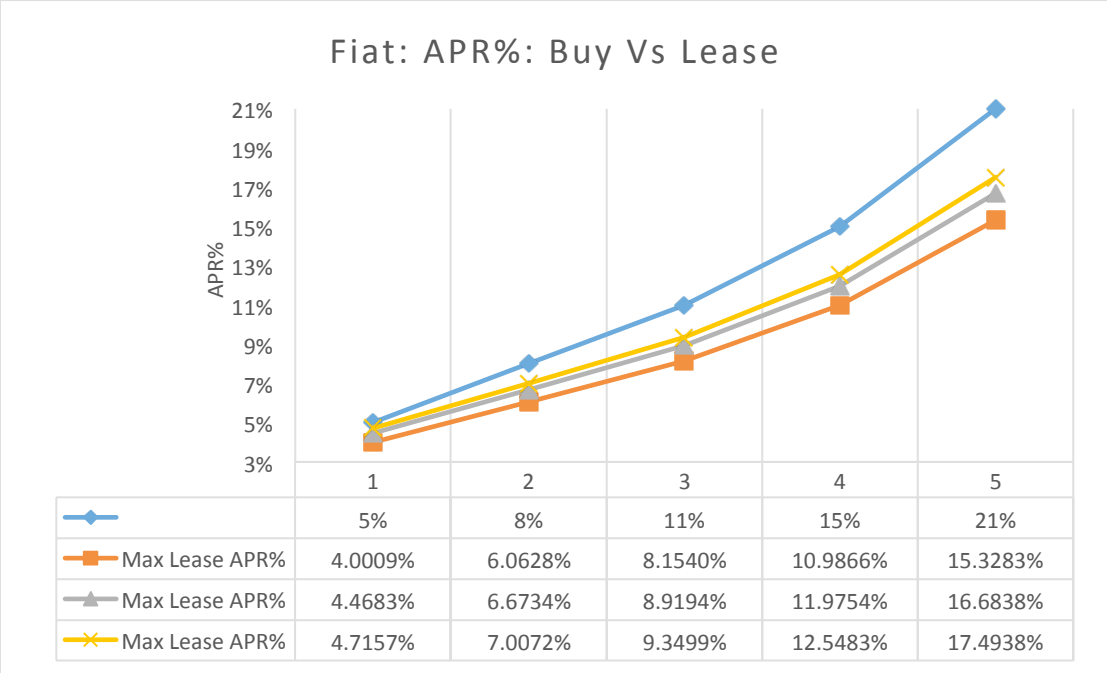
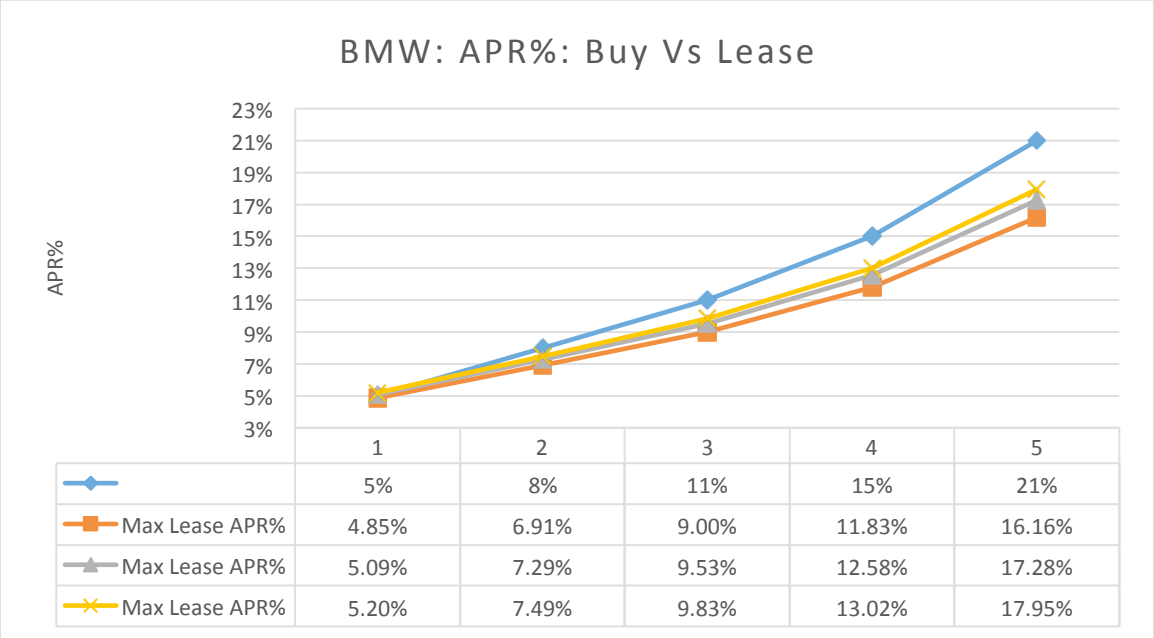
APPENDIX A: RESULT PLOTS

A.1 APR SHIFT ANALYSIS



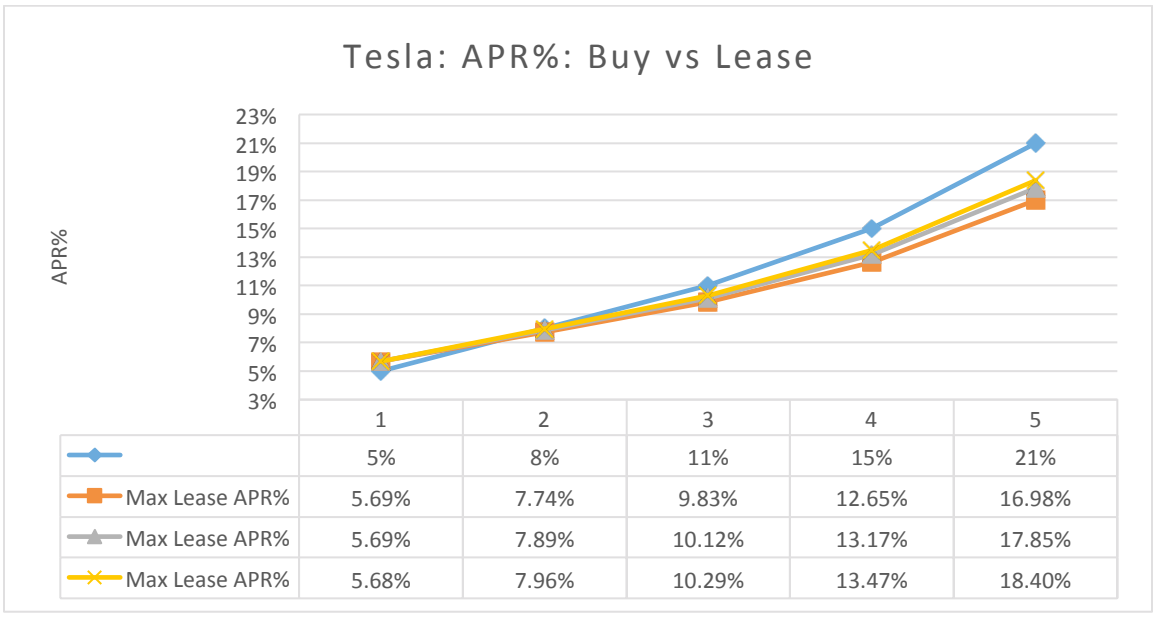
	1	2	3	4	5
	5%	8%	11%	15%	21%
Max Lease APR%	4.0009%	6.0628%	8.1540%	10.9866%	15.3283%
Max Lease APR%	4.4683%	6.6734%	8.9194%	11.9754%	16.6838%
Max Lease APR%	4.7157%	7.0072%	9.3499%	12.5483%	17.4938%

FIGURE 3: FIAT - APR%: BUY VS LEASE



	1	2	3	4	5
	5%	8%	11%	15%	21%
Max Lease APR%	4.85%	6.91%	9.00%	11.83%	16.16%
Max Lease APR%	5.09%	7.29%	9.53%	12.58%	17.28%
Max Lease APR%	5.20%	7.49%	9.83%	13.02%	17.95%

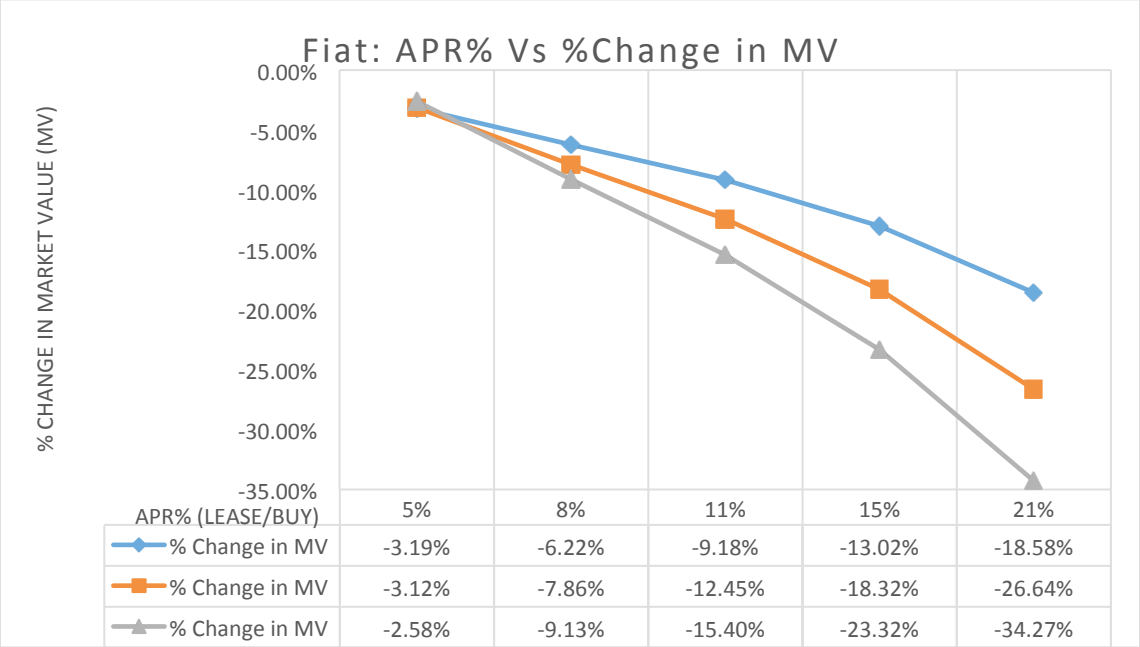
FIGURE 4: BMW - APR%: BUY VS LEASE



	1	2	3	4	5
	5%	8%	11%	15%	21%
Max Lease APR%	5.69%	7.74%	9.83%	12.65%	16.98%
Max Lease APR%	5.69%	7.89%	10.12%	13.17%	17.85%
Max Lease APR%	5.68%	7.96%	10.29%	13.47%	18.40%

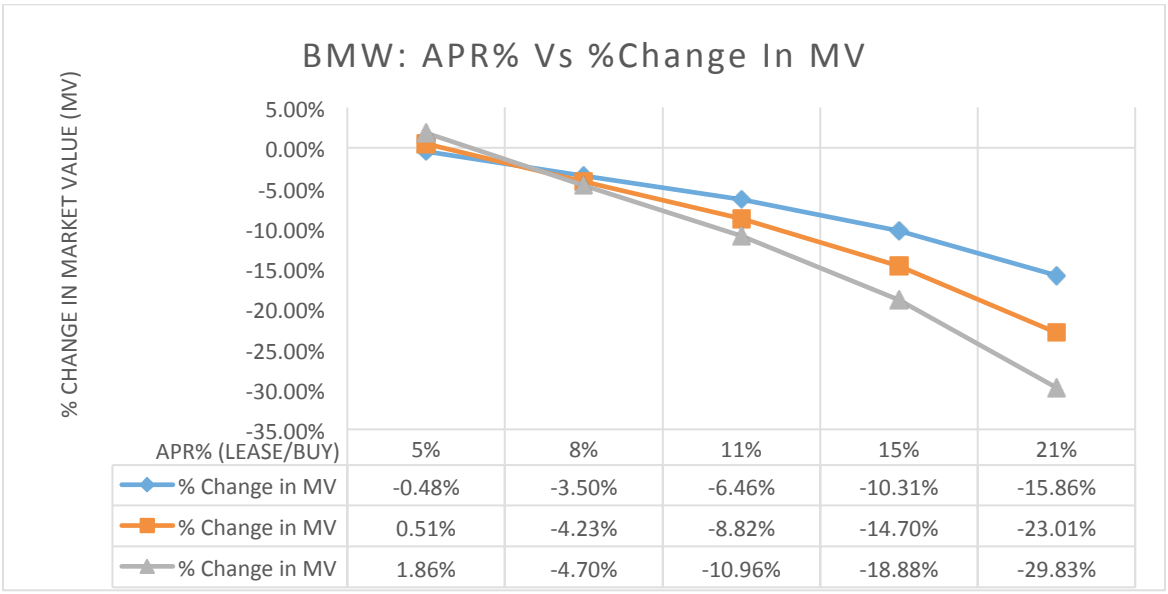
FIGURE 5: TESLA - APR%: BUY VS LEASE

A.2 BUY MARKET VALUE ANALYSIS



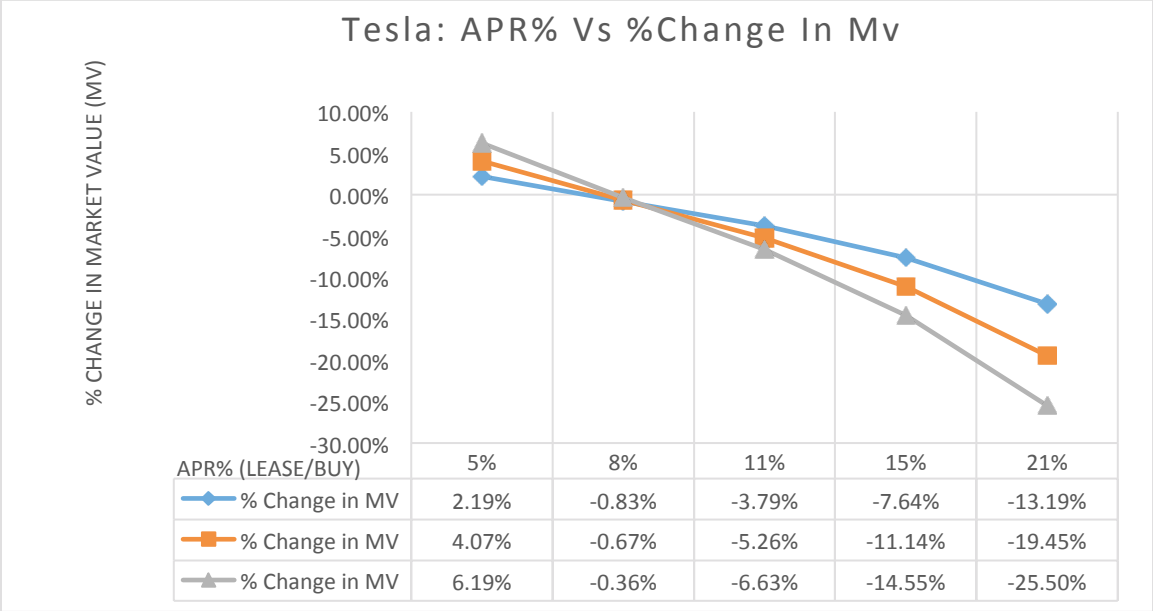
APR% (LEASE/BUY)	5%	8%	11%	15%	21%
% Change in MV	-3.19%	-6.22%	-9.18%	-13.02%	-18.58%
% Change in MV	-3.12%	-7.86%	-12.45%	-18.32%	-26.64%
% Change in MV	-2.58%	-9.13%	-15.40%	-23.32%	-34.27%

FIGURE 6: FIAT - APR% VS % CHANGE IN MV



APR% (LEASE/BUY)	5%	8%	11%	15%	21%
% Change in MV	-0.48%	-3.50%	-6.46%	-10.31%	-15.86%
% Change in MV	0.51%	-4.23%	-8.82%	-14.70%	-23.01%
% Change in MV	1.86%	-4.70%	-10.96%	-18.88%	-29.83%

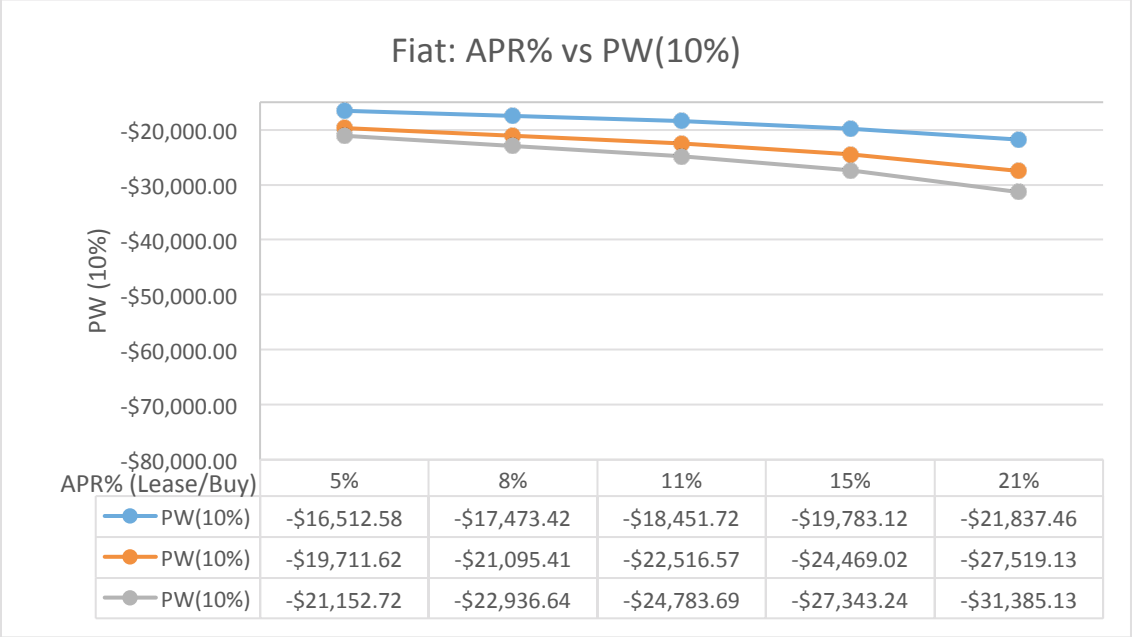
FIGURE 7: BMW - APR% VS %CHANGE IN MV



APR% (LEASE/BUY)	5%	8%	11%	15%	21%
% Change in MV	2.19%	-0.83%	-3.79%	-7.64%	-13.19%
% Change in MV	4.07%	-0.67%	-5.26%	-11.14%	-19.45%
% Change in MV	6.19%	-0.36%	-6.63%	-14.55%	-25.50%

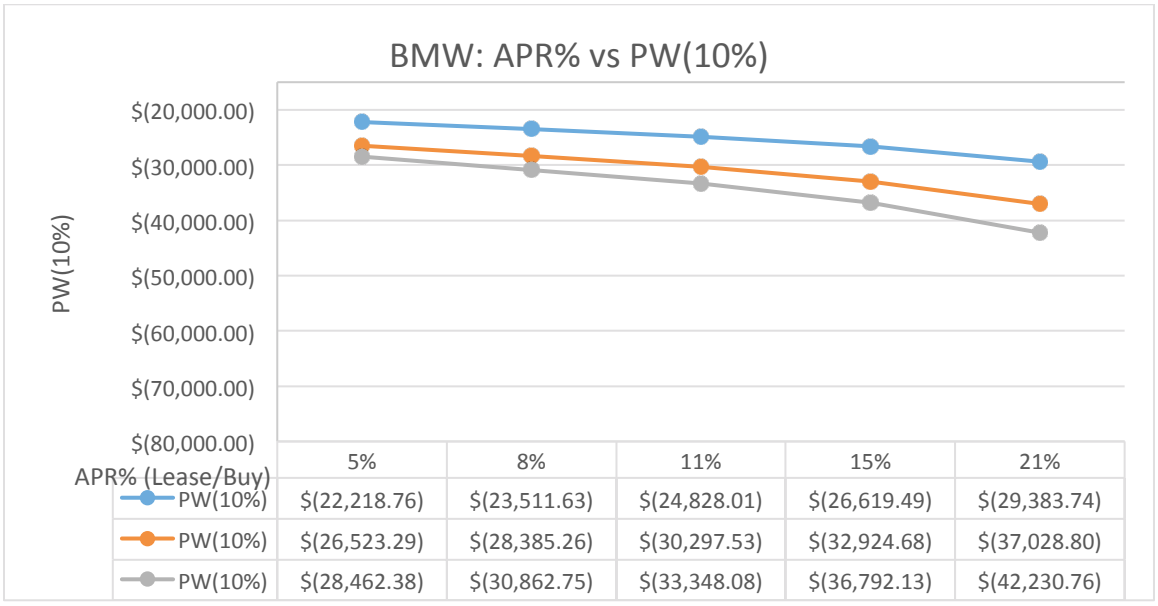
FIGURE 8: TESLA - APR% VS %CHANGE IN MV

A.3 PW(10%)



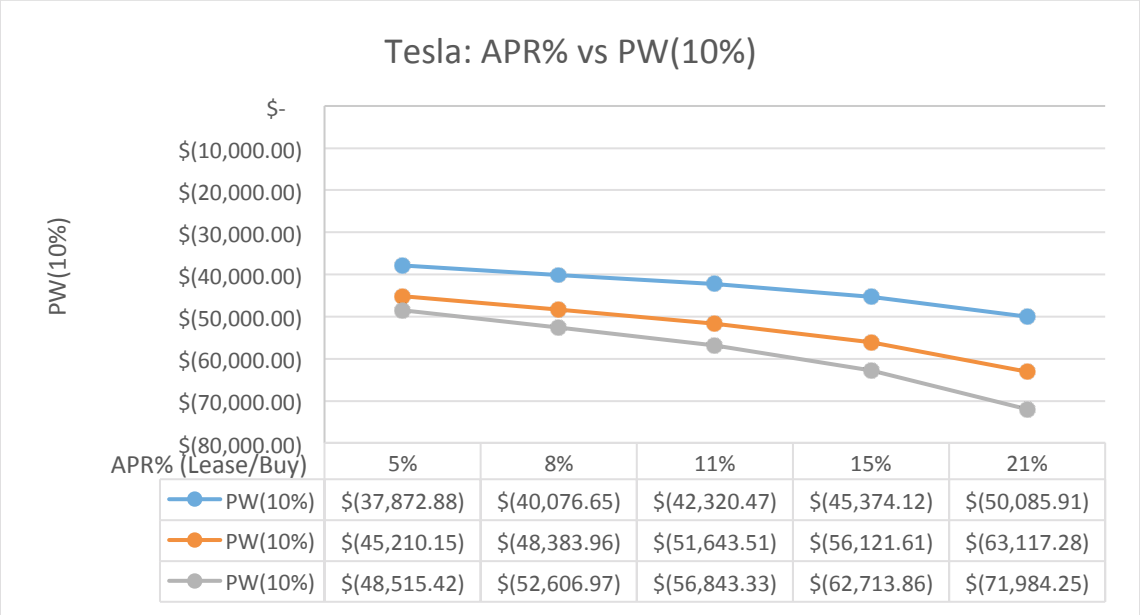
APR% (Lease/Buy)	5%	8%	11%	15%	21%
PW(10%)	-$16,512.58	-$17,473.42	-$18,451.72	-$19,783.12	-$21,837.46
PW(10%)	-$19,711.62	-$21,095.41	-$22,516.57	-$24,469.02	-$27,519.13
PW(10%)	-$21,152.72	-$22,936.64	-$24,783.69	-$27,343.24	-$31,385.13

FIGURE 9: FIAT - APR% VS PW(10%)



APR% (Lease/Buy)	5%	8%	11%	15%	21%
PW(10%)	$(22,218.76)	$(23,511.63)	$(24,828.01)	$(26,619.49)	$(29,383.74)
PW(10%)	$(26,523.29)	$(28,385.26)	$(30,297.53)	$(32,924.68)	$(37,028.80)
PW(10%)	$(28,462.38)	$(30,862.75)	$(33,348.08)	$(36,792.13)	$(42,230.76)

FIGURE 10: BMW - APR% VS PW(10%)



APR% (Lease/Buy)	5%	8%	11%	15%	21%
PW(10%)	$(37,872.88)	$(40,076.65)	$(42,320.47)	$(45,374.12)	$(50,085.91)
PW(10%)	$(45,210.15)	$(48,383.96)	$(51,643.51)	$(56,121.61)	$(63,117.28)
PW(10%)	$(48,515.42)	$(52,606.97)	$(56,843.33)	$(62,713.86)	$(71,984.25)

FIGURE 11: TESLA - APR% VS PW(10%)

APPENDIX B: FINANCIAL MODEL

B.1 LEASE

	Lease		
	Fiat 500e	BMW i3 BEV	Tesla
Adjusted Sale Price =	$32,700	$44,000	$75,000
Lease/Loan Term =	36	36	36
Lease Money Factor =	0.002083	0.002083	0.002083
Lease APR % (Compounded Monthly) =	5.0000%	5.0000%	5.0000%
Effect Interest Rate =	5.1162%	5.1162%	5.1162%
Acquisition Fee =	-$895.00	-$795.00	-$700.00
Lease Miles/Year =	10,000	10,000	10,000
Residual Value/Book Value EOY =	$14,373	$19,340	$32,966
Book Value - Market Value =	0%	$0	0%
Market Value (MV) EOY =	$14,373	$19,340	$32,966
Monthly Payment =	-$609.16	-$819.66	-$1,397.14
First Month Payment =	-$1,504.16	-$1,614.66	-$2,097.14
Actual Miles/Yr =	10,000	10,000	10,000
Penalty for Overage =	-$0.25	-$0.25	-$0.25

Deposition Fee =	-$375.00	-$350.00	-$300.00
Last Payment =	-$984.16	-$1,169.66	-$1,697.14
Total Differential Cost =	-$23,199.58	-$30,652.70	-$51,297.21
Total Interest Cost =	-$4,872.93	-$5,992.98	-$9,263.61
PW(10%) =	-$20,044.22	-$26,450.26	-$44,215.98
FW(10%) =	-$27,023.26	-$35,659.76	-$59,611.18

B.2 BUY

	Buy		
	Fiat 500e	**BMW i3 BEV**	**Tesla**
Adjusted Sale Price =	$32,700	$44,000	$75,000
Lease/Loan Term(reg+title+plate) =	36	36	36
Lease Money Factor =	-	-	-
Lease APR % (Compounded Monthly) =	5%	5%	5%
Effect Interest Rate =	5.1162%	5.1162%	5.1162%
Acquisition Fee =	$0	$0	$0
Lease Miles/Year =	-	-	-
Residual Value/Book Value EOY =	$14,373	$19,340	$32,966
Book Value - Market Value =	0%	0%	0%
Market Value (MV) EOY =	$14,373	$19,340	$32,966
Monthly Payment =	-$980.05	-$1,318.72	-$2,247.82

First Month Payment =	-$980.05	-$1,318.72	-$2,247.82
Actual Miles/Yr =	-	-	-
Penalty for Overage =	-	-	-
Deposition Fee =	-	-	-
Last Payment =	-$980.05	-$1,318.72	-$2,247.82
Total Differential Cost =	-$20,908.39	-$28,133.61	-$47,955.02
Total Interest Cost =	-$2,581.74	-$3,473.90	-$5,921.42
PW(10%) =	-$19,711.62	-$26,523.29	-$45,210.15
FW(10%) =	-$26,574.85	-$35,758.21	-$60,951.50

APPENDIX C: LIST OF EV CONSIDERED FOR THE PROJECT AND FINAL SELECTION

Model	Year	Price	Battery (kWh)	EPA (miles)	MPGe Highway	MPGe City	MPGe Combined	Motor (kW)
Mitsubishi i-MiEV	2015	$23,845	16	62	99	126	112	49
Smart Fortwo EV	2015	$25,750	17.6	68	93	122	107	55
Chevy Spark	2015	$27,645	18.4	82	109	128	119	105
Nissan Leaf	2015	$29,860	24	84	101	126	114	80
Ford Focus EV	2015	$29,995	23	76	99	110	105	107
Fiat 500e	**2015**	**$33,200**	**24**	**87**	**108**	**122**	**116**	**83**
VW E-Golf	2015	$34,270	24.2	83	105	126	116	85
Kia Soul EV	2015	$34,500	27	93	92	120	105	81
Chevy Volt	2015	$35,170	17.1	38	-	-	98	111
Merc-Benz B-Class eDrive	2015	$42,375	28	87	82	85	84	132
BMW i-3	**2015**	**$43,350**	**22**	**81**	**111**	**137**	**124**	**130**
Tesla Model S 70D	**2015**	**$75,000**	**70**	**240**	**89**	**98**	**93**	**245**
Cadillac ELR	2014	$75,995	16.5	37	-	-	82	135
Tesla Model S2	2015	$105,000	85	270	88	90	89	515