Research Project Report

Competitive Analysis on Battery Electric Vehicle (BEV) market: A case study of Tesla Motor

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Contents

Abstract

With the growing of BEV market opportunities, car manufacturers have been developing new models with better performance, in order to gain competitive advantage. Tesla, as a luxury BEV market leader, are facing challenges both from industry and competitors perspective.

In order to investigate the degree of competitiveness in BEV market, Porter's Five Forces and SWOT analysis are conducted to identify the current environment situation. DEA technical efficiency is conducted to benchmark the degree of efficiency among all the competitors.

The results of analysis indicated several critical issues related to Tesla's future business development. More specifically, market analysis shows that threats from substitution are considered high. Further, how to reduce cost and standard charging time are regarded as future challenges that require Tesla's improvement initiatives, in order to maintain its competitive advantage.

1. Introduction

Owing to the growing concern of sustainability and environmental protection awareness, the customers indicates, in car industry, more interests in Electric Vehicles (EV) including Hybrid Electric Vehicle (HEV), Plug-In Hybrid Electric Vehicle (PHEV), and Battery Electric Vehicle (BEV). Especially the BEV has been growing in recent years as manufacturers continuously develop new or updated products with new performance features in response to the emerging market need.

Tesla motor is considered as a leader in luxury BEV market segment. Its success has been attributed to technology innovation, unique business strategy, and attractive product features. However, with the advent of battery vehicle technology, competitors are able to design and manufacture BEV with better performance. Thus, the research question is what will be the degree of competitiveness of current BEV market for Tesla. This leads to the objective of this project, which is to investigate the competitive environment in BEV market by conducting market and competitor's analysis. The research outcome is expected to identify the strength and weakness of Tesla's current performance in order to benchmark its competiveness among the competitors.

2. Literature Review

2.1 Electric Vehicle:

2.1.1 Definition:

Electric Vehicle mainly include HEV, PHEV, and BEV which are distinguished as follows [1].

- HEV: A vehicle that is powered by an on-board engines supplemented by electricity that is recovered via regenerative braking.
- PHEV: A hybrid vehicle that features a larger battery than a HEV and is therefore able to be recharged via the National Grid and operate over a short distance in electric-only mode.
- BEV: An electric vehicle that is powered solely by electricity stored in onboard batteries. A BEV does not feature an on-board engine and is charged by plugging into the National Grid.

2.1.2 Advantages and Challenges:

Battery Electric Vehicle also termed as All-electric vehicles simply run on electricity and normally propelled by an electric motor with rechargeable battery packs. EVs have several advantages over vehicles with internal combustion engines (ICEs) [2],[3]:

- Energy efficient: Electric vehicles convert about 59–62% of the electrical energy from the grid to power at the wheels whereas conventional gasoline vehicles only convert about 17–21% of the energy stored in gasoline to power at the wheels.
- Environmentally friendly: There is no tailpipe pollutants from BEV, although the power plant producing the electricity may produce them.

- Performance benefits: Electric motors provide quiet, smooth operation and good acceleration and require less maintenance than ICEs.
- Reduce energy dependence: Electricity is a domestic energy source and don't rely on imported petroleum

Conversely, EVs is still facing some significant challenges mainly on its battery [4].

- Driving range: The driving range for BEVs is only about 100–200 miles before recharging, which is considered less than gasoline vehicles.
- Recharge time: The recharging time for the battery pack will take 4 to 8 hours. For some vehicle with fast charging option can recharge the vehicle to 80% capacity in about 30 min.
- Battery cost: The large battery packs are considered expensive and need replacement sometimes.
- Bulk & weight: The space for accommodating battery packs are heavy and influence the allocation of the entire vehicle space.

The above advantages and challenges may be summarized that fuel economy, motor power, acceleration, range, charging time, battery capacity, and weight are key performance attributes needed to be focused both from manufacturers and customers' perspectives.

2.2 BEV Market Outlook:

According to the EV Obsession website, the Electrified Car sales in USA (All Electric and Plug-in Hybrid) is increasing from 2011 to 2013. Especially, the 100% electric car sales increased 228.88% in 2013 compared to 2012, whereas the plug-in

hybrid electric sales increased 26.87% in that time period. This indicated that there is strong demand of 100% electric vehicle (Battery Electric Vehicle) [5].

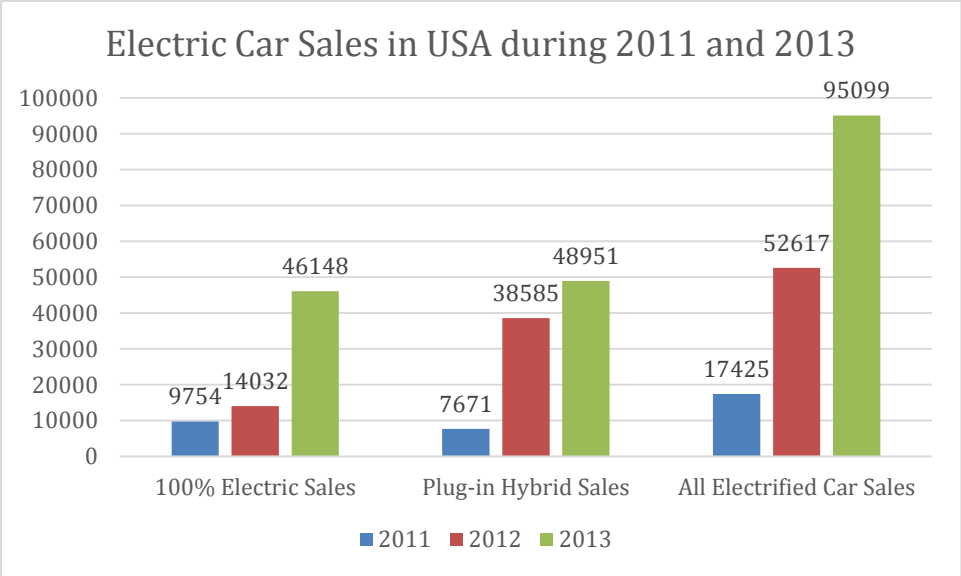

Figure 1: Electric Car Sales in USA during 2011 and 2013

Source: http://evobsession.com/electric-car-sales-increased-228-88-2013/

According to the most recent selling statistics, we may find that pure electric vehicle are still growing. Nissan Leaf and Tesla Model S have been ranked top 1 and top 2 among all the BEVs in USA in both 2013 and 2014. These data imply that the demand for BEV is increasing and the market tend to be more competitive [6].

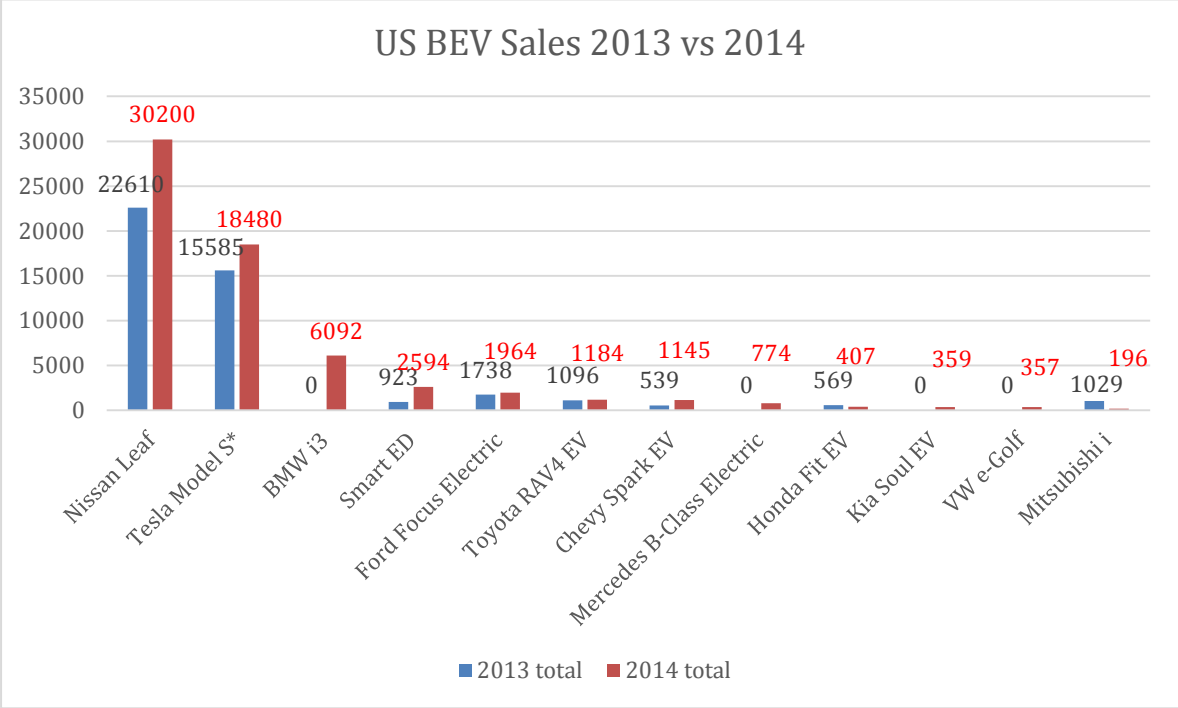

Figure 2: BEV sale in US from 2013 to 2014

Source: http://evobsession.com/tesla-sales-updates-estimates//

Based on above historical data and trend, it won't be surprised to find that with the assumption of increasing vehicle availability, government influence, decreasing HEV/PHEV prices, and gasoline/diesel prices, the Navigant Research forecasts global Compound Annual Growth Rate (CAGR) will grow 2.4% for Light Electric Vehicle between 2013 and 2020. This includes the CAGR of 11.5% for HEVs, 31.9% for PHEVs, and 31.5% for BEVs [7].

2.3 BEV Market Drivers:

According to M. E. Mangram (2012), four BEV market drivers have been identified as major factors that contribute to the growth or change of BEV industry. These drivers include Technological developments, Infrastructure development,

Public policy, and Energy Economics, which are briefly described as follows and depicted in the figure below [8].

Technological developments: Battery range limitation and high cost are considered as two of the critical factors hindering growing adoption of BEVs. With the breakthrough of the battery technology, the BEV will not only result in cost reduction but also lead to the increase of the sale volume.

Infrastructure development: The spread or density of charging stations relates the degree of convenience of using BEV. The viable charging options provided by the manufacturers will also relate customers' decision behavior.

Public policy: In view of the greenhouse gases consideration, the government often encourage public to adopt alternative transportation technology. As a result, these subsidies for both manufacturers and customers will be likely to enhance the BEV market expansion.

Energy economy: Due to the scarce nature of oil, the gasoline price is not likely to be greatly reduced. Conversely, the electricity price is relatively cheaper, which is often accepted for an alternative energy options.

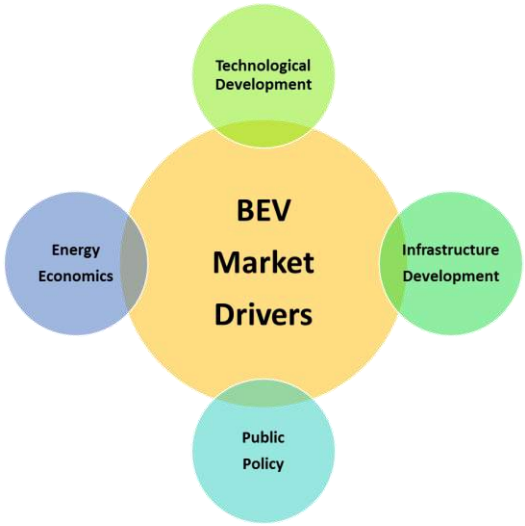

Figure 3: BEV market drivers
Source: M. E. Mangrm, The globalization of Tesla Motors: a strategic marketing plan analysis, Journal of Strategic Marketing, p. 292, 2012.

2.4 Market Analysis:

In order to evaluate the competitive market environment for Tesla motors, a market analysis including Porter's Five Force Analysis and SWOT analysis which are briefly described as follows:

Five Force Analysis: Five forces include "Rivalry among existing competitors", "Threat of new entrants", "Threats of substitute products or services", "Bargaining power of buyers", and "Bargaining power of suppliers". Porter said that "Awareness of the five forces can help a company understand the structure of its industry and stake out a position that is more profitable and less vulnerable to attack." He also suggests the following tactics to reshape the forces in our own favor: to neutralize the supplier power by standardizing specification, to counter customer power by expanding service, to temper price by differing products, to scare new entrants by elevating fixed cost, and to limit the threat of substitutes by offering wider product

accessibility [9]

SWOT analysis: SWOT stands for strength, weakness, opportunity, and threat. It was originated by Albert S Humphrey in the 1960s and can be used for assisting the formulation of strategy [10]. SWOT analysis targets on identifying the strengths and weaknesses of an organization as well as the opportunities and threats in the external environment. After identifying these factors, the development of appropriate strategies may focus on enhancing strengths, reducing the weaknesses, exploiting the opportunities or countering the threats [11].

2.5 Competitors Analysis:

Typically, the competitors' analysis will involve in selecting critical factors to be evaluated on each of the competitors, in order to identify the degree of competitiveness of the company or product under evaluating. Among these analysis, productivity and efficiency can be cited as indicators or measures of competitiveness [12]. Therefore, for this project, it is proposed to use Data Envelopment Analysis (DEA) and calculate technical efficiency score for competitors' analysis.

DEA utilizes mathematical programming and can handle numbers of variables and constraints for decision making on the basis of efficiency value [13]. DEA has been found to be used in several products or industry to benchmark efficiency or productivity by means of productivity measurement concept (Output/Input). With different assumption of return of scale, there are CCR and BCC models to be used for calculating technical efficiency.

CCR model: Employ CRS concept, which means that if output increases by that same proportional change as all inputs change then there are constant returns to scale. The OB dotted line depicts the CCR model and represents the efficient frontier as shown in figure below. The CCR efficiency value for D is (PQ)/(PD) and also called "technical efficiency" (TE).

BCC model: Employ VRS concept, which stands for Variable Return to Scale, meaning an increase in inputs does not result in a proportional change in the outputs. An example of BCC model is shown on the solid lines connecting A and B, as well as B and C where A, B, and C are all on the frontiers. The BCC efficiency value for D is (PR)/(PD) and also called "pure technical efficiency" (PTE). For this case, BCC efficiency should be larger than the CCR efficiency. [14]

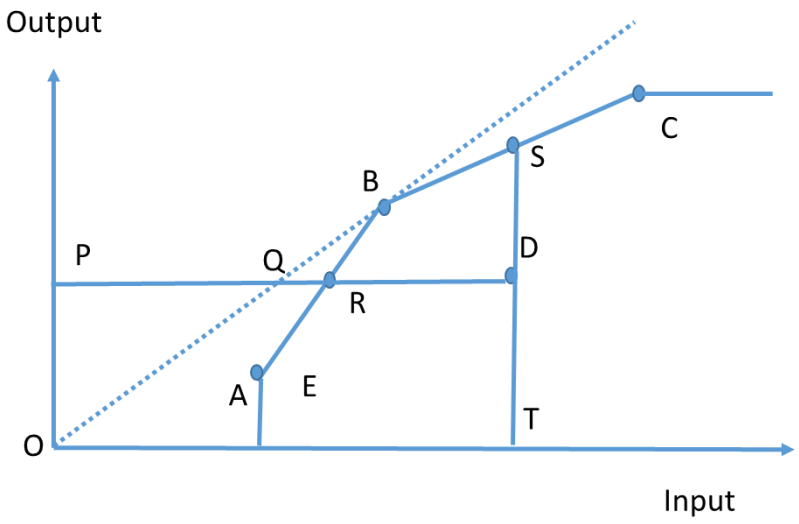

Figure 4: DEA CCR & BCC model
Source: W. W. Cooper, L. M. Seiford, K. Tone, Data Envelopment Analysis, Springer, p.90, 2007

Currently, there are some DEA software tools available. Among them, PSU ETM

has developed DEA tools for calculating DEA and TFDEA (Technology Forecasting DEA). DEA tools have been developed in various forms including Excel Add-In, Web App, and CRAN TFDEA package for R language application. For this project, the Web App version will be adopted for conducting the DEA calculation.

When using the DEA Web App, the following differences of settings is needed to be recognized for interpretation [15].

- Input oriented vs Output oriented
  - Input oriented: minimize inputs while satisfying at least the given output level
  - Output oriented: attempts to maximize outputs without requiring more of any of the observed input values.

3. Tesla Motor Case Study:

3.1 Company Overview

Tesla Motors, Inc. is an American company that was founded in 2003. Tesla designs, manufactures, and sells electric cars and electric vehicle powertrain components. Tesla HQ is located on Palo Alto, CA [16]. They have factory and assembly facilities in California and Netherlands. Their employee are about 6,000 as of Jan. 2014. With its corporate culture focusing on moving fast, continuing innovation, doing the impossible and thinking like owners, Tesla is capable of streamlined vehicle development and meeting superior economics efficiency. Tesla gains impressive market share to prove its competences and excellent performance

[17].

3.2 Company vision and strategy

Tesla's vision statement: "Create the most compelling car company of the 21st century by driving the world's transition to electric vehicles." reflects its intention to design and manufacture the best BEV ever and lead the EV market transition.[18] Their company strategy mainly emphasize on the capability of technology innovation in both product and service.

Tesla thinks that their product expertise including design capability, vehicle engineering, powertrain engineering, and software engineering, make its product look impressive without sacrificing the expected functions and performance. In addition, their direct showroom marketing approach, make to order purchasing pattern, and mobile rangers service support model is unique and differentiate other car manufacturers [19].

3.3 Company Products

Tesla currently has manufactured or been developing the following 4 BEV models including Roadster, Model S, Model X, and Model 3.[20]

Roadster (sport car): Tesla Roadster is the first high-performance, two seats, and electric convertible sports car. Roadster has the following technical features including 3.7 seconds acceleration rate and range of 244 miles. Its base price is $109,000 and has been sold about 2,400 units as of Sep. 2012.

Figure 5: Tesla Roadster

Source: http://www.teslamotors.com/

Model S (luxury sedan): Model S is a four-door, five-adult passenger BEV sedan. Its technical features include 4.4 acceleration rate and range of 265 miles. Tesla offer 40 kWh, 60 kWh and 85 kWh options for Model S with base price of $52,400, $62,400, and $72,400 respectively. Tesla believes that Model S is recognized as a fascinating combination of functionality, convenience, styling, superior performance and energy efficiency. As of December 31, 2014, Tesla had delivered almost 57,000 Model S vehicles. [21]

Figure 6: Tesla Model S

Source: http://www.teslamotors.com/

Model X (crossover UV): Model X is a crossover BEV blending with minivan and SUV functionality. It has stylish exterior with dual motor AWD technical features.

Tesla plans to start production in late 2014.

Figure 7: Tesla Model X

Source: http://www.teslamotors.com/

Model 3 (mainstream and affordable EV): Model 3 has a range of 200 miles, with first deliveries expected to begin by 2017 or 2020. It is targeted on mass market with competitive range, affordability, and performance. The starting price is about US$30,000.

Figure 8: Tesla Model 3

Source: http://www.teslamotors.com/

4. Market Analysis for Tesla

4.1 Five Force Analysis

By adopting Porter's Five Forces model, the market analysis is conducted for

Tesla as follows [22][23][24]:

Industry Competitors: Due to high entry barrier and niche market (Luxury BEV), the competition is considered moderate. As indicated in Tesla's annual report, the competitors may include BMW, Mercedes Benz, Audi, Lexus, Fiat, and VW. For example, new models such as BMW i3 is considered as relatively smaller scale of luxury BEV, whereas BMW i8 is upper scale size of PHEV. These models seems not targeted on this purely full size luxury BEV market segment. However, with the growing rate of EV market, Tesla may need to continuously be vigilant on any new competitive models in this segment.

Potential Entrants: This part of threat is considered low to moderate. Because as mentioned above, currently only small numbers of competing vehicles have been launched. Some of them are targeting on PHEV market. In addition, due to high entry cost and technical barrier, it is not likely that new competitors will be able to launch new product in the luxury BEV market segment, which require strong brand image and reputation.

Substitutes: This part of threats are considered high. As Tesla indicated in their annual report, the total EV market including HEV, PHEV, and BEV is very competitive. With various EV choices in mind, the customers may go for HEV and PHEV due to the relatively high price of BEV. This substation effects may hinder the Tesla's growth rate to some extent.

Buyers: No matter B2C or B2B, due to niche market, strong demand, and no comparable technology available, the bargaining power is considered low from buyers'

perspective. This might justify why Tesla model S still receive large reservations from customers.

Suppliers: For battery companies, the bargaining power is low, because Tesla purchase batter cells from commercial available products and tend not to establish long term agreement with battery companies. Tesla uses these battery cells to design for themselves and also sell these battery packs to some BEV manufacturers. Namely, the suppliers need Tesla to increase their battery demands. For motor, chassis, transmission, and powertrain system, Tesla mainly develop them in house.

The result of five forces is depicted in the figure below.

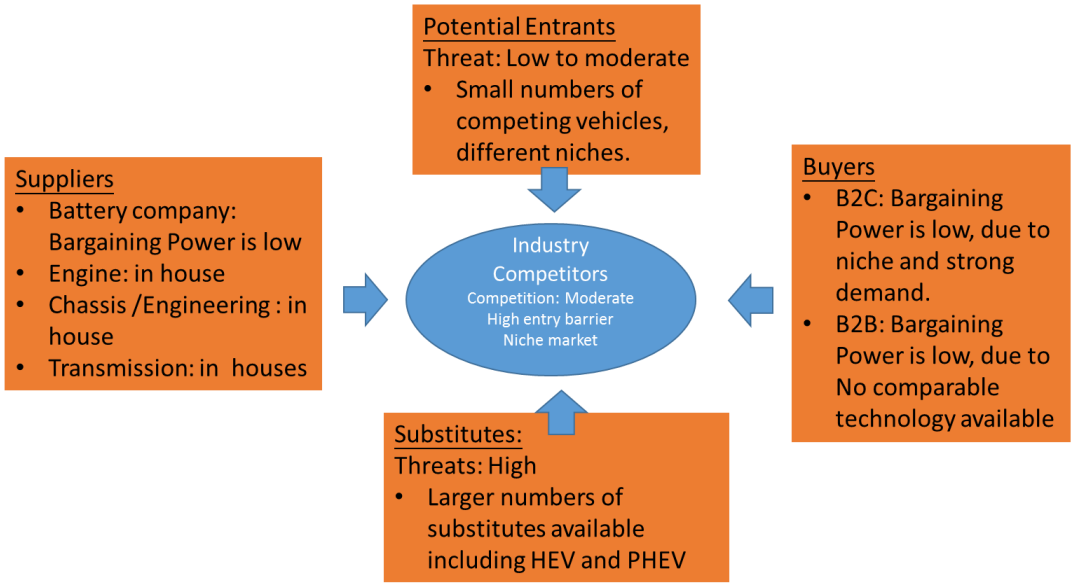

Figure 9: Five Forces analysis for Tesla
Source:

1. E. Fleming, Tesla Motors Inc., A Comprehensive Strategical Evaluation, Fleming & Moar Consulting Ltd., 2014
2. http://www.slideshare.net/joseangeldf/darden-school-of-business-tesla-strategic-analysis
3. https://prezi.com/odfko5i1kaqp/tesla-and-porters-five-forces/

4.2 SWOT Analysis

By reviewing relevant literature, the SWOT analysis for Tesla is addressed as follows:

Strength: Tesla specializes in leading edge proprietary technologies including vehicle design, powertrain technology, battery technology etc. The superior products with exceptional performance justify their sale performance. In addition to technical aspect, the CEO's forward thinking leadership, company brand image, first mover advantage, and unique business model including make to order and mobile customer service are also considered as Tesla's core competencies and expertise that enable them to be competitive in the BEV market.

Weakness: Probably we cannot blame Tesla for their relatively high price, because they target on luxury BEV segment. However, relatively high cost can be regarded as one of critical factors influencing buyers purchasing behavior. This may partly justify why smaller scale of Nissan Leaf BEV is very successful. The other weakness identified may due to lack of economies of scale, so that the product cost is not easily be reduced. Tesla rely heavily on continuing innovation. Once there is no obvious improvements on their products or services, the competitiveness may be reduced to some extent.

Opportunities: As indicated in EV market literature, the growing EV market create opportunities for Tesla and other competitors to continue developing more attractive products to increase acceptance of EV. Increasing oil price and looking for alternative sources of power may also considered as chances for customers to switch from

gasoline vehicle to EV. With increasing sustainability awareness and government support, incentives and mandates for widespread BEV adoption, the BEV market will be very likely continue to grow in the near future.

Threats: Large motor company investments on new models and potential technology breakthrough might jeopardize Tesla's market leader position. For example, Chevy will launch Bolt BEV with range of 200 mile range for just $30,000. This may pose a challenge for Tesla's future Model 3. Besides, limited EV support infrastructure and future possibility of losing government subsidies will impose threat on Tesla's future growing target.

The SWOT analysis is shown in figure below.

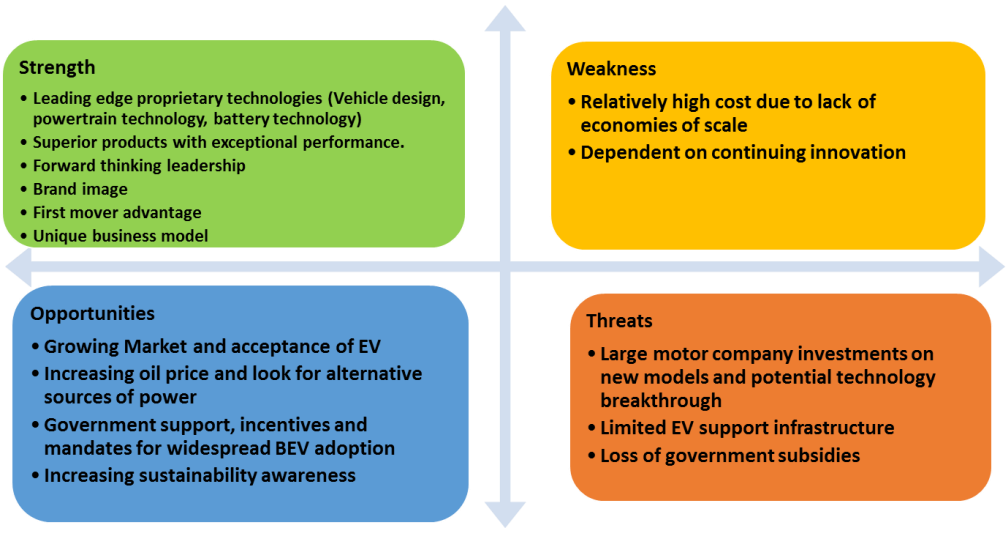

Figure 10: SWOT for Tesla
Source:

1. M. E. Mangram, The globalization of Tesla Motors: a strategic marketing plan analysis, Journal of Strategic Marketing, vol 20, No 4, pp. 302~303, July 2012.
2. http://www.slideshare.net/joseangeldf/darden-school-of-business-tesla-strategic-analysis

5. Competitors Analysis for Tesla

5.1 Technical Efficiency Analysis setting

5.1.1 Definition of the data set parameters:

Based on the implications from BEV literature, Price, Combined MPGe, Motor output power, Combined Range, Battery Capacity, and Charging Time are selected for decision variables. By considering the concept of minimizing inputs and maximizing outputs, the price or MSRP (Manufacturer's Suggested Retail Price) was chosen as input variables, whereas MPGe, Output Power, Range, Battery Capacity, and 1/Charging time were used as output variables. Those key parameters in data set are defined in the Table 1 below.

Table 1: Definition of decision variables

Types	Variables	Abbreviation	Definition
Input	Price	Price	MSRP (Manufacturer's Suggested Retail Price)
Output	Combined MPGe	MPGe	MPGe refers to Miles per Gallon of Gasoline Equivalent and 1 gallon of gasoline=33.7 kWh. A "combined" estimate that represents a combination of city driving (55%) and Highway driving (45%).
Output	Motor Output power	Output power	The power of a vehicle electric motor is measured in kilowatts (kW). 100 kW is roughly equivalent to 134 horsepower
Output	Combined Range	Range	When the vehicle is fully charged, this value represents the approximate number of miles that can be travelled in combined city and highway driving before the vehicle must be recharged.
Output	Battery Capacity		Battery Energy Capacity measured by Am hr.
Output	1/Charging Time		The inverse of the quickest time required to recharge the BEV into full capacity at 240 volts.

5.1.2 DEA implementation

The dataset used in this report is attached as Appendix and mainly extracted from

Fuel Economy and Green Vehicle Guide data files released by US Department of Energy and US Environmental Protection Agency in 2014. The BEV DEA model is conducted by using PSU ETM TFDEA Web App which is web version of Excel Add-in developed by Lim and Anderson. [25] With the consideration of increasing the performance and fuel economy with minimal changes in the price, the output orientation has been selected for implementation. Besides, variable return of scale (VRS) were used for calculation, due to no obvious evidence on the proportional change between input and outputs.

5.2 Technical efficiency Results

As the table and figure show that the most efficient DMUs include 500e, i3, e6, Spark and Tesla Model S in 2014. This implies that the above manufacturers all have the capability to develop a competitive and efficient BEV.

Table 2: Efficiency results for 2014

Make	Model	Model year	efficiency
Mercedes-Benz	B-Class Electric Drive	2014	0.94
Ford Motor Company	Focus Electric FWD	2014	0.98
Chrysler Group LLC	500e	2014	1
Honda	FIT	2014	0.98
BMW	I3 BEV	2014	1
Nissan	LEAF	2014	0.97
Mitsubishi Motors Co	i-MiEV	2014	0.93
Mercedes-Benz	Smart fortwo elec. drive (coupe)	2014	0.90
BYD Motors Inc.	e6	2014	1
Toyota	RAV4 EV	2014	0.76
General Motors	SPARK EV	2014	1
Tesla	Model S (60 kW-hr battery pack)	2014	1
Tesla	Model S (85 kW-hr battery pack)	2014	1

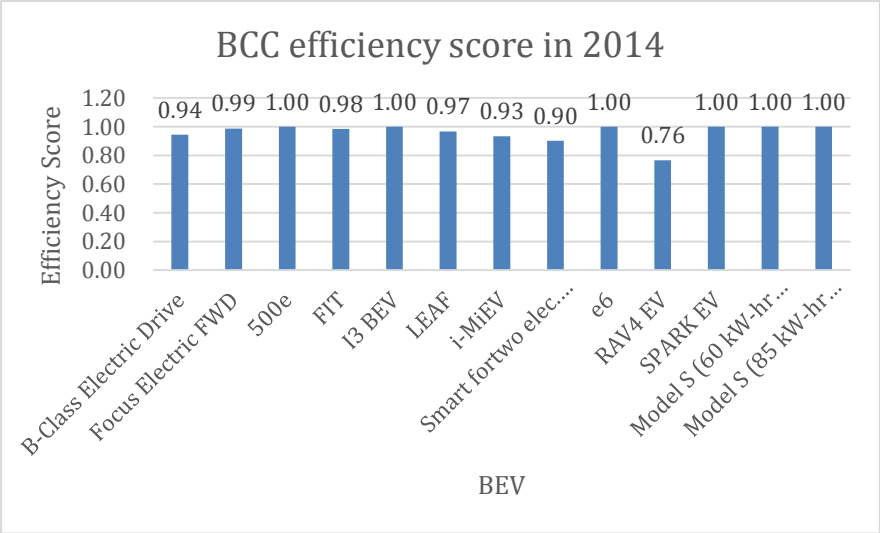

Figure 11: Efficiency score among BEVs in 2014

In comparison with Mercedes B-Class and BMW i3 BEV, Tesla Model S is featured with large power, long range, and battery capacity. However, the standard charging time at 240v is relatively under performance. The price of Tesla model S is considerably high.

Table 3: Comparison of luxury BEV in 2014

Model Year	Product	Make	Price	Output Power_kW	Range_(mi)	MPGe	Charging Time	Battery Capacity (Am hr)	Efficiency
2014	B-Class Electric Drive	Mercedes-Benz	41450.00	132.00	85.00	84.00	3.50	120.00	0.94
2014	I3 BEV	BMW	41350.00	125.00	81.00	124.00	4.00	60.00	1
2014	Model S (60 kW-hr battery pack)	Tesla	69900.00	225.00	208.00	95.00	10.00	245.00	1
2014	Model S (85 kW-hr battery pack)	Tesla	79900.00	270.00	265.00	89.00	12.00	245.00	1

6 Discussion

By conducting market analysis, some critical issues or risks may need Tesla's attention to focus on. For instance, with more improvements in BEV technology from competitors, Tesla will be very likely to face a more competitive environment in the

future. In view of large options of alternative products, Tesla need to continue highlighting the advantages and benefits of pure electric vehicles by leveraging its innovation capabilities. In addition, continuing extensive R&D investments may have conflict with the intention of reducing the selling price. Furthermore, the effect of opening its patent source to public involves risks of losing core technology advantages. These issues are viewed to have significant impact on Tesla's future business development.

In terms of competitors Analysis, Tesla's product technical efficiency is good, meaning its performance in motor power, range, MPGe, battery capacity, and charging time is considered satisfactory. This may partly justify the market leader position in luxury BEV market segment. However, based on the comparison to other competitors, Tesla may need to reduce cost, standard charging time, in order to enhance its competitive advantage in technical excellence.

7 Conclusion

The prospect of BEV market is quite positive, which will very likely attract more companies to develop more competitive and innovative products especially with better technical performance. Five forces analysis shows that the threats from competition is low to mediate, but there is high threat from substitution. The bargaining power is considered low due to niche market. SWOT analysis indicates that Tesla specialized on its BEV technology and innovative business model, whereas cost is considered as weakness and there are threats from the competitors' new

products. In terms of product technical efficiency, Tesla model S is considered efficient in major performance parameters. However, the cost and standard charging are regarded as critical factors for improvement.

8 Future Study

In terms of market analysis, future topics may include financial analysis, Eco system analysis, Patent analysis, and Global Strategy analysis. For competitors' product efficiency analysis, other DEA model such as scale efficiency, allocative efficiency may be explored to better differentiate the performance difference. Other upcoming Tesla models such as model X and 3 may also needed to conduct competitive analysis in more detail.

Appendix:

US BEV dataset in 2014

Model Y	Product	Make	Division	Release Date	2014 Pric	Price	Output Po	Range_(	MPGe	Chargin	Battery Capacit	1 / char
2014	B-Class Electri	Mercedes-Benz	Mercedes-Benz	41809	41450	41450	132	85	84	4	120	0.29
2014	Focus Electric	Ford Motor Comp	Ford	41463	29170	29170	107	76	105	4	75	0.28
2014	500e	Chrysler Group LL	Fiat	41513	31800	31800	82	87	116	4	63	0.25
2014	FIT	Honda	Honda	41431	36625	36625	92	82	118	4	20	0.25
2014	I3 BEV	BMW	BMW	41816	41350	41350	125	81	124	4	60	0.25
2014	LEAF	Nissan	NISSAN	41639	28980	28980	80	84	114	5	66	0.20
2014	i-MiEV	Mitsubishi Motors	Mitsubishi Motors (	41760	22995	22995	49	62	112	6	50	0.17
2014	Smart fortwo e	Mercedes-Benz	Mercedes-Benz	41518	25000	25000	55	68	107	6	52	0.17
2014	e6	BYD Motors Inc.	BYD	41691	35000	35000	75	127	63	6	200	0.17
2014	RAV4 EV	Toyota	TOYOTA	41523	49800	49800	115	103	76	6	130	0.17
2014	SPARK EV	General Motors	Chevrolet	41428	26685	26685	104	82	119	7	60	0.14
2014	Model S (60 k	Tesla	Tesla Motors	41639	69900	69900	225	208	95	10	245	0.10
2014	Model S (85 k	Tesla	Tesla Motors	41639	79900	79900	270	265	89	12	245	0.08

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