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Tesla Motors

"Tesla is in California, so it is not April Fool's yet!" tweeted Elon Musk, CEO of Tesla Motors, around 10 PM PT on March 31, 2013. "First profitable Q for Tesla thanks to awesome customers & hard work by a super dedicated team"[1] he had tweeted a few minutes earlier. And indeed, on May 8, Tesla announced a net income of more than $10mln on $560 mln in sales.[2] Tesla had outsold both Nissan and GM in electric cars in the U.S.[3] Its Model S had sold more than the BMW 7 and Audi A8 combined.[4] Tesla raised its Model S sales target for its first full year from 20,000 to 21,000 cars.[5] Over the next three months, its stock price almost tripled.[6]

In its 10 years since founding, Tesla had launched both a high-end limited edition "Tesla Roadster" and its "Model S" production car, and was now taking reservations on its upcoming "Model X" electric crossover SUV. Despite a public controversy about its range, the Model S had received the coveted Car of the Year award and earned the highest rating that *Consumer Reports* ever gave to a car, an astonishing feat for a company that was only at its second car. While some of its most visible EV competitors went bankrupt or halted production,[7] Tesla became profitable. Elon Musk wanted Tesla to be a mass manufacturer of electric cars.[8] Becoming profitable meant that that goal was within reach. Or was it not?

The Car Business

America was sometimes said to have a love affair with cars.[9] In 2011, American households owned 1.17 vehicles per licensed driver, with almost 20% of households owning three or more cars.[10] The average trip was less than 10 miles, with less than 1% of trips exceeding 100 miles.[11] Households spent on average more than 15% of their income on cars, gasoline, and related expenses.[12]

At more than 3% of GDP and 1.7 million employees, the car business—manufacturing, distribution, and service—was one of the largest industries in the U.S.[13] It was also concentrated, with the three largest car companies making up 49% of the U.S. market in 2012, though that was down from 98% in 1969.[14] Despite this high concentration, two of the three large U.S. car manufacturers went bankrupt in 2009. Since WWII, no U.S. firm had successfully entered the car industry with a mass-produced car, until (maybe) Tesla.

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Car Design[15]

A car was a complex marvel of technology with thousands of parts, often sourced from more than a thousand suppliers.[16] A typical car consisted of a number of subsystems: 1) The *powertrain* made the car move and was the most complex part of the car. It consisted of the engine, the transmission, and a number of auxiliary systems. The *engine* in a conventional car (CVs) was an internal combustion (IC) engine that converted gasoline into power in the form of a fast-rotating axle. Because of its size and weight, the engine was typically placed above the front wheel axis, and then required a special design to prevent it from being pushed into the car's passenger cabin in a crash.[a] The *transmission* transformed the rotation of the engine axle into an appropriate rotation speed for the wheels through a variable set of gears. This was necessary because IC engines had a limited speed range in which they were effective, losing power and stalling below 700 rpm[b] while topping out at 7000 rpm.[17] The transmission also permitted to disconnect the engine from the wheels when the car was standing still to allow the motor to keep running. Transmissions were complex and required their own lubrication. In most cars, the transmission powered the front wheels. Such front-wheel drive cars had more conservative handling and were cheaper to make than rear-wheel drive cars, such as BMW and Mercedes, which required a costly and space-taking connection between the motor in the front and the rear wheels. The *auxiliary systems* included fuel storage and injection system, the exhaust system with catalyzer to eliminate polluting fumes, the cooling system to prevent the engine from overheating, the oil system to lubricate the moving (and hot) parts of the engine, and the—typically electronic—control system to control the engine and all related systems. 2) The *chassis* was the foundation of the car and included a supporting frame, wheels, steering system, and braking system. 3) The *body* of the car was the space where passengers resided and included the dashboard and the air conditioning as some of its more complex elements.

Given this complexity, cars were difficult and expensive to design. Developing a completely new car would involve hundreds of engineers and was estimated to cost between $1bn for a regular car—excluding expenses for retooling and factory modifications—up to $6bn for a global car like Ford's Mondeo but then including retooling and plant modifications. Such new car design would take four to five years, though simpler redesigns of an existing model were often done in less than a year.[18]

Car Manufacturing

Cars were manufactured in huge assembly plants, often the size of more than 50 football fields. A traditional assembly plant would reach its minimum efficient scale at between 100,000 and 250,000 cars per year and a plant of such size could cost as much as $1–$2 billion.[19]

A typical car assembly plant would consist of a body shop, a paint shop, and the assembly line.[20] In the body shop, sheets of metal were stamped or pressed into panels that were then welded together by robots to a car body. The car body and the doors got painted in the paint shop, after which the assembly line assembled the car by attaching all parts to the body. In a traditional plant, the assembly line was a slow-moving chain from which the unfinished cars were suspended and that moved the car bodies past stationary assembly stations where workers added, in a very particular sequence, all the necessary parts. As there were a lot of interactions among the different parts of a car, an error early in the assembly process could lead to cumulative problems down the line. Cars that

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[a] Many cars were designed to ensure that the engine would slide under the passenger cabin in case of a serious crash.

[b] Rpm stands for "rotations per minute" and measures the rotation speed of an axle.

needed repairs were repaired in a repair zone at the end of the assembly line, which could take up more than 10% of plant floor space in a traditional assembly plant.[21]

Almost all assembly plants would produce multiple versions of the same car through each other on the same line, with a sophisticated control system that indicated to each station which parts to add to the particular car at the station. Sometimes even two completely different car models were produced on the same line. But building multiple models on the same line really challenged the production design as work would often become unbalanced; i.e., some assembly stations would have much more work than others.[22] To produce a broader mix of cars required a more flexible production system, which typically had less scale economies,[23] leading to plants with minimum efficient scale between 50,000 and 100,000 cars per year.[24]

Cars were not only expensive to design but also expensive to make, with manufacturing cost making up about 80% of a car's final selling price (**Exhibit 1**). Moreover, car manufacturing had a considerable learning curve. It was estimated, for example, that both the number of defects and the assembly time in a particular plant dropped by about 70% over the first two months that a new car model went into production with a 90% experience curve for at least the first year.[c,25] Across the industry, average assembly time dropped by about 3% per year.[26]

Car Marketing, Distribution, and Service

Car producers were among the heaviest advertisers in business. GM and Ford spent respectively US$ 4.2 bln and US$ 3.9 billion on advertising in 2010, which exceeded Coca Cola's US$ 2.9 bln.[27] The estimated brand value of companies like Toyota, Mercedes-Benz, and BMW was estimated at around US$ 30 bln each, which was more than Disney at US$ 27 bln or Pepsi at US$ 16 bln, while Ford's brand value was estimated at around US$ 8 bln, and Nissan and Porsche at around US$ 5 bln each[28].

Cars were sold through dealerships.[29] A dealership franchise had a mutually exclusive relationship with a car manufacturer: in exchange for the dealer being exclusive to one manufacturer—though potentially selling multiple brands of the same manufacturer—it would get an exclusive territory for one or more of the manufacturer's brands. (Some dealer companies would own dealership franchises for different brands, but these franchises would be physically separate standalone entities.) A car dealer would market cars through advertising, a showroom, and salespeople; sell the cars and potentially finance them; service the car; and provide repairs. Some observers had questioned, however, whether it was optimal to combine sales and service in one entity.[30] **Exhibit 2** captures the typical revenue and cost structure of a U.S. dealership. New car sales had limited profitability but brought in business for the far more profitable service and repairs business. Dealers would also make profits from ancillary offerings at the time of sale, such as financing, special coatings or other treatments, and pre-paid service plans. Ford and GM both had more than 4,000 dealerships in 2011 versus about 1,600 for Toyota.[31]

Given their complexity, cars needed regular maintenance and occasional repairs. The engine with its moving parts exposed to heat and large forces, was the focus of most maintenance and repair. Indeed, the most frequent maintenance task was changing the motor oil. Most manufacturers recommended change intervals of 7,500 or 10,000 miles, although dealers and oil service centers sometimes recommended changes at 3,000 or 5,000 miles.[32] In terms of repairs, 7 to 9 out of 10 repairs were related to the powertrain.[33]

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[c] A 90% experience curve means that the cost decreases to 90% of its former value, i.e., decreases by 10%, every time the cumulative production doubles.

Electric Cars[34]

Electric cars were popular in the late 1800s. In fact, the first speeding ticket was issued to an electric car (driving 12 mph)[35] and the Hartford Electric Light Company even operated an exchangeable battery service. But electric cars were quickly overtaken by the internal combustion engine. The interest in electric cars increased again sharply in the late 20th century when oil prices shot up and when improvements in battery technology increased their range.

The main difference between an electric car and a conventional car was in its powertrain, which consisted of an electric motor and a battery pack, but that difference had implications for the rest of the car's design and manufacturing, for example, through its greater simplicity (**Exhibit 3**).

The electric *motors* that were used in cars were fairly conventional motors that had been widely used for more than a century. In contrast to IC engines, such electric motors could develop a strong torque (rotational force) at a very broad range of speeds. As a consequence, electric motors could be used without a transmission. They were also much smaller and didn't need the motor oil and cooling that IC engines required (though EVs needed some form of cooling for the battery). The lack of heat, however, necessitated some other way to warm up the cabin in cold weather, such as an electric heater or a reversible air conditioning. A nice feature of an electric motor was also that it could function as a brake and then generated electricity to charge the battery. (Converting the car's energy back into electricity was the key feature of hybrid cars such as the Prius.)

The *battery* was the most expensive, heaviest, and most challenging component of an EV. The Nissan Leaf's battery was estimated to cost about US$ 15,000[36] and its weight equaled that of an IC engine.[37] Early EVs and hybrid vehicles had used a variety of battery technologies, but all recent electric cars used Li-Ion batteries because of their high capacity per weight. Li-Ion batteries had been introduced in the early 90's and powered most electronics, including laptops (**Exhibit 4**). A complete EV battery would be assembled out of a large number of battery cells (similar to consumer batteries but typically considerably larger) that were combined into modules and then further into the battery pack. The modules and pack played an important role as they monitored and managed the batteries both for efficiency and for safety, controlling for example charging, balancing, usage, and temperature. **Exhibit 5** captures the cost structure of a newly developed EV battery, like Nissan Leaf's. Costs decreased by about 10% per year between 2009 and 2012.[38] The experience curve for Li-Ion batteries was estimated to be between 85 and 90%.[39] Some also expected a rush to build capacity, leading to overcapacity from 2015 onwards.[40] There was some speculation on new battery technologies that might replace Li-Ion, but these seemed still far away.[41] Li-Ion itself, however, was in fact a family of battery technologies with new variations being developed continuously.

In terms of design, all-electric passenger vehicles came in two types: existing cars that were converted to electric, like the Ford Focus Electric, and cars that were designed from the ground up as an electric car, like the Tesla and the Leaf. Converted cars could use the design and production infrastructure of the CV from which they were derived but did not leverage the specific characteristics of the electric powertrain. For example, converted cars typically put the battery and motor where the IC engine used to be, whereas in both the Nissan Leaf and Tesla S the battery pack was part of the floor of the passenger cabin. Not only did this free up space both inside the cabin and for cargo storage, it also considerably improved the handling of the car as it gave the car a low center of gravity. In particular, with the heavy IC engine mounted above the front wheels of the car, conventional cars had a high center of gravity and hence tended to swing or sway a bit when turning. Conventional cars were also more complex than EVs.

Governments actively promoted the adoption of EVs to combat pollution, smog, and climate change. One measure was direct tax-subsidies for the purchase of an EV. In 2013, the U.S. federal government gave a $7,500 tax credit for the purchase of EVs such as the Leaf or the Model S. Individual states often gave additional incentives. California, for example, gave another $2500 purchase rebate, and gave EVs free access to HOV lanes until 2015. Some states, including California, also required that a minimum percentage of a car manufacturer's fleet sales were zero-emission vehicles (ZEV). Manufacturers that fell short could buy ZEV credits from others who were above the mandated minimum. The rule encouraged the production of EVs directly and by giving producers of EVs an extra source of income.[42] However, the price of such credits was expected to drop quickly as all producers started selling more EVs.[43]

There were, however, also important hurdles to adoption. These fell into two broad categories.[44] The first were issues related to EVs being a new technology with considerable uncertainty about longevity, resale value, and safety. The second were different sources of "range anxiety," which included the limited range of most EVs, the time it took to charge a car , and the early lack of charging stations. The latter issue was being resolved, as many companies and public entities started offering both private and public charging stations. The Department of Energy, for example, listed more than 6,000 public charging stations in 2013.[45] Some companies also offered free charging spaces to their employees. On any regular outlet, EVs would recharge between 5 and 10 miles of range per hour. But higher-amp household outlets could double or triple that, while Tesla's Supercharger could charge 150 miles of range in 30 minutes.[46] To reduce range issues, Tesla also operated a network of more than 15 Supercharger stations where customers could charge their car for free. It also introduced a battery swapping service that could exchange a depleted battery for a charged one in about 90 seconds.[47] To reduce worries about resale value, finally, Tesla guaranteed a resale value pegged to similar BMW and Mercedes models, backed by Elon Musk's personal fortune.[48]

Nissan Leaf[49]

In 2007, Nissan started the most ambitious EV project by a mass car producer: the Nissan Leaf. Carlos Ghosn, CEO of Nissan and its alliance with Renault, believed that EVs would capture 10% market share by 2020—an estimate higher than those of competitors and observers—and he wanted to position Nissan and Renault as the leaders in this field.[50] Over the next few years, Nissan and Renault invested over US$ 5.6 billion in the project, including US$ 1.7 billion for modifying an assembly plants and building a battery plant in Tennessee and another US$ 650 million for doing the same in the U.K.[51]

The Leaf was a fully electric mid-sized family sedan with front-wheel drive that was, in terms of design and size, in the same class as the Ford Focus or the Volkswagen Golf (**Exhibit 6**). The Leaf was designed from the ground up as an electric car to leverage the benefits of the EV technology. In fact, the technology was sufficiently different that Ghosn expected to rely more on outside hires rather than on Nissan's experienced IC engineers.[52] Developing the car took three years, which was much faster than Nissan's standard four-year development cycle, despite being a completely new car.[53]

Nissan was also focused on developing new battery technology. Due to its first-mover status in the mass EV market, Ghosn saw an opportunity to build a lead and become a supplier to others in the industry in a market that was expected to grow to US$ 25 billion by 2020 (though estimates varied from US$ 5 billion to US$ 60 billion, depending on the scenario).[54] To develop the battery, Nissan started a joint venture with NEC, which did not have a large battery business but had skills in some key technologies. Nissan Leaf's Li-Ion battery, which consisted of 192 cells, had a cost structure as in

Exhibit 5—after appropriate adjustments—and used electric heating and air-cooling for heat control. There were, however, some isolated but well-published complaints from customers in Arizona that their batteries lost capacity quickly, forcing Nissan to institute a warranty system.[55]

The Nissan Leaf was launched at the very end of 2010 to great reviews. While it sold only 38 cars that year, Ghosn projected annual sales of 500,000 by 2013, which is the level where he believed the Leaf could be profitable without subsidies.[56] Worldwide sales for 2011 and 2012, however, were only about 21,000 and 26,000 respectively.[57] When the 2012 sales failed to meet downward revised expectations, Nissan replaced the head of its EV unit.[58] In January 2013, Leaf production began in the Tennessee plant, where it shared the production line with the Altima mid-size sedan and Maxima full-size sedan.[59] At the same time, Nissan reduced the price for the base model from $35,200 to $28,800.[60] Sales through mid-2013 nearly doubled from the year before and overtook GM's Volt plug-in hybrid. In August 2013, GM lowered the price of the base model of its Volt plug-in hybrid from 39,995 to 34,995 in a move that was widely perceived as a competitive response to Nissan's price cut, though Ghosn didn't see the cars as competitors as the Volt was a hybrid rather than an EV.[61]

Fisker

Fisker Automotive was a producer of electric sports car, which was started by Henrik Fisker, a car designer who had worked on the Model S before founding Fisker Automotive. Fisker designed its own car body, but outsourced almost everything else, including the design and manufacturing of the powertrain.[62] In March 2013, Fisker was rumored to be preparing bankruptcy after having stopped production eight months earlier.[63]

Tesla

Tesla Motors was founded in 2003 and named after Nikola Tesla, one of the inventors of the electric AC induction motor. The founding team included Elon Musk and Tesla's CTO, JB Straubel. Musk provided most of the capital and became chairman of the board and head of product design. In 2007, when Tesla was faced with product delays and quickly dwindling capital, Elon Musk took over as CEO and reduced headcount. Musk quickly became the face of Tesla. Born in South Africa, with an engineering and an economics degree from the U.S., he sold his first start-up, Zip2, for more than US$ 300 million to Altavista.[64] He then co-founded Paypal, of which he was CEO and chairman, and sold the company in 2002 to eBay for US$ 1.5 billion. The sale gave Musk the capital to pursue his dreams. Over the next years, he started the space transportation company SpaceX, became the largest shareholder and chairman of SolarCity, a provider of solar power systems, and co-founded Tesla.

None of Tesla's founders had a background in the car industry and neither did its original engineering team.[65] Over time, Tesla assembled a team that was a mix of specialists from the car industry and people with their roots in Silicon Valley (**Exhibit 7**). Musk believed that Tesla's Silicon Valley roots gave it an important edge when it came to this kind of innovation.[66]

Tesla Roadster

Tesla's first production car—and the first-ever high-end production EV—was the Roadster (**Exhibit 8**). Tesla designed and produced the car's powertrain in-house in California and then combined it with a body and chassis—derived from the Lotus Elise—that was co-designed by Lotus and Tesla and assembled by Lotus in the U.K.[67]

The US$ 109,000 Roadster was a high-end sports car that could accelerate from 0 to 60mph in less than four seconds, which was faster than a Ferrari Testarossa and in the same range as more recent Ferrari models, and had a range of nearly 250 miles.[68] The car received a lot of press coverage. But instead of focusing on its environmental benefits, reviewers used expressions like "head-turner," "jaw-dropper," "future of the automobile," and "profoundly humbling to just about any rumbling Ferrari or Porsche that makes the mistake of pulling up next to a silent, 105 mpg Tesla Roadster at a stoplight."[69] Some observers thought that it changed how people thought about electric cars.[70]

In developing the car battery, Tesla made a surprising choice. Instead of developing a new special-purpose battery for cars from scratch, as Nissan and other car manufacturers were doing and as Fisker had outsourced to A123, it assembled its rechargeable battery pack from slightly modified industrial-grade commodity Lithium-Ion batteries in the 18650 form factor, supplied by Panasonic.[71] The 18650 form factor was slightly larger than an AA battery and was the most commonly used battery for, e.g., laptops. The number of cells was an order of magnitude larger than the Nissan Leaf: almost 7000 cells versus the Leaf's 192. Tesla and Panasonic cooperated to modify the design for car usage, paying particular attention to safety and the risk of overheating and fire. Tesla also designed a liquid cooling system to keep the batteries on their optimal temperature. While the battery pack and powertrain were originally assembled and tested in Thailand, Tesla moved the operations to California because it felt that it was better to have engineering and manufacturing under one roof.[72] The powertrain design was proprietary and Tesla did not reveal much about it.

Per its contracts with Lotus, Tesla built 2500 Roadsters. When the contract ran out in 2012, Tesla stopped taking orders.[73] There were rumors that Tesla would introduce a successor by 2014 or 2015, but the company did not make any commitments, instead focusing on its Model S and Model X.[74]

Model S

Tesla's first truly mass-produced car was the model S (**Exhibit 8**), a high-end electric car meant to compete with the Audi A6 and BMW 5 series. (**Exhibit 9** compares Model S, BMW 528i, and Nissan Leaf.) The Model S could accelerate from 0 to 60mph in under 6 seconds, which was 10% faster than a BMW 5 and almost twice as fast as the Nissan Leaf.[75] The car was launched in June 2012 and soon started getting rave reviews, including being selected as the 2013 Car of the Year and receiving the highest Consumer Reports rating ever.

Design Tesla designed the Model S completely in-house, at a cost of about $0.5 bln[76]. The powertrain was an evolved version of the Roadster's. The Tesla S had rear-wheel drive, like BMW and Mercedes, but avoided the extra costs that rear-wheel-drive typically imposed, as the small electric motor could be positioned next to the rear axis. For the battery, Tesla used an improved version of the technology it had developed for the Roadster. Tesla's 85kWh battery, for example, consisted of more than 7,000 cells in the 18650 form factor.[77] The new battery was estimated to have double the energy density—energy storage per kg of battery—which reduced the weight of the car and presumably also used less material.[78] Tesla's 60kWh battery pack was estimated to cost about US$ 15,000–US$ 18,000, which at $250–$300 per KWh was less than half the estimated cost per KWh for the Nissan Leaf.[79] For the Model S, the batteries were assembled into a rigid flat pack that formed the bottom of the car (**Exhibit 3**). This gave the car great handling and exceptional rigidity, allowing Tesla to be the only car to offer an all-glass panoramic roof.[80] (Traditional convertible cars needed additional reinforcement to compensate for the loss in rigidity from removing the roof.)

The car also had a number of other new and unique design features.[81] Being developed in Silicon Valley, the car was controlled by software that could be wirelessly updated through its cellular connection and allowed the driver to easily customize the car's behavior, including suspension and steering behavior. The level of electronic integration impressed other car companies and was considered a benchmark.[82] The car also had a 17" touchscreen in the middle console to control almost all its functions, from air conditioning and lights to entertainment system. This reduced the need for buttons or other manual controls, simplifying the dashboard and other parts (**Exhibit 10**). The car also had no traditional key but a wireless fob. When the driver approached the car, the car automatically unlocked and the door handle, which was retracted, slid out. The car started when the driver buckled in. Another unusual feature was that the brake lights lit up based on how much the car was slowing. Many of the car's components, including its suspension, were custom-designed rather than standard components available off the shelf.[83] Analysts worried that this might put Tesla at a cost disadvantage.[84]

Manufacturing In contrast to the Roadster, Tesla decided to bring the full assembly of the Model S in-house. Observers questioned Tesla's ability to do so successfully, given its lack of experience in car design or assembly, an issue that Tesla itself openly recognized. [85] But the crisis in the car industry played in its favor. It purchased the massive and recently idled NUMMI plant in Fremont, California—formerly a joint venture between GM and Toyota which at its height produced 500,000 cars per year—from Toyota for $42 million, a deal that was financed through a $50 million capital injection by Toyota and that was part of a broader cooperation.[86] While Tesla' current output was 21,000 cars per year, VP of manufacturing Passin estimated that the plant could reach 100,000 cars per year without really stretching the equipment.[87] Tesla also bought much of its production equipment at a discount from struggling manufacturers. Musk gave the example of a $50 million hydraulic stamping press that Tesla acquired for $6 million from "a car manufacturer in Detroit."[88] According to some estimates, Tesla spent less than a third of the $1bln it would normally cost to get such a plant operational.[89] Tesla also brought a large part of its parts production in-house, making e.g. 90% of Model S-specific plastic parts on its injection molding machines, which was unusual for a plant with low volume, and manufacturing its complete powertrain in-house.[90]

Sales and service Instead of independent dealerships like other car manufacturers, Tesla built a network of company-owned stores with salespeople on salary rather than on commission. Musk argued that "existing franchise dealers have a fundamental conflict of interest [as it is] impossible for them to explain the advantages of going electric without simultaneously undermining their traditional business."[91] This approach put Tesla in conflict with the dealership lobby, which had pushed many states to pass laws requiring car companies to sell through independent dealerships recognized by the dealership association. In some of these states, Tesla was able to sell online from other states. But the Texas legislature had passed a law that did not allow Tesla to do so and the North Carolina legislature almost passed a similar law.[92]

In marketing the Model S, Tesla stressed speed, comfort, and handling, before talking low emissions. It also focused on the potential cost savings from gas and reduced service and repairs.[93] While estimates varied widely, the total cost of ownership of the Model S seemed similar to that of the BMW 5-series with which it competed, with higher initial price but lower gas and maintenance cost.[94] Tesla's service operations were independent from its sales network, unlike the dealership structure of traditional car manufacturers. For the annual check-up or repairs, Model S owners had a number of options: go to a licensed Tesla service center, call up a mobile service and repair team ("Tesla Rangers"), or have their car exchanged for a loaner through Tesla's valet service.[95] Early on, there were reports of problems with handles and windscreen wipers, but Tesla was able to resolve these with a wireless software update.[96]

Drivetrains

Tesla also sold electric powertrains to other car manufacturers and provided design services for electric powertrains. It had developed and was producing powertrains for the Toyota Rav 4 EV, in a deal that was expected to generate about $100 million between 2012 and 2014.[97] A similar deal with Daimler might be worth almost $300 million.[98]

Racing on

Tesla was off to a great start in 2013. In the first half of 2013, it sold 10,500 model S cars and was expanding sales to Europe. Musk said that Tesla planned to be shipping 40,000 Model S per year by the end of 2014.[99] Tesla had also started taking reservations for its next vehicle, the Model X. The Model X (**Exhibit 11**) was a cross-over SUV with some unique features, such as wing doors and dual motor all-wheel drive.[100] The model X would share the powertrain and many components with Model S.[101] Tesla had been profitable in the first half of 2013 and by September its market cap was about a quarter of that of BMW. (See **Exhibits 12** through **14** for financials of Tesla and of BMW for comparison.)

But Elon Musk was clear that he wanted to go further and build a lower end mass-production EV. In a blog post titled "The Secret Tesla Motors Master Plan (just between you and me)," he stated that the plan was to "[b]uild sports car, [u]se that money to build an affordable car, [u]se that money to build an even more affordable car." [102] He had explicitly stated that this rumored Gen 3 model would be comparable to a BMW 3 and carry a price of about $35,000.[103]

Was Gen 3 the logical next step or a bridge too far? And was Tesla here to stay to become the first U.S. firm since WWII to successfully enter the car industry with a mass-produced car?

Exhibit 1 Estimated Cost Structure for a $25,000 IC Car

	% of Car Price
Production	
Materials and parts	50
Body	18
Chassis	14
Powertrain	18
Mfg & assembly cost	10
Production overhead	
Maintenance & operations	8
R&D	7
Depreciation & Amortization	5
Warranty	2
General & Admin	2
Transport	2
Marketing & Sales	5
Net profit & tax	4
Dealer gross margin	5
Price	100

Source: Casewriter estimates based on R.M. Cuenca et al. "Evaluation of Electric Vehicle Production and Operating Costs," Argonne National Laboratory working paper ANL/ESD-41, November 1999; Anant Vyas et al. "Comparison of Indirect Cost Multipliers for Vehicle Manufacturing," Argonne National Laboratory technical memorandum, April 2000; and McKinsey Global Institute, "Multinational Company Investment in Developing Economies," McKinsey Global Institute, October 2003.

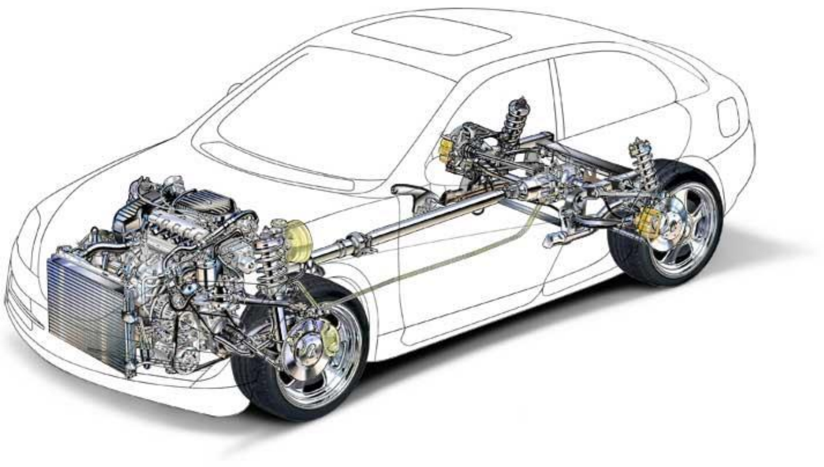
Exhibit 2 Typical Revenue and Cost Structure of U.S. Dealer

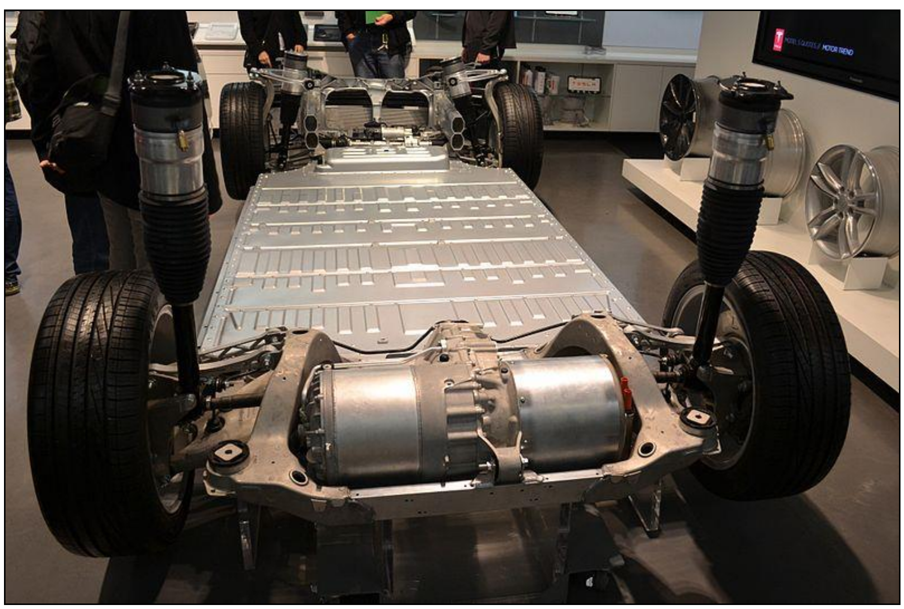
	% of Sales	Share of Gross Margin
New-vehicle sales[a]	56%	30%
Used-vehicle sales[a]	32%	26%
Parts and Service	12%	44%
Gross profit	14%	
Payroll	8%	
Advertising	1%	
Rent & Eq	1%	
Other	2%	
Net profit before taxes	2%	

Source: Casewriter, based on NADA "Dealership Financial Profile," NADA, December 2012, http://www.nada.org/NR/rdonlyres/CA8D6479-43DC-4DD6-9F6D-E7C76DED7413/0/NADA_Dealership_Financial_Profile_122012.pdf and NADA "State of the Industry Report 2013," NADA, 2013, www.nada.org/Publications/NADADATA/2013/, all accessed August 2, 2013.

[a]New-vehicle and used-vehicle sales and gross margin included service contracts and fees from the sale of finance & insurance. The latter two comprised respectively 15% and 21% of the gross margin on new and used vehicles.

Exhibit 3 Powertrain of Conventional Internal Combustion Engine and Tesla Model S





Source: www.stock-automotive-illustration.com/Generic-car-system-files/engine-drive-sus-line.jpg and upload.wikimedia.org/wikipedia/commons/thumb/f/f3/Tesla_Motors_Model_S_base.JPG/800px-Tesla_Motors_Model_S_base.JPG.

Exhibit 4 Litihium-Ion Battery Market

	Annual Sales (US$ bln)	Cumulative Sales (US$ bln)	Usage Share (%) Consumer	Industrial	Automotive
2010	10.6	75.6			
2012	11.7	98.5	64	22	14
2016	22.5	172.8	52	23	25

Source: Casewriter analysis based on Malavika Tohani, "Global Lithium-Ion Battery Market," Frost & Sullivan, February 2013 and Frost & Sullivan, "World Lithium Battery Markets," Frost & Sullivan, July 1998, accessed May 26 2013

Exhibit 5 Cost Structure of Newly Developed Li-Ion Battery of 24KWh

	Cost ($/KWh)[a]
Variable Cost	500
Fixed Cost	700

Source: Casewriter estimates based on data from the following sources: Haresh Kamath, "Lithium Ion Batteries for Electric Transportation: Costs and Markets," EPRI presentation, September 22, 2009, www.arb.ca.gov/msprog/zevprog/.../presentations/kamath.pdf, accessed August 10, 2013; Andreas Dinger et al., "Batteries for Electric Cars," BCG Focus, 2010, www.bcg.com/documents/file36615.pdf, accessed August 10, 2013; Mike Ramsey, "Nissan Says Leaf Electric Will Be Profitable With U.S. Plant," *Wall Street Journal*, March 13, 2010, http://online.wsj.com/article/SB10001424052748704635204575242382820806878.html, accessed August 4 2013.

[a] Variable and fixed are relative to the number of units manufactured per year. The data are based on annual sales of 10,000 units and cumulative sales of 20,000 units.

Exhibit 6 Nissan Leaf

Source: upload.wikimedia.org/wikipedia/commons/2/22/2013_Red_Nissan_Leaf_SL.JPG.

Exhibit 7 Selected Prior Experience of Part of Tesla Motors Management Team

Elon Musk: Co-founder, CEO, and Product Architect
Co-founder, CEO, and Chairman of Paypal. Co-founder of Zip2.

JB Straubel: Co-founder, CTO
CTO and Co-founder of aerospace firm Volacom, Propulsion engineer at Rosen Motors (working on the combination of micro-turbine and flywheel)

Deepak Ahuja, CFO
Controller of small cars development at Ford, CFO of Ford South Africa, Engineer at Kannametal

Franz von Holzhausen, Chief Designer
Director of Design Mazda North America, Design Director GM

George Blankenship, VP Sales and Ownership Experience
VP of Real Estate at Apple, VP Retail Strategy GAP

Gilbert Passin, VP Manufacturing
General Manager Production Engineering (West Coast) Toyota North America, Chief Production Engineer future Corolla, VP of Manufacturing at Toyota plant, VP operations Mac

Arnnon Geshuri, VP HR
Chief Staffing Architect at Google, VP HR at E*Trade Financial

Source: Casewriter, based on Tesla Motors, "Executives," Tesla Motors Website, http://www.teslamotors.com/executives, accessed August 10, 2013.

Exhibit 8 Tesla Roadster and Model S

Source: http://upload.wikimedia.org/wikipedia/commons/3/3a/Roadster_2.5_windmills_trimmed.jpg and http://upload.wikimedia.org/wikipedia/commons/9/94/Model_S_driving.jpg.

Exhibit 9 Comparison of Tesla Model S, Nissan Leaf, and BMW 528i

	Tesla Model S	Nissan Leaf	BMW5
MSRP (after tax credits in CA)	61,070	19,650	48,725
Time 0-60 mph	5.6	10.3	6.1
Horsepower (5000 rpm)	302	110	240
Range (miles, EPA)	208	75	N/A
Volume (cu ft)	120	116.4	116
Cargo capacity with all seats (cu ft)	26.3	24	14
Max cargo capacity (cu ft)	63.4	30	14
Drive	Rear wheel drive	Front wheel drive	Rear wheel drive
Safety rating NHTSA (on 5)	5	4	5
Sum of subratings NHTSA (on15)	15	12	14
Consumer reports rating (on 100)	99	78	81
Annual fuel cost ($/15000miles)	468	384	2112
U.S. sales Jan-June 2013	10,500	9,839	25,891

Source: Casewriter, using data from Wikipedia, "BMW 5 Series", "Telsa Model S," "Nissan Leaf," wikipedia.com, op cit., accessed August 12, 2013; Tesla Motors, "Specs" Tesla Motors website, http://www.teslamotors.com/models/specs, accessed August 12, 2013; Edmunds.com, "Compare cars," edmunds.com, www.edmunds.com/car-comparisons/, accessed August 12, 2013; *ConsumerReports*, "Profiles," *ConsumerReports*, April 2013; goodcarbadcar, "Sales stats," goodcarbadcar.com, www.goodcarbadcar.net/p/sales-stats.html, accessed August 12, 2013; Safercar.gov, "5-Star Safety Ratings," safecar.gov, www.safercar.gov/Vehicle+Shoppers/5-Star+Safety+Ratings/2011-Newer+Vehicles, accessed August 12, 2013.

Exhibit 10 Dashboard of Nissan Leaf and of Tesla Model S

Source: image.motortrend.com/f/oftheyear/car/1201_2012_motor_trend_car_of_the_year_contenders_and_finalists/35700616+w799+h499+cr1+ar0/2012-Nissan-Leaf-dash-view.jpg and http://stwot.motortrend.com/files/2013/04/2012-Tesla-Model-S-Dash.jpg.

Exhibit 11 Tesla Model X

Source: upload.wikimedia.org/wikipedia/commons/3/3a/Tesla_Model_X_Geneva_2012_trimmed.jpg.

Exhibit 12 Income Statement Tesla Motors (in US$ thousand)

	H1 2013	2012	2011	2010
Revenues	966,931	413,256	204,242	116,744
Car Sales & Powertrains	847,531	372,756	201,542	113,944
Regulatory/ZEV credits	119,400	40,500	2,700	2,800
Cost of revenues	770,128	383,189	142,647	86,013
Gross profit	196,803	30,067	61,595	30,731
Operating expenses				
R&D	107,171	273,978	208,981	92,996
SG&A	107,008	150,372	104,102	84,573
Total operating expenses	214,179	424,350	313,083	177,569
Loss from operations	-17,376	-394,283	-251,488	-146,838
Net income (loss)	49	-396,213	-254,411	-154,328

Source: Casewriter estimates based on Tesla Motors, August 9 2013, 10Q, (Palo Alto, CA), files.shareholder.com/downloads/ABEA-4CW8X0/2498579025x 0xS1193125%2D13%2D327916/1318605/filing.pdf, accessed August 12, 2013.

Exhibit 13 Assets on Balance Sheet Tesla Motors (in US$ thousand)

	Jun-13	Dec-12
Cash and cash equivalents	746,057	201,890
Restricted cash	1,362	19,094
Accounts receivable	113,544	26,842
Inventory	254,891	268,504
Prepaid expenses and other current assets	13,688	8,438
Total current assets	1,129,542	524,768
Operating lease vehicles, net	131,468	10,071
Property, plant and equipment, net	595,579	552,229
Restricted cash	7,059	5,159
Other assets	24,196	21,963
Total assets	1,887,844	1,114,190
Invested Capital	1,401,299	575,082
Detail on Property, Plant, and Equipment		
Machinery, equipment and office furniture	267,979	223,745
Tooling	211,793	172,584
Building and building improvements	59,910	50,574
Leasehold improvements	58,492	39,224
Land	28,886	26,391
Computer equipment and software	26,402	22,125
Construction in progress	37,082	75,129
	690,544	609,772
Less: Accumulated depreciation and amortization	-94,965	-57,543
Total	595,579	552,229

Note: Tesla's 2013 pre-tax WACC was estimated to be around 17.3% (Source: Casewriter analysis based on Bloomberg).

Source: Tesla Motors, August 9 2013, 10Q, (Palo Alto, CA), files.shareholder.com/downloads/ABEA-4CW8X0/2498579025x0xS1193125%2D13%2D327916/1318605/filing.pdf, accessed August 12, 2013.

Exhibit 14 Income Statement and Invested Capital BMW Group, excluding financial services (in million Euros)

	2012	2011
Revenues	57,293	51,306
Cost of revenues	40,377	35,653
Manufacturing costs[a]	37,648	33,594
Warranty expenditure	1,200	918
Other cost of sales	1,529	1,141
Gross profit	16,916	15,653
Operating expenses		
R&D	3,993	3,610
SG&A[b]	6,369	5,775
Total operating expenses	10,362	9,385
Operating Profit	6,554	6,268
Net income (loss)	4,107	4,301
Invested Capital	16,880	14,883

Source: Casewriter estimates based of BMW Group "Annual Report 2012," BMW Group.

Note: BMW's 2012 pre-tax WACC was estimated to be around 12% (Source: BMW annual report).

[a] Manufacturing costs included 2,298 and 2,324 mln Euros in depreciation and amortization of property, plant, and equipment, on a total of 13,053 and 11,444 mln Euros in property, plant, and equipment assets.

[b] SG&A includes marketing, advertising, sales personnel, and expenses for administration not attributable to development, production, or sales.

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