2018

Charging down the Road: A Historical Analysis of the American Auto Industry and Tesla Inc.

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A thesis submitted in partial fulfillment of the
requirements for the degree of
Bachelor of Science
Environmental Program & Honors College
University of Vermont
2018

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Abstract

Electric vehicles have experienced waves of popularity since the early 20th century. This thesis examines the role of electric vehicles and automobility in the past, present and the future of personal transportation. Additionally, it brings together the history of the American automobile industry and the complex contemporary narrative of Tesla Inc, the young and ambitious auto manufacturer that exclusively builds electric vehicles. This analysis ends with a discussion on the author's understanding of how a company like Tesla was able to come to fruition, how a similar path could be taken by a new or existing automaker, and what these narratives mean for the current age and future of personal transportation in today's environmentally conscious climate.

Acknowledgements

I would like to start by saying thank you to my parents, Curt and Kristen Dzialo, whose constant support and care was unwavering throughout my education. I will be forever grateful for your sacrifices, your attention, and your love.

Thank you to Kelsey Oliveira, for listening to me talk about this project for the past two years. You encouraged me to work harder and to learn more than I ever could have without you.

Thank you to each and every one of my friends who have read and critiqued this study. A special thanks to my "American history consultant," Ben Kaliff and to my roommates, Andreas Panos and Chris Barry, for letting me keep the lights on late to work and for helping me laugh through this academic year.

This study would not have been possible without the help of my thesis advisors, Curt Ventriss, Brendan Fisher, and Robert Williams. Thank you all for your generous commitment of time, energy, and mentorship.

Thank you to the University of Vermont Environmental Program, The Honors College, and The Rubenstein School for providing me with the means to succeed both in this project and in my greater academic journey.

Table of Contents

Introduction

"Knowing how automobiles are made, how they operate, and how they are used and knowing about traffic laws and urban transportation policies does little to help us understand how automobiles affect the texture of modern life. In such cases a strictly instrumental/functional understanding fails us badly." *Langdon Winner: The Whale and The Reactor, A search for Limits in an Age of High Technology.*

The cars, trucks, vans, and SUVs that are on the roads today are a result of careful design and transition over long periods of time reminiscent of Darwinian evolution. Functionality, speed, efficiency, and design are all elements in automobiles that have developed over time and changed in accordance to what human life and cultures have demanded. Historically speaking, automobile shortcomings in safety, affordability, and efficiency are normally corrected by the automobile industry in order to keep people on the road. However, the use of fossil fuels and correlating environmental degradation have remained key tenants throughout the age of automobile-centric transportation.

At the end of the 19th century electric vehicles with rechargeable batteries were the preferred type of automobile for personal and professional use. These lead-acid battery powered machines were promptly left to rust when fossil fuels for internal combustion engines (ICEs) became easily accessible, which ensured that ICE-run vehicles were the economically responsible choice for everyday consumers (Pistoia, 2010). Only in recent decades have electric-powered vehicles have made a social and manufacturing comeback linked with the modern environmental movement.

Some scholars (Hoyer, Larminie & Lowery) point to the 1962 publishing of Rachel Carson's book Silent Spring as the point in time where conventional automobiles were first acknowledged to be a key source of harmful air pollutants. Carson's book, of course, also spoke about the dangers of agricultural pesticides that were the source of environmental contamination while separate debates were arising about urban pollutants. Furthermore, in 1950 Dr. A.J. Haagen-Smit published "The Air Pollution Problem In Los Angeles," in which he detailed the presence and sources of smog that swept through Los Angeles County California, one of which was the "half million automobiles driving around in Los Angeles" (Haagen-Smit, 1950). The emissions from the combustion of leaded fuel in automobiles were most prevalent and noticeable in large cities, like Los Angeles, and made them unpleasant places to live causing burning sensations in the eyes and throat after long exposures. Electric vehicles are viewed by environmental groups to serve as a mitigation tool for emissions created by ICE vehicles, and, in more recent years, they have become a beacon of hope as a potential piece of the puzzle for combating the effects of climate change and transitioning to a future filled with renewable energy (Larminie & Lowry, 2003).

In this thesis, I examine the role of automobiles in the past, present and the future of personal transportation. Additionally, I bring together the history of the American automobile industry and the complex contemporary narrative of Tesla Inc, the young and ambitious auto manufacturer that exclusively builds electric vehicles. With these narratives written and examined side by side, this thesis concludes with a discussion comparing the narratives with the goal of finding similarities and trends that could uncover potential questions for further research and many difficulties that exist in transitioning to an electric vehicle focused future.

It is important to note, for readers of this writing that this research is focused on the

United States, and builds off of historical events and literature that are primarily American. While I do acknowledge international affairs often, they will not be touched on in great detail. The writing that follows this introduction is a result of historical research and careful examination of the economic, social, political, and environmental factors that have played a role in shaping the present day automotive industry and culture in the United States. Further, a major theme that I have grappled with in my study is transition. More specifically the transition from analog to digital. This transition has materialized in several different ways throughout the history of automobiles, both conventional and electric, and offers insight that assists in a complete understanding of the profound effect cars have had on human life since the 20th century.

This study can be broadly defined as a comparative historical analysis under the context offered in such books as *Comparative Historical Analysis in the Social Sciences* by James Mahoney, however, the resulting product has proved to be much more. The style and order of writing is a result of a change in original intent by the author. I began this project with a plan to write a thesis project in the style of a narrative policy analysis as described by Emery Roe in his book *Narrative Policy Analysis*. Studies in this style are completed by first writing the historical narrative that is told most commonly, writing the counter narrative second, followed by a comparison between the two, and finally completed with a meta-analysis of the comparison (Roe, 1994). After completing the research, the first chapter, I came to the realization that it would be more better to go about this project from a broader historical analysis perspective rather than to focus in on only policy aspects of the subjects at hand.

The narratives uncovered and examined throughout this project have proven to me that their implications have potential standing in the fields of environmental studies, economics, science and technology studies, and sociology. Such implications will be teased out further throughout the 4 sections of this thesis. Those sections, labeled as individual “chapters,” are summarized below.

In the preface, I offer a brief outline of the history of electric vehicles. This is to give the reader a general knowledge of electric vehicles in the United States and some of their roots abroad. This information serves as important context and background knowledge necessary to a full understanding of how internal combustion engine cars became a leading mode of transportation, and how/why electric vehicles are making a second ‘comeback’ in automotive culture. In this section, I discuss the niche markets that electric vehicles dominated in the early 1900's and the series of events that lead to their eventual obsolescence. These events go on until the early 1990’s, however, they offer a perfect starting point for the first chapter.

In chapter one*,* I write about the birth of the American auto industry, and how the car became intertwined with life in the United States. This narrative explores the concept of oligopoly, as well as American self-identity, and the development of perceived obsolesces in cars fostered by the automobile industry. It attempts to make sense of today's state of automobility, a term defined later on and sets the stage for chapter two.

In this chapter, I unravel the short yet packed history of Tesla Incorporated. From its beginnings as an idea for an adaptation of a prototype car, to its current state under the tenure of celebrity businessman/engineer Elon Musk. This section questions just how a new company found footing in an industry overpowered by few long-term leading companies, examines the influence of environmental awareness, and seeks an answer to the question of how Tesla creates ‘desirable’ electric vehicles.

In the final chapter, I conclude my writing with a synthesis of facts and a discussion about their relevance to one another and the future of cars and car culture in the United States, as well as the emerging transition to renewable energy sources as a whole. Here I will address my takeaways from this research as well as my suggestions for future research on the topics covered.

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Preface - History of Electric Cars in the U.S.

The First Electric Cars

In electric vehicle literature, the history of electric cars is almost always linked to the history of their batteries. It is difficult to pinpoint the very first electric car or a definitive event that can be called the 'invention' of the electric car. Because of this obscurity, the invention of the electric car is credited to a number of smaller technological advances made by inventors who tinkered with Alessandro Volta's[1] electric battery. These advances including the electric motor, controllers, and improvements in the chemical electric battery (USDOE, 2014). In the United States, a Vermont blacksmith, Thomas Davenport, has been noted in EV literature to be the creator of the first American DC motor[2] in 1835 (Burton, 2013). While Davenport's motor only powered a toy model, his design was readily reconstructed as an operational scale-sized vehicle by Scottish inventor Robert Davidson (Guarnieri, 2011). In 1881, Gustave Trouve of France unveiled the world's first electric vehicle to be powered by a rechargeable battery. That vehicle was a small boat, which would inspire even more inventors to tinker with discharging and recharging of batteries. Next, professors Ayrton and Perry worked together to create a land vehicle, an electric tricycle to be exact. The trike could drive at around 9 miles per hour, and go as far as 25 miles when the battery was full (Burton, 2013). While this is by no means impressive by today's specifications, the trike is thought to have inspired what was then (1881-1882) a

[1] "Alessandro Volta, in full Conte Alessandro Giuseppe Antonio Anastasio Volta (born February 18, 1745, Como, Lombardy [Italy]—died March 5, 1827, Como), Italian physicist whose invention of the electric battery provided the first source of continuous current" (Editors, 2017)

[2] A DC motor is a device that transforms electrical energy into mechanical energy. Electrical energy can be defined as a **D**irect **C**urrent system (Herman, 2009).

growing market demand for electrically driven vehicles. Following this influx of interest in electric propulsion, two men, Paul Elwell and Thomas Parker, decided to open up shop in Wolverhampton England manufacturing rechargeable batteries, motors, and controllers. This Wolverhampton machine firm was up and running by 1882. This was 3 years before the unveiling of the first gasoline internal combustion engine powered car by Carl Benz (Guarnieri, 2011).

Finding a Niche with the Urban Wealthy and in the Cab Industry

In 1895 Thomas Edison expressed his concerns about the limitations of electric automobiles. He cited their short ranges, as well as their speed limitations given the capacity of the day's batteries. Nevertheless, in the 1890's electric cars were personal vehicles to generally wealthy folks living in larger cities, as those who drove them needed to have access to electricity in order to charge the battery. Given that the electric car was utilized by those living in cities it should come as no surprise that electric "horseless carriages" were adopted by the taxicab industry around this time in history. By 1897 it was commonplace to see "Electrobats" (a model name for an electric cab designed by Henry Morris in 1894) to be cruising on the streets of New York City competing for the business of riders with horse-drawn carriages. Passengers nicknamed the cars "lightning cabbies," and the novelty of riding in such a vehicle propelled the demand for electric cars on the streets. The cab fare for riding in an electric car was the same or comparable to that of riding in a horse-drawn carriage, and in a short time, Morris's cabs could be seen not only in New York but on the streets of European metropolises like London and Paris. While the cabs operated mainly in cities, this time period saw the building of electric vehicle "charging stations" where a cab driver could operate his car over a sliding platform and have his depleted battery replaced in only a few moments time (Burton, 2013). In Nigel Burton's *History* *of Electric Cars*, the author includes a quote from an 1897 issue of "American Mechanist" which summed up the success of electric cabs in New York:

> The electric hansoms, offered for public use only since March 15th of this year (1897), are meeting the public favor to the extent it is claimed of paying current expenses and leaving an actual profit, the rates of hire being the same as those of horse-drawn hansom cabs in New York City (Burton, 2013, p. 40).

The Electric Vehicle Company

Electric cab success in the U.S. prompted European firms to run their own services that, like their American counterparts, catered to and were favored by the wealthy living in cities. The success of electric cabs also inspired Isaac Leopold Rice, the wealthy lawyer and president of Electric Storage Company in Philadelphia. Rice bought Morris and his partner Salom’s company, the Electric Carriage and Wagon Company, and created the Electric Vehicle Company (Guarnieri, 2011). Meanwhile, at the consumer level, those who could afford them, preferred the electric car to its horse-drawn, steam driven, and gasoline powered counterparts for their reliability, ease of operation, and their smooth and quiet ride. At the time, gasoline-powered vehicles were difficult to operate, expensive, and clunky due to their primitive construction and the still under development internal combustion engine (USDOE, 2014). Out of this common desire for electric vehicles, came the rise of Pope Manufacturing Company of Hartford Connecticut's automobile building operations in 1897. The Pope Company, which prior to this time had become the nation's leader in bicycle manufacturing, dabbled in both electric and gasoline vehicles and was well respected for doing so after building a good reputation with consumers for their quality bicycles. While Pope was building both gasoline and electric vehicles they heavily favored the electric fleet building only 40 gasoline cars to 500 electric over the span of 1897-1899 (Hoyer, 2008).

When the chief engineer of the company, Hiram Maxim, spoke up to express his displeasure with the electric focus of the company he was silenced by general manager George Day who said: "You cannot get people to sit over an explosion" (Rae, 1984). This quote was in reference to the current design of internal combustion engine vehicles in the United States where the engine was located directly below the operators' seat. Later on, Isaac Rice joined forces with William Whitney, a politician, and businessman who saw great potential in Rice's Electric Vehicle Company and shared a vision with Rice of complete electric vehicle monopoly. The Electric Vehicle Company went on a campaign of aggressive and brilliant consolidation measures that saw them purchase The Pope Company and move their production from New York to Pope's former Hartford grounds. The Electric Vehicle Company's crusade was not yet over, however, as the company bought out the formidable market opponent, the Riker Company. Before selling out the Riker Company was heralded for their improvements in cabin design and reliability of their vehicles for private use, something that the Electric Vehicle Company was not yet excelling at due to their focuses on taxiing and cab renting (Kirsch, 2000).

The First Failure of The Electric Car

Although electric cars success into the first 10 years of the 20th century, their downfall in the market was considered inevitable after the financial collapse of the Electric Vehicle Company. When their taxi fleet experienced battery failures the cost of repair outweighed the profits that the cars would be bringing in. Because there were simply so many cabs the likelihood of battery failure increased, and the combination of loss of profits and the cost of repair was a blow to the mighty Electric Vehicle Company (Burton, 2013).

Internal combustion engine technology was booming as inventor George Selden had utilized his patent, which he filed for in 1879, for the design of a reliable and small-scale version of the internal combustion engine for use in an automobile. Selden was then legally able to call for royalty payments on any vehicle manufactured using his methods. In 1899 both the media and the competition looked down upon a deal in which the Electric Vehicle Company purchased the patent from Selden for a payment of 5,000 a year plus a small share of royalties. This could not save the company, however, and ownership shut its doors in 1907. Corporations and ICE technologists rejoiced at the collapse of the Electric Vehicle Company as down with the company went the hopes of electric vehicles to remain at the top of the market. Automotive historian John Rae called the Electric Vehicle Company "A parasitical growth on the automobile industry . . ." (Burton, 2013 and Rae, 1984). While the Electric Vehicle Company was not the only manufacturing company building electric vehicles at this point in time, it is by far the largest and most influential in historical context, after its fall in 1907 those small scale EV operations were no match for the ICE industry strengthened and battle tested after years of competition with the EVC.

In the year 1912 one could purchase a personal gasoline-powered vehicle for $650 USD, while an electric model of similar capabilities cost $1,750 USD. According to the U. S. Department of Labor Statistics Consumer Price Index calculator $650 in 1913 (this calculator does not have function for the year 1912) has the same buying power as $15,943.97 in 2017, and $1,750 in 1913 has the same buying power as $42,926.09 in 2017 (BLS, 2017). These numbers were the result of a significant price drop on ICE vehicles after the breakthrough of mass-production by Henry Ford in 1908 that allowed his Model T, and effectively other gasoline powered vehicles, affordable and available everywhere. Also in 1912, Charles Kettering's electric starter was first introduced on gasoline powered vehicles, eliminating the need for the unreliable and difficult to operate hand crank that came standard on ICE vehicles (Kettering, 1915). This simple detail that is absolutely essential to our everyday automobiles today sparked an influx of gas-powered vehicle sales. Shortly after (the 1920s) the United States road systems were heavily improved, smooth, and connected towns and cities together. Journeys between towns became favorable among city and rural dwelling Americans, and such a trip would be a task only for a powerful gasoline powered vehicle (USDOE, 2014). Those same rural Americans had no other choice in transportation, as many at the time still were without constant and reliable sources of electricity. The fuel for these ICE vehicles was not scarce, as crude oil was discovered in Texas both on and off shore ensuring bountiful fuel for Americans (TSHA, 2014). These factors lead to what can only be called a functional extinction of electric vehicles by the year 1930. Electric vehicles held on for some time as a preferred mode of transportation for in-town errands and trips, but they simply could not handle the demands of inter-town driving. An extremely wealthy person at the time who could afford two vehicles for these two uses. The fact of the matter was if you could only afford one vehicle it should be a gas-powered one fit to perform both tasks. After the Model T, middle-class Americans could, after some saving, afford their very own car and would use it in and out of town. The functionality of the ICE simply was better suited for the demands of society leaving EV's in the past.

Waves of Demand 1930s-1990's

Over the next 70 or so years that followed the events outlined above, electric cars never returned to the mainstream. Some manufacturers quietly tinkered until consumers turned to them during the Arab Oil Embargo of 1973 when gasoline prices reached their peak after soaring to all-time highs throughout the late 60's. These international affairs lead politicians in the United States to call for the end to U.S. foreign oil dependency. This call to action, while beneficial to the popularity of at least the idea of a major electric vehicle comeback, was not the only effort to restore the electric vehicle to its place in the automobile market. Many authors who write about automotive history cite growing environmental concerns that appeared after the publishing of Rachel Carson's *Silent Spring* in 1962 (Pistoia, 2010). Researchers were already discovering the harmful contributions that automobiles made to atmospheric pollution as was outlined in Dr. A.J. Haagen-Smit publication "The Air Pollution Problem In Los Angeles." This 'perfect storm' of environmental concern and oil rationing in the western world led auto manufacturers, governments, and even certain oil companies to prepare for "the end of oil." This panic led to the passing of the Electric and Hybrid Vehicle Research, Development, and Demonstration Act by the U.S. Congress in 1976, which stated:

> An Act To authorize in the Energy Research and Development Administration a Federal Program of research, Development, and Demonstration designed to promote electric vehicle technologies and to demonstrate the commercial feasibility of electric vehicles ("Electric and Hybrid Vehicle Research, Development, and Demonstration Act," 1976).

The act focused on five main parts. First, the U.S. dependence on foreign oil was an issue of national security and must be reduced. Second, the U.S. importation of foreign oil jeopardized the balance of payments of the nation. Third, that transportation was the highest employer of petroleum products in the nation. Fourth, that electric and hybrid vehicle integration could and would cut oil use and dependence. Finally, electric and hybrid vehicle integration was plausible due to factors such as improved electric vehicle technologies and capabilities, the absence of emissions in EVs ("Electric and Hybrid Vehicle Research, Development, and Demonstration Act," 1976). This began a short burst of increased innovation and experimentation in hybrid and electric vehicle technology the likes of which had never been seen before. Scientific American staff writer Seth Fletcher wrote that "The 1973 oil embargo supplied this simmering research scene with apocalyptic urgency and essentially unlimited funding" (Fletcher, 2013). That is exactly what electric vehicles had at their backs as the major U.S. automakers of the time took heed of the government's advice and rolled out prototypes. General Motors did at the 1973 EPA Symposium on Low Pollution Power Systems Development, as well as operational EVs for use by industries that required the use of automotive fleets such as the U.S. Postal Service which employed the American Motor Company’s electric delivery jeeps in a 1975 test program (USDOE, 2014).

This time period also saw prominent petroleum companies such as Exxon begin to prepare for their own obsolescence. In 1976 Stan Whittingham published an article in *Science* in which he described a feasible rechargeable lithium battery (historically EVs contained lead-acid batteries) while working in the research and development department for Exxon. While his primitive lithium battery was not yet perfected, the roots of all current batteries used in modern EVs can be traced back to Whittingham’s (Whittingham, 2004). In the 1980’s this whirlwind of electric vehicles would fall just as hard as it did at the turn of the century, only this time its demise was much faster. Just as environmental concerns and a spike in oil prices ensured a vigorous foray in EV development, the disinterest and drop in oil prices led to the opposite. In the 1980s, President Ronald Reagan’s administration purposefully moved the nation away from environmental issues. At the same time OPEC members increased production of crude oil and offered new pricing arrangements in order to offset their poor revenues and lower the price of fuel at the pump. As always, different automakers tinkered with electric vehicle design and function, but these projects were novelties and barely entered the mainstream market (USEIA, 2002).

The Modern Era: 1990’s-Now

President George H. W. Bush was responsible for a revision of the Clean Air Act in

1990, which included proposed legislation that was believed to be able to mitigate the effects of three identified "major threats" to the environment. Those three threats were acid rain, urban air pollution, and toxic air emissions (EPA, 2015). This act, as well as the Energy Policy Act of 1992 which created a comprehensive framework for creating a competitive wholesale energy/electricity generation market from multiple sources including several renewable energies (USEIA, 2017), increased once again some interest in electric vehicles by manufacturers. In a response to these federal actions as well as new regulations issued by California Air Resources Board, improvements in electric vehicle power functionality allowed automakers to experiment with modifying existing models of vehicles to be outfitted with EV capabilities. Modified gas models were of a superior build to their electric-in-mind designed ancestors and thus could attain higher speeds and further distances. This experimentation did not stop the creation of new battery-powered electric vehicles and hybrids, however, as it was in this same time period that the most popular (well-known) electric cars in history was built from the ground up to be an EV. That vehicle was General Motors' EV1, the subject of Chris Paine's 2006 documentary *Who Killed The Electric Car* (USDOE, 2014).

The EV 1 boasted an 80-mile range and a 0mph to 50mph time of just 7 seconds. It was new, it was hip, and it was wildly popular among young people and devout environmentalists. General Motors' was fearful when it came to the production of their EV1. The production costs were extremely high for GM standards, and although the EV1 garnered a devout cult following GM valued the number of sales more than the quality of sales. The EV1 was discontinued in 2001, and General Motors ate their losses after not allowing the few EV1 models it built to be sold. When the leases were up on the manufactured vehicles, the company did not allow the cars to be leased or sold further and took them into company facilities to be scrapped (Paine, 2006).

Following the rise and fall of the EV1, there came yet another lull in the popularity of EVs in the market. The pleasant economic climate during the Clinton administration in the white house and the low fuel prices diminished the demand for fuel-efficient vehicles. Nonetheless, this time period saw the rise of hybrid electric vehicles from Japan such as the first Toyota Prius in 1997 (first released in 2000)– the first hybrid-electric to be mass-produced. The Prius became so prevalent in U.S. markets that they became the best-selling hybrid of the 2000-2010 decade (Duoba, Ng, & Larsen, 2001). While the Prius, being a hybrid-electric vehicle, still uses conventional gasoline, its vast popularity and versatility surviving through an early 2000's decade that was more or less apathetic towards fuel efficiency proved that EVs could be marketable when mass produced and were of a quality build. The Prius found, even more, success in the mid-late 2000's when gas prices once again were on the rise, and new environmental concerns began to arise concerning global climate change and global warming (Burton, 2013).

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Chapter 1 – The Auto Industry of the Analog Age

"The rise of the American oligopoly makes it an important time to reexamine how antitrust enforcers and regulators think about concentrated industries. Here's a simple proposal: when members of a concentrated industry act in parallel, their conduct should be treated like that of a hypothetical monopoly." – *Tim Wu, Columbia Law School, The New Yorker*

The Industry Takes Shape

The automobile represents the quintessential American industry. If the history of the United States from the late 1800's to the present day were viewed only from behind the windshield of an automobile there would be very little the driver and passengers would not see. In many ways, freedom to move and travel freely, to endlessly roam, or to pass from destination to destination is a uniquely American freedom. Modern cities and towns in the United States stand in monument to the automobile and its functionality. Roads divide and unite us simultaneously, in addition to serving as the ultimate form of control over where we go and what we see. The automobile's historical narrative is a long and turbulent journey that has, in turn, infused the car and personal mobility with American culture so deeply that the two are inseparable. Yet, there was a time in history when American's needed to be convinced that driving personal vehicles could provide uses beyond sport and leisure. This section will serve to break down this narrative, to examine the fine details that lead to the current state of affairs, and to analyze transitional societal trends in the age of analog technology.

Automotive historian, John Rae, argues in his 1984 book that the invention of the automobile is argued semantically over patents which had been created in several different European nations around the 1890's. The first running carriage powered by gasoline was built in Germany by Benz and Daimler. In the United States, however, it is not the invention of the automobile that is key to the beginning of its narrative. Rather, it is the American “pioneers” who began to tinker and experiment in just how to take this technology to a marketable product through reasonable means of production (Rae, 1965).

In 1883, Frank and Charles Duryea used the mechanical skill learned in bicycle repair to build the first "American automobile" in Massachusetts, based on the Benz design. The brothers entered manufacturing of thirteen cars with financial backing from a private source, a group of Springfield investors. Elwood Haynes, an engineer by trade, built a personal vehicle and later entered business with two machine shop owners in Indiana. Their operations ceased after a dispute over credit, the same goes for the Duryeas (Kennedy, 1941). At about the same time Henry Ford was acting chief engineer of the Detroit Edison company, an electric utility provider.

In 1895, Thomas Edison, Ford’s friend and employer at the time, denounced electric powered automobiles as impractical given their limitations on range and speed. This conclusion coming after he and Henry Ford built one together in a joint project. The high price of maintenance due to the precise mechanics of a steam-driven automobile made it less than a formidable opponent to the internal combustion engine economically. Further, there was no match for the power and reliability that internal combustion engines could offer drivers at the time.

By 1897, the Pope Manufacturing company began to manufacture and sell automobiles, both gas and electric, at a commercial scale with success not yet seen in the United States (Rae, 1965). The Pope name was trusted and had solid footing to venture into automobiles after succeeding in the manufacturing of bicycles for some time. In Cleveland Ohio, Alexander Winton opened his own motor vehicle operation under the moniker of the Winton Motor Carriage Company. After selling what he claimed to be the first gasoline-powered vehicle assembled for sale (non-prototype) in 1898, Winton set out in one of his vehicles to drive from Cleveland to New York in an advertising stunt that would earn him a lucrative investment of $5,000 from a private investor (Flink, 1990). After the success of this venture, it was not uncommon to see Winton driving his cars in racing events, much like Henry Ford the two men saw racing as an opportunity for free advertising.

The following year, 1899, the United States was home to 30 firms legally classified as auto-manufacturers. The companies were small compared to the modern-day giants of American industry, whose roots were rapidly taking form at this point in history. Very few of these 30 were able to reach maturity, as many dwindled out after reaching dead ends in startup funding, sales, or ownership. From 1900 to 1910 eleven companies began to control the United States auto market by out competing the smallest of competitors economically. Those companies were the following: Maxwell, Olds, Reo, Hudson, Overland, Marmon, Packard, Studebaker, Buick, Cadillac, and Ford. Ransom Olds, the founder of Olds Motor Works, secured for his firm a stable foundation on which he would build what would appear to be the perennial leader in the industry for some time.

Olds accepted a private financial backing in the form of $200,000 from a pair that had worked with him in the past. After a fire in 1901 destroyed all but one prototype buggy in Olds Detroit manufacturing plants, the company confirmed that it had begun to plan to refine its focus onto only this model. This stroke of luck and pure coincidence pushed Olds into 1904 with a production level of 5,000 automobiles. Occurring only after a local business group invested funds to relocate the Olds grounds to a former Lansing Michigan fair site. Eventually, disputes arose between Olds and his partners, Smith and Son who provided the $200,000 in financial backing. Olds believed in building economical cars (wallet friendly) for every American to commute with, while the Smiths saw a future in extravagant touring cars to be afforded only by America's elite. This argument would resolve in Olds moving on from his namesake company to build the REO brand. Olds Motor Works became known for its quality as a "training ground" for young professionals in the field to hone their skills before venturing out on their own (Curcio, 2001). The most notable of these individuals being Jonathan D. Maxwell who went on to form Maxwell-Briscoe which later became known as Chrysler, which would stand the test of time and be addressed later in this historical study.

Back in 1899, Henry Ford was busy gathering the necessary financial contribution from private sources, in his case a union of businesses in Detroit. Ford left Detroit Edison, and alongside his new backers, he took on the role of superintendent of the newly organized Detroit Automobile Company which would fail in November 1900 under pressure from highly established companies like Olds, and Packard of Ohio. It was replaced by a new firm under the name of the Henry Ford Company. Ford himself was criticized by his partners, who took claim in that Ford was so absorbed in activities such as racing his cars for publicity, that he deserted his responsibilities in the production sector. Ford was later dismissed by his board, and Henry Leland took his spot and rebranded the company Cadillac Motor Car.

In the interest of space, the origins of the remaining successful turn of the century auto-makers will not be discussed here. Let it be known, however, that of the dozens of firms that were opened in this time very few reached maturity. The new auto world was an alluring field of manufacturing that many mechanists, business groups, and bankers saw as a remunerative opportunity. This craving for new industrial dynamism was a siren call to a very much free market in early 20th century America. Entry was financially painless and there were no legislative constraints on the products being built and sold. Funding was abundant in the form of financial backers from corporate financiers to local banks and personal assets (Langlois & Robertson, 1989). The open competition promoted by the industry in its earliest forms encouraged survival of the fittest in the companies taking a part in it. Mass production changed the industry further, and the new environment of economic freedom and accelerated production gave Henry Ford, and some of his competitors, the resources to reach their full innovative capacities with the technology they had available.

Why Detroit?

While the future of the industry may have remained unclear to those participating in it at this time, the aspect that one could be certain of was that the American automobile industry was becoming increasingly more concentrated in Detroit. Like all Great Lakes cities, Detroit was well positioned to accept shipments of building materials in bulk. Hardwood from Michigan had been providing support to the carriage industry for generations in the area, and many carriage makers were able to make the transition to automobiles. These reasons, while notable and certainly contributing factors, hold little weight compared to the mostly coincidental event that prominent names in automobile entrepreneurs relocated to the Detroit area. Ford, Dodge, Leland, and Olds among others each claimed their stake in Detroit city limits claiming middle America as the capital of the automotive world for far longer than any of them may have imagined. At the beginning of the 1910's automotive firms in the Detroit area became much more popular than competitors in the New England and Ohio regions and subsequently moved ahead in sales, pushing weaker and smaller firms out of contention. This increased revenue for the newly consolidated Detroit automobile companies lead to heavy investment in research and development pushing their automobiles far beyond the non-Detroit cars in both affordability and technologic soundness (Palmer, 2012).

Once the industry was off the ground in Detroit, the American auto industrialists were able to conceptualize the automobile as something that was never thought of in Europe. That being, the car as a daily consumer product attainable by all citizens. Whilst American's sought-after cars of their own as each of their neighbors began to purchase them, the United States government feared what might come with a new age of transportation in the country. The federal government heavily invested in railroad transportation during the 1860's, and funded four of the five transcontinental railroads built via land grants. In total, the Pacific Railroad Acts of 1862 through 1866 granted rail companies 103 million acres of public land allotted for sale or loan to finance construction. The railroad kept American's together, while the automobile drove us apart. At least in the mind of government officials at the time. Even Woodrow Wilson warned, before his time in office, that the automobile encouraged socialism by giving the poor something to envy in the rich. Wilson was speaking then as the president of Princeton University during a speech in 1906, and according to author Brian Ladd, his opinions on the culture of the automobile were shared with most Europeans rather than Americans (Ladd, 2008).

The Automobile and Sense of Self

Historian and cultural studies author Cotton Seiler, in his book *Republic of Drivers* that claims automobility became "entrenched in political institutions, the economy, the landscape, and cultural life. . .". Automobility, simply defined, is the use of the automobile as a means of personal transportation. Seiler argues that the concept took on a deeper root in the United States as a "shaper of public policy and the landscape, a prescriptive metaphor for social and economic relations, and a forge of citizens."

Before the rise of automotive Detroit, Americans had taken on the persona of strong and free individualism criticized by foreign nations and popularized through politics and modern philosophy. Ralph Waldo Emerson was famed for claiming individualism as the ethos of an authentic and true self (Emerson, 2012). Identity for Americans was often found in their profession and was perpetuated by modern transportation. People were beginning to be able to travel far and wide each experiencing a truly individual and personal lifestyle, one that only automobiles would be able to enhance (Seiler, 2008). In order to reach this fulfillment, the automobile needed to become available to every American, and built in a way that kept the industry afloat. Ironically, this need for increased availability would require many Americans to work in the factory system and give away any self-identity they received from their profession, in order to gain it back via automobile.

When the phrase “every American” is used above, it cannot be ignored that the social climate of the early 1900’s normally defined this to mean white heterosexual males. Travel, mobility, or the freedom to move (on a large scale), has been defined most interestingly to me by geographer Eric Leed. Quoted in Seiler’s Republic of Drivers he says, “[T]he voluntariness of departure, the freedom implicit in the indeterminacies of mobility, the pleasure of travel free from necessity, the notion that travel signifies autonomy and is a means for demonstrating what one "really" is independent of one context or set of defining associations-remain the characteristics of the modern conception of travel” (Leed, 1991).

The roots of this definition in American society were perhaps not formed in, but certainly in an important developmental stage during westward expansion in the nineteenth century. During the United States expansion into western territories, a picture was painted to those remaining in the East that white settlers and frontiersmen were bringing civilization to “savage” societies of Native Peoples. Between the narratives passed from the frontier to the Eastern states, and the ideology of manifest destiny which existed in the United States as early as the mid-

1700's a time when slavery was legal and practiced, and women not yet afforded the right to vote (Billington & Ridge, 2001). Americans seized the land they desired, and gained the space to roam they believed was rightfully theirs giving those economically empowered to do so the freedom to gain autonomy through travel. This freedom was limited, of course, by political institutions such as legalized segregation and the designation of Native American reservations.

Segregation, in particular, created boundaries invisible to the eye, yet it stood tall against the relatively modern idea of a right to movement, and by this time, automobility. Even so, African Americans expressed the same roaming idealism of white Americans seeking newfound freedom in automobile travel. This expression of resilience was materialized by Victor H. Green, author of The Negro Motorist Green Book, a travel guide for black Americans with detailed listings about attractions and lodging that would accept African American patronage (Foster, 1999). This resilience and desire show just one example of how desired mobility was in American society, and how it allowed people of different backgrounds to identify as American. That was not always the case. As I touched on briefly above, throughout American history the idea of selfhood has evolved as daily life and technologies have changed. It can be argued then that the largest diversion from traditional self-identity occurred around the year 1911 when industrial organization was revolutionized.

Frederick Winslow Taylor, author of *The Principles of Scientific Management* which describes his methods for industrial organization and theory of efficiency, would complicate this identity crisis even further. Taylorization took factories and small-scale manufacturing to new heights through ruthless efficiency measures which limited factory worker's tasks to eliminate skilled labor and brought work to the workers along moving systems among other details. There is no better example of Taylorization in perfect working order than in the production of Henry

Ford's Model T. While Taylorism transformed industrial labor around the country, turning workers into cogs of a greater machine, the systematic organizational processes were absolutely essential to the creation of the automobile as we know it today. This revolutionary modern car mass produced for quality and a small price tag made automobility available to more people than ever before and in a somewhat predictable way re-introduced sovereign selfhood in a new way (Saylor, 2018).

After the introduction of Taylorism, American consumer culture and self-identity was changed completely. No longer did people identify with their trades but with their possessions, post-depression of 1920-21 the economy soared allowing American consumerism to reach heights it previously could not have dreamed of. Automobiles, with their already long history of opportunism, could not have come of mass-produced age at a more perfect time for the industry. In 1921 the federal government joined the bandwagon of supporting the automobile. By enacting the Federal-Aid Highway Act of 1921, the U.S. Government acknowledged the auto industry as a staple industry for America's future and cars as the American way to travel. The act supplied the first hints at what would become the national highway system under Eisenhower, by covering half of the construction cost while calling for the states to cover the rest. The states did so by taxing gasoline at prices from one to two cents per gallon (NSSGA, 2017).

As the factories put more cars on the road and income increased for many Americans during the economic boom of the 1920's many working class people were able to purchase their first personal vehicles. Economic prosperity of the working class in the United States would ultimately stun the economic upper class by eliminating the car alone as a status symbol for wealth and power. Mass-produced vehicles, prior to this time, had been stigmatized for their inexpensive construction and appearance. To combat insecurity in their positions and status, wealthy societal elites sought vehicles created by boutique auto firms with bold designs and new markers of pleasing aesthetic design (Gartman, 2004). Such societal trends forced the automotive companies were perfecting modern techniques of sales and marketing. These methods included increased production to keep prices competitive, while also allowing for the purchase of cars on credit rather than the traditional practice of cash only exchanges. This allowed for companies to better market a "trade-up" to the next model when customers came in to pay their due bills. John Rae writes in his book, The American automobile: a brief history, that “by 1929 there was one motor vehicle for every six people in the United States” (Rae, 1965). The 1920-21 depression, before leading to the absolute economic boom, took down minor auto-makers who had not built the capital at the level that industry elites were able to during the years of Taylorism. This virtual natural selection restructured the industry into what historians call a clear-cut oligopoly of three firms. These companies became known for some time as “the Big Three,” their names still around today: Ford, Chrysler, and General Motors. GM, of course, a conglomerate born from a collection of smaller firms namely Cadillac, Oldsmobile, Pontiac, and Buick. While smaller firms continued trying to “make it,” the three ran the market for automobiles in the U.S. relatively unopposed. Of the nearly 100 auto companies that existed in 1920 only 44 remained in the year 1929.

Sustainability of The Industry and the Rise of Environmental Concern

The biggest threat to the profits of the leaders was the novel concept of “the used car.” Ford and its competitors were now stuck in a predicament that they had not anticipated fully, that their cars may last for long enough that they become what we call today “used cars,” that would not be traded in due to the repetitiveness of the models and the reliability of the vehicle itself. The automakers could not simply build lower quality vehicles to fall apart within short amounts of time in order to rake customers back in, such a practice would be a clear attempt at industrial planned obsolescence, a crime against sustainability and certainly drive away consumers. As a solution, Alfred Sloan of General Motors came up with the idea for annual models. Every model in a company's' fleet would get a complete redesign each year drawing in new and existing customers alike and creating true used cars as older models were traded and left to rust. This deceptive practice can be labeled no other way than as perceived obsolesce. While it is not necessary to purchase a new vehicle one may be predisposed to do so upon viewing a new annual model and perceiving their own car to be inadequate or completely obsolete. This practice, while cunning, has been a driving factor to continued innovation and competitiveness between brands leading into the state of the art vehicles on the road today. However, it can be argued that before this moment automakers had not thought, on an industrial scale, about the impact that their products had on the lives of individuals. This marks an important milestone, years before the start of the modern environmental movement, in which one could see a lack of sustainable practices in major American industry and disregard for such practices even when an opportunity arises to go in a sustainable direction.

In the 67 years since the appearance of smog in Los Angeles County California documented by Dr. A.J. Haagen-Smit who cited the "half million automobiles driving around in Los Angeles" as a contributor to the phenomenon causing burning eyes and sensations in locals' throats. The auto industry, as it was, took a stand, which John Rae points out followed a cyclical pattern that re-occurred with every major public issue affecting the industry for the following 20 years. A spokesperson for the industry would step up to deny the existence of a problem at all, next the group of major manufacturers would admit that the problems were in fact in existence but the industry had no way to stop it or moral obligation to do so. Lastly, the claim from the industry would be that while they could do something, it would be time-consuming and costly above the threshold of a possibility. Rae argues that most of the time, they were right, and those who spoke out against the autos were crushed by the realization that no change would be coming because it is "unreasonable." In times like this, the still conglomerated auto industry was able to metaphorically shrink down to its individual companies in order to appear as a classic American firm rather than a goliath modern world to which the charge of solving public issues seemed reasonable (Rae, 1965).

As the federal and California state governments began to deal with the air pollution problem, the “Big Three” signed a cooperative agreement that dismissed any competition amongst themselves in terms of innovations that could potentially create less harmful emissions from their vehicles. The automakers at this point in time realized the power they held in both the industry and in American transportation (Woutat, 1992). The Department of Justice subsequently sued “all major domestic automobile and truck manufacturers” for direct violation of the Sherman Antitrust Act which was drafted to prevent the monopolization of industry and unfair dealing. The case was brought to Federal district court in California, where the automakers walked out unscathed after claiming the following, "No one company should be in a position to capitalize upon or obtain a competitive advantage over the other companies in the industry as a result of its solution to this problem." What finally regulated the otherwise unchecked industry at this time of air pollution crisis was Congress’ passing of the Motor Vehicle Air Pollution Control Act of 1965. Federal standards were put into place after studies were conducted on the technological and economic feasibility of editing future model years of vehicles. The results of the Clean Air Program’s dealings with the auto industry have been graded a partial success, but with no clear goal or universal constitution of “clean air”, this can be left for open debate.

Additionally, it can be argued that the auto industry was unfairly treated to some extent by government restrictions with no clear endgame (definition of clean air at the time).

Globalization and The Big Three

Nevertheless, the industry continued to enter the familiar process which saw it walk away from the site of public policy issues that could be attributed in part to the transportation sector. In the 1970's, however, the auto industry was faced with the reality of globalization when the oil crisis brought the Big Three together in new ways united against the common competition. The ramifications of practicing planned obsolescence began to catch up with manufacturers of automobiles when oil prices skyrocketed due to the events in the middle-east, and consumers at the home front became more self-aware of their gasoline consumption habits and in turn their personal emissions. Compact and efficiency oriented cars from manufacturers in Asia rose in popularity as capital mobility allowed foreign auto-makers to penetrate the U.S. market like never before. In a time of globalization, the Big Three and their domestic suppliers, dealers, and subsidiaries were preoccupied with scrambling to best foreign competitors in their own market that they paid little attention to each other. In a way, this panic of the 1970's brought the still growing oligopoly closer together by keeping them separated in times of trouble.

Over the next 30 years or so, the Big Three took part in self-indulgent business practices and continued to hold their stance on forced innovations including on the electric car. Even when an electric vehicle from a Big Three member was a rousing success with consumers, GM's EV1, it was pulled off the market forcefully after the company decided it was no longer economically responsible to produce or lease the car. State-level fleet requirements for zero emission vehicles eliminated the possibility of cornering the market for modern electrics as all auto-makers were required to devote fleet space to hybrids and fuel efficient internal combustion engine vehicles

(Fragapane, 2010). Detroit continued to run the show the way it always had, which ran them into trouble in the early 2000's. Critics of the industry called it out when things turned sour in September 2008 saying that because of their "corporate malpractice" and hubris that the "market should have brought them to their just end." The firms approached the U.S. government for funds to avoid bankruptcy and were granted $25 billion in loans to be issued until March of 2009. The government knew that the bankruptcy of the big three, would decimate the mid-western economy and put millions of Americans out of work. Just like concentration in Detroit had occurred in the first place, it showcased major benefits in the modern era in one word: miraculously.

Moving On From Analog

So, what are we left with today? A relatively in-check yet still all mighty oligopoly running their industry with faux competition against each other but unity against foreign firms. The "open-market" that had existed when the Big Three were just getting on their wheels has been boarded up and abandoned. Entry into this industry is nearly impossible between the required funds and strong union of existing powers ready to crush any new idea or firm at a moment's notice. Self-aware that the country they exist in cannot allow them to fail, the firms that remain going through procedural processes with federal and state government to remain in good standing while continuously resisting innovation outside their scope of comfort measured by economic factors.

Yet, equally as valid is the view that the leaders of the industry have faced many hardships since 1960 that should be the prerequisite for praise and forgiveness for stubborn practice. The Big Three, and their leaders faced business conditions never before encountered by other industries and handled them with little to no formal training in the matter garnered through past experience. They were charged with finding solutions to everything from air pollution to energy conservation when they had no intention or knowledge of their part in forming the issues when they began operation and contributing to them. They have been subject to wild swings in American culture and consumer habits culminating with an all-out crisis which pertained to the key ingredient in the use of their product. As environmental consciousness grows ever more mainstream in the United States and abroad the Big Three must remain alert to consumer demands and become more willing to change. This will require a fundamental institutional change to promote innovation and take risks on emerging technologies such as modern all-electric vehicles something the industry had to work hard to overcome in its formidable years.

The modern demeanor of the industry's largest companies and their relatively stagnant behavior is important to note as this has not been the protocol for the auto industry before. Taking a step back from the timeline of events above and analyzing them at a more macro-scale allows us to see just how much the industry has transitioned, and with-it society and American culture. In my research, I came across a transitional concept normally attributed to studies on media, but applicable in fields such as science and technology studies as a tool for examining transitioning of technologies and of their applications. That concept is the great transition from analog to digital. Easily manipulated for different project purposes, this transition theory examines the divide between what is considered analog and digital through both technology and human interactions with that technology.

Although analog and digital transitions seem to be self-predictive, with the digital always prevailing at the 'end' of any given technology's narrative, it is not always clear cut. Our societal understanding of what analog and digital are is constantly changing, and in response our behaviors with those technologies change and adapt as well. Looking back to the history of electric vehicles as outlined in the preface of this thesis, gasoline powered motor carriages overtook them as the more pragmatic technology of the times. Before them both reigned the horse drawn carriage, an impressive technology at a time when the alternative was horseback or traveling by foot. Further, the social concept of what it meant to own a car evolved over time from a tool used for a job, in this case travel, to a status symbol in the mid 20th century. The idea of the car as a tool can be considered a metaphor for an analog-ness, where the item simply is what it does, without much depth of meaning beyond it. The idea of an automobile representing a status symbol is more digital in nature in that it gives power and intangible attributes to the object and creates a network of thought and social structure in its user. Physiologist Ralph Gerard explored a similar dichotomy in 1951 when he wrote that "an analogical system is one in which one of two variables is continuous on the other, while in a digital system the variable is discontinuous and quantized" (Wilder, 1998).

It is in examples such as these that have shown me that transition, and the dichotomy between what is considered analog and digital can be remarkably fluid. The way that we view technologies is open to evolution just in the way that the technologies and the industries that build them are. It is unique then that such a disruptive technology and product like the automobile so often sees further development and 'greater good level' changes stifled by the very few companies that run the auto industry. In the next chapter, I will be exploring the rise of what many believe to be the next wave of automobility through the narrative of the company that assisted in its creation.

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Chapter 2 – Tesla and the Digital Age

″Well, I didn't really think Tesla would be successful. I thought we would most likely fail. But I thought that we at least could address the false perception that people have that an electric car had to be ugly and slow and boring like a golf cart." - *Elon Musk, CEO Tesla Inc.*

Our Digital Present

At the start of Chapter 1, I called the automobile the quintessential American industry. The car, however is much more than an industry, a product, or a single technology. Rather it is a sociological icon, a way of life, an influencer of culture and engineering. The automobile was an innovation of life on earth, so great in fact that it secured a permeant spot at the top of the National Academy of Engineering's list of the greatest engineering achievements of the 20^{th} century (NAS, 2018). Interestingly enough the automobile is second on this list only to electrification. Several of the innovations on this list are technologies that came into being relatively late in the century, including computers and the internet yet they populate the same list of engineering achievements like agricultural mechanization and refrigeration. The speed at which new 20^{th} century technologies were created and amalgamated themselves into society was staggering. The result is a post-modern digital age unlike any other time in history, with increased consumerism, and daily life and communications being dependent on technology (Wilder, 1998). Our contemporary business and economic models are focused on technology and information. It is here that Tesla Motors found an intervention point in a seemingly locked automotive market.

Cluster Based Economics

The reality of globalization in the 1970's sent the Big Three into an uncoordinated scramble to best the emerging foreign automakers in the United States Market. Globalization undoubtedly changed the understanding of competition between companies and even nations (Featherstone, 1990). Location of a firm has thus become less important to business as goods and services can be moved around the world quickly, efficiently, and with just a few keystrokes on a computer. However, location has not yet lost a role in the economics of competition as similar companies continue to set up shop in close proximity to one another. For instance, high concentrations of mutual-fund companies can be found in Boston, aerospace and defense builders in Seattle, and of course automotive firms in Detroit.

These conceptualizations on location were publicized and studied by economic theorist Michael Porter in 1998, and published in the Harvard Business Review under the title *Clusters and the New Economics of Competition*. In his work Porter states; “Today’s economic map of the world is dominated by what I call *clusters:* critical masses—in one place—of unusual competitive success in particular fields. Clusters are a striking feature of virtually every national, regional, state, and even metropolitan economy, especially in more economically advanced nations” (Porter, 1998). Porter claims that there is a paradox in the global economy in that “competitive advantages in a global economy lie increasingly in local things—knowledge, relationships, motivation—that distant rivals cannot match.” How is it then that a new automaker could challenge the Big Three’s auto supremacy all the way from Silicon Valley?

Clusters, according to Porter are extremely vulnerable to what he calls “internal rigidities,” that is, group thinking that depletes competition and collective idleness that can stagnate innovation and limit novel advances in products. Until very recently, for the Big Three, rigidities have shaped in the form of continued production of internal combustion engine driven vehicles regardless of the potency of modern alternative drive-train vehicles, as well as increasing dependence on third-party suppliers. These rigidities, promulgated in the 21st century have exposed the Big Three too, for the first time in decades, to new domestic competition by eliminating engineering leadership that would otherwise lead to proprietary innovation and cleaner technology in an environmentally conscious age (Parkman, 2015).

This chapter will detail the narrative of that aforementioned domestic competition from its start to present day, in order to explain just how the first American automaker to debut in 90 years has defied the odds to become successful and begin to change the world beyond automobility (Pelley, 2014). That automaker is Tesla Inc.

Tesla's Beginnings

"Tesla was founded in 2003 by a group of engineers who wanted to prove that people didn't need to compromise to drive electric – that electric vehicles can be better, quicker and more fun to drive than gasoline cars" (Tesla, 2017a). This statement, found on the Tesla website *about* tab may seem strange to those that have only a surface level knowledge of the company. As an electric car maker, it is easy to make the assumption that Tesla was founded on environmental and sustainability principles, but in reality, it was really the challenge of engineering a desirable electric vehicle that brought the "group of engineers" together. It was in fact 2002 when Martin Eberhard and Marc Tarpenning drafted business plan and specs for a car and company that would become Tesla, but what today's Tesla Inc. will not tell visitors to its site is that the original Tesla Roadster that "started it all" was itself inspired by the work of an engineering firm in Los Angeles called AC Propulsion (Zart, 2017).

AC Propulsion specialized in alternating current power generation and electrical controllers, they combined these two crafts in order to develop a two-seat hobby car driven by their newly developed modern AC drive train and lead-acid batteries called the tzero. The tzero boasted a 0 to 60mph time of just 4.2 seconds and a driving range of around 70 to 80 miles on a charge. AC Propulsion was a part of a unique niche of "boutique electric-car makers" in California at the time that grew by exploiting the need of electric drive consulting for the Big Three due to California's zero-emissions mandates (Baer, 2014). While the tzero was revolutionary in the early 2000's, Eberhard saw more to be done. Eberhard, a modest Silicon Valley entrepreneur with a love for cars, made his fortune selling his e-book reader company, NuvoMedia and bore witness first hand to the quick rise of billion-dollar laptop and cell phone markets. He saw that his colleagues throughout the valley investing heavily in research and development for lithium-ion batteries and pondered, why couldn't that technology be transferred to cars (Shnayerson, 2007)?

Eberhard became close with AC Propulsion president Tom Gage, and founder Alan Cocconi by investing in the company, and entered talks about the possibility of converting their engineering project to a full-scale automotive startup. The operators at AC Propulsion, however, were content with their current work and had no interest in putting in the effort to mass market and manufacture electric cars. Eberhard was discouraged but did convince AC Propulsion to help him build a prototype tzero with a lithium-ion battery system (Zart, 2017). Eberhard took that vehicle home and quickly partnered up with Marc Tarpenning, a fellow entrepreneur with whom he had founded NuvoMedia and had become close friends with. Together the two studied the vehicle and the automotive industry to develop a business plan in order to form what would become Tesla Motors named after the father of the AC electricity supply system, Nikola Tesla.

Eberhard and Tarpenning "had no experience making cars, and (we) had a lot to learn" according to Eberhard. While the pair took part in painstaking research to make up for their lack of experience, they came to a stunning realization that the "automotive ecosystem had quietly made itself inviting to startups" (Baer, 2014). In an interview with business journalist Drake

Baer, Tarpenning is quoted “We discovered that in the preceding 20 or 30 years, the car industry had completely refactored itself, it turned out that no car company made windshields anymore. They always bought them from the windshield makers, and the rear-view mirrors were purchased from the rear-view-mirror makers." The most important detail of this discovery to Eberhard and Tarpenning at the time was that the Big Three had even been outsourcing their systems and onboard electronics as these elements were not a part of an auto maker’s normal expertise. Lucky for the Tesla pair this was their specialty, and they were prepared to track down the correct manufacturing partners in order to wrap their digital technologies in an elegant metal package. The two entrepreneurs inadvertently discovered the cluster economics work of Michael Porter in a real-time incidence and were ready to exploit the auto industries built up "rigidities" for all they were worth.

Tarpenning bought the internet domain *Teslamotors.com* in April of 2003, and the company was officially incorporated on July 1st of the same year. August of 2003 saw Eberhard and Tarpenning opening the first Tesla office in Menlo Park California, and set out on perfecting their pitches to new investors. They started with pitches to people that would never invest in such a company, these executives were mostly friends from the partner’s NuvoMedia years, as a way of practicing and workshopping how to market such a product. The original executive summary drafted by Eberhard and Tarpenning offered seven bulleted points about the would-be Tesla Roadster, including its impressive acceleration of 0 to 60mph in 3.9 seconds and bold prediction of a 300mile range. The preliminary round of pitches that the partnership endured helped them to iron out details that they had not previously considered due to simple ignorance of the auto industries’ inner workings. Such details included the franchise/dealership sales model, which the pair decided not to follow in order to avoid the opportunity to receive direct feedback from consumers. Eberhard and Tarpenning also discovered the impossibility of building an entire car from scratch, even if they followed the rigidity influenced methods of the Big Three by getting many parts from external manufacturers the costs would simply be too high. The solution, building in and around existing chassis. The team settled on the Lotus Elise frame as its small size and lightweight could accommodate Tesla technologies. Eberhard and Tarpenning struck the deal with Lotus at the 2003 Los Angeles Auto show, and later signed a contract with AC Propulsion for further development of the Tesla Motor within the newly decided upon frame (Baer, 2014). With the plans finalized, for the time being, the two set off in search of a true investor in Tesla.

Early Investments, Meeting Musk

Tarpenning and Eberhard's expertise that they formed in Silicon Valley businesses served them well as they entered their next stage of attracting investors. Tesla, by Silicon Valley standards, might have been considered a hardware company. Selling a product that is a physical item capable of entering commerce and going home with a consumer is inherently risky. The makers of that product cannot remotely update it, or fish out bugs that may have gone unnoticeable in the factory through careful monitoring of usage like software engineers can do for a new mobile application. The founders of Tesla we well aware of these facts, and began securing funds from friends, family, and some unrelated investors that saw great promise in their mission. Eberhard and Tarpenning were on their way to a successful start-up but they had not yet found an investor that would be willing to invest based on belief in the same ideals that the company was founded on rather than monetary potential alone (Fallick, 2006).

Tarpenning and Eberhard found those desired qualities of an investor in Elon Musk. By the time that the pair first met Musk at Stanford University conference put on by the Mars

Society, Elon had already begun to make his name known through bold business moves and increasingly large projects. In 1995 Musk and his brother started a company called Zip2 with a $28,000 loan from their father. The company was the Musks' vision of an online *Yellowpages* and was sold to Compaq for $307 million and $34 million in stock in 1999. Elon took his $22 million and went on to found X.com, a secure online payment system that would evolve into PayPal by 2001 (Musk, 2003). That transition coming an entire year after Musk was relieved of his position as the chief operating officer. He retained $165 million in 2002 when PayPal was purchased by eBay. Musk channeled both his funds and momentum into SpaceX starting in 2002 creating a company that "designs, manufactures and launches advanced rockets and spacecraft. . . with the ultimate goal of enabling people to live on other planets" (SpaceX, 2017). Musk was, and still very much is a big thinker by industry standards reminiscent of automobile pioneers reveled in America's past. After hearing him speak at the Mars Society conference, Eberhard and Tarpenning wanted him on board at Tesla Motors.

After a brief e-mail correspondence, the pair traveled to Musk's SpaceX office to pitch him their rehearsed plan for Tesla. Musk had driven the tzev created by AC Propulsion too and, like Eberhard, encouraged Gage and Cocconi to put their car into commercial production but the AC team again turned down the opportunity. Musk and Eberhard connected quickly in their meeting, and the shared experience with AC's tzev car was a powerful one. Because of this, Eberhard found that he did not need to pitch the electric car to Musk, but rather converse about their shared interest in creating a car 'superior in every way' to internal combustion vehicles. The three also shared the idea that Tesla should first focus on making the attractive model at a high price to gather attention before bringing the technology's price down in an economy of scale fashion for all to profit from. It was clear to Eberhard and Tarpenning that Musk was on board, as their 30-minute scheduled time with him lasted nearly two hours according to Eberhard. Their assumptions were correct, and the paperwork was finalized in April of 2004 making Elon the leading investor and chairman of the board (Hess, 2017).

With Musk on board, more funding made its way into Tesla's budget, and the young company needed to get their design set as quickly as possible in order to build their cars and sell them. Eberhard, Tarpenning, and third co-founder Ian Wright (who was brought on in between incorporation and the signing of Musk) faced a grand challenge in the design of their first car. While they had chosen the Lotus Elise base as the guideline for the shape of the original Roadster that is where the line was drawn between conventional car building and purpose-built innovation. Malcolm Powell, a former employee of Lotus and later VP of vehicle integration recalls the Roadster calling for newness in a way that "every other new car was not." Further, the Roadster was to be built with carefully sourced parts from the wide range of auto manufacturers and powered by Tesla's own technology developed in-house. In this way, it can be argued that Tesla's vehicles would be truly "new," while 'new' GM or Ford vehicles, limited by only a pool of parts from known preexisting models could not be considered new in the same sense (Baer, 2014). This point of view reinforces the argument that the Big Three was significantly weakened by rigidities causing complacency and stagnation of innovation in accordance with Porter's writing.

Building the First Tesla

After meticulously crafting the designing details through both personal consultations and finally a design contest, the early Tesla team was able to piece together their first prototype vehicle in 2005. This early Roadster was considered a development mule by the team, a vehicle built for testing using prototype parts and built quickly so that testing for large-scale issues could be addressed immediately. This particular car was built upon a Tesla-modified Lotus Elise chassis, powered by a Tesla engineered battery pack, and using a drivetrain developed by AC Propulsion (Easto, 2017). By now Tesla had grown to 140 employees and had taken on a new Chief Technology Officer in JB Straubel who is considered one of the founders of the company today (LaPedus, 2007). Straubel's reputation in the world of automotive tech precedes him, as he had worked on electric vehicle projects before, but none like this. His colleagues, including Eberhard, allowed him the honor of the first ride in a Tesla, as they believed it was his skill that was responsible for the amazing power they projected the car to have. When Straubel stepped on the pedal their testing was proven right and the car held together just fine by prototype standards (Segal, 2008).

Growing Pains

In February 2005, Tesla Motors raised $13 million in funding during the Series B investment rounds. Leading contributors included Valor Equity Partners and Elon Musk (Crunchbase, 2017). By spring 2006, launched a publicity plan to respond to the growing suspense and rumors floating around Silicon Valley. Tesla felt the pressure from the outside and put together a debut plan culminating in a PR event in July of that year. The event attracted wealthy investors, business people, and Hollywood names all of whom were given the opportunity to sign a preorder agreement for Tesla's "Signature One Hundred – 100 cars sold at $100,000 each with a signature of the company's principles written on a plaque inside" (Baer, 2014). The event featured test drives and speeches, and both went extremely well according to Tesla's leadership. Martin Eberhard was quoted by Baer, in his in-depth piece, saying that "anybody who got into one of those cars had their opinion of electric cars instantly changed." Speakers at the event included Eberhard and Musk, and according to Tesla's VP of customer service and support, Mike Harrigan, Eberhard was clearly the better speaker. He was accessible but confident, and he was also unintimidating. A friend of Eberhard, when asked about Elon Musk's presentation, was quoted by Baer to have said "Elon's ability to speak in public and convey the sense of the company was not nearly as good as what Martin had done. . . He just didn't seem to be nearly as effective in making people excited and believe in this trend" (Baer, 2014). At this time Eberhard was "the Tesla guy," a role that Musk has filled in recent years making his name simply inseparable from the brand. Within a month after the event, Tesla had "sold" 127 vehicles via pre-order, that Tesla projected delivery dates for during the summer of 2007. A successful media strategy coordinated by Harrigan led to Tesla making headlines in *Motor Trend, Wired, CNET,* and *The New York Times* to name just a few. The media attention boosted Tesla out of obscurity and made Eberhard an entrepreneurial figure to be held. Musk, who was used to being at the forefront of his companies, was feeling overlooked by both his Tesla colleagues and the media. He wrote an email to Harrington, which has now become public, stating the following:

> The way that my role as been portrayed to date, where I am referred to merely as 'an early investor' is outrageous. That would be like Martin [Eberhard] being called an 'early employee.
>
> Apart from me leading the Series A & B and co-leading the Series C, my influence on the car itself runs from the headlights to the styling to the door sill to the trunk, and my strong interest in electric transport predates Tesla by a decade. Martin should

> certainly be the front and center guy, but the portrayal of my role to date has been incredibly insulting.
>
> I'm not blaming you or others at Tesla — the media is difficult to control. However, we need to make a serious effort to correct this perception.

A few weeks past after this message was sent and received, and more articles about Tesla were published in media such as the New York Times that in no way featured Musk's prominence. Eberhard recalls the situation becoming the first time that the two "bumped heads" was due to this unequal or inadequate press coverage. He stated that their technical disagreements about the vehicles they were building were always resolved and remained civil, but this instance was the first time Eberhard marked an emotional disagreement with Musk (Santos, 2017). While his motives remain unclear, it is quite possible that Musk desired more attention in order to promote himself and his other businesses. Musk was still running SpaceX privately and had a large role in Solar City, his solar energy enterprise founded by his cousins, on July fourth of 2006.

The first Tesla Roadster was delivered to Tesla headquarters in February of 2008, two years after Eberhard had predicted (Richard, 2008). Back in 2006, Musk was worried about a crisis of confidence with Tesla's customers. He wrote in an email in October 2006, "(We could either) sacrifice a six-month first-mover advantage in a market that is like the Internet circa 1992 (but slower moving) or focus every bit of energy on getting our product right." The two worried that pushing back expected delivery dates would worry consumers, and waiver their confidence that Tesla would provide them with a quality product. Tesla encountered manufacturing issued hand over fist throughout 2006 and 2007, pertaining to the system they expected to work in which most parts of the vehicle were sourced to Lotus in England and arrived at the Tesla garage pieced together only leaving a few detail to be bolted on and fabricated by the team to make it truly a Tesla car. Design changes, and higher than expected volume of orders made Tesla responsible for several cars at a time rather than the one at a time speed at which they could realistically work. Eberhard was in a panic and was quoted stating “I had never run a company that was getting that big, it was time for us to bring in some professional management capability” (Baer, 2014). Musk and Eberhard then presented to a board meeting in which they presented their plan to bring in a new CEO to relieve Eberhard so that he could move onto a different role developing the next Tesla car, the Model S. Eberhard was ready to step down and mentioned how similar practices had taken place in companies like Google stating: "It was a completely friendly discussion, with a couple of speeches from board members about how it was very much the normal course of a startup for the entrepreneur-founder to move into a different role as the company grew. Someone on the board cited Google as an example."

What followed were turbulent times for the young company both internally with personnel and externally with their product. A trip to the Lotus plant in England taught Elon Musk that the Roadster was behind schedule by two months, and further setbacks came in California due to Musk’s particular sense of style and functionality. Musk-caused setbacks were the bane of Tesla employees’ jobs, and the stress of finding a new CEO with Eberhard had made his actions all the more frantic. The search for the next CEO of Tesla Motors began in February 2007 and the media became wise to the company’s actions by June. Musk was earnest in his attempt to help care for Eberhard’s public image, as the story leaking out of Tesla at the moment was that he was being fired. This was not the case at all, and Elon promised in an email to

Eberhard that "I would be happy to correct the perception that you are being fired." This comradery was quickly subsided when Eberhard received a phone call from Musk in August 2007 on which he was told the board had found his replacement in Michael Marks, an early investor. Eberhard was irate, not that a replacement had been found, but that the decision had been made without him. With the help of a lawyer, Eberhard determined that the meeting was in direct violation of the companies agreed upon code of conduct, and therefore must be rescheduled and held with Eberhard present. Martin Eberhard stepped down and took a role as president of technology but was shut out of just about every daily operation of Tesla Motors. Mike Harrigan has said of Musk since this occurrence: "Once he determined that Martin couldn't be the CEO of Tesla any longer, that was it. He was fired."

The departure of Eberhard from Tesla became evermore tiresome as time went on as the co-founder filed a civil complaint [3]against Tesla and Elon Musk seeking damages for the standing that the company failed to fulfill its severance obligations and inaccurately portraying Musk as a founder (Stein-Lemos, 2009). Michael Marks filled space at Tesla, but the overwhelming sense was that his position would be only temporary. When asked about Eberhard, he was quoted:

> Martin is a very good technical guy, and he had a vision, but he wasn't a particularly good CEO," Marks said. "But that's not the least bit unusual. Martin is an engineering visionary, not the guy to

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[3] The court files that came out of this case are the source from which many of the direct quotes and email exchanges from Tesla's principle actors came to be featured in this chapter. The quotes were pulled by Business Insider Reporter Drake Baer in his article on Tesla for Businessinsider.com.

> run a business. If he was, he would have done the things I did. He came up with a lot of the technical aspects of the car. Most guys who can do what Martin could do aren't very good at running businesses. Maybe they should have made that move earlier. The company wasn't getting the best use out of him, he was spending a lot of time running the business where he wasn't well equipped.

Ze'ev Drori took over Marks's CEO position in November of 2007. He kept production on schedule and saw the beginning of regular production, final assembly and preparations for customer delivery, begin on March 18, 2008 (Hill, 2008).

Going Public

In October 2008, there were Tesla's being driven on public roads by the people who bought them many months prior. It was then that Ze'ev Drori stepped down into a vice chairman position, leaving the CEO position open for Elon Musk. Musk, through Tesla, made some major announcements. The first was that there would be a companywide lay-off mostly due to the closing of a satellite office outside of Detroit, the second was that production of the Model S would be pushed back until 2011 while the company builds a new headquarters and manufacturing plant in San Jose. Thirdly Musk announced that Tesla's goal for equity financing was to reach $100 million, as it was currently awaiting the clearing of a loan granted by the United States Department of Energy that could only be used after an environmental review of the San Jose building (Miller, 2008). Musk led what was left of Tesla after Eberhard through a proverbial sea of recalls, customer complaints, financial troubles, and technological tweaking to make the Roadster a success on the scale that the founders intended it to be selling more than 1,000 of the two-seater model. To his credit, Musk was able to secure an initial public offering

(IPO) for Tesla of 13.3 million shares (Chafkin, 2010). Interestingly the report that was created by Musk and his team to apply for the IPO reveals that Tesla makes the most significant amount of its revenue by selling emissions credits to other automakers. Entrance into the stock market gave Tesla $226.1 million to develop its Model S sedan, which it intended to make more marketable beyond the richest one percenters. The public offering also had historic prevalence, as Tesla Motors became the first American car company to go public since Ford did fifty-four years prior. This moment in time solidified Tesla as a true "car company," and Elon Musk was responsible.

Since its IPO, Tesla has released the Model X and unveiled the Model 3. Model X is Tesla's answer to SUVs, it offered 295 miles on a single charge and has a 0 to 60mph time of 2.9 seconds. Tesla claims that it is the "safest, quickest, and most capable sport utility vehicle in history" (Tesla, 2017c). The Model 3 is meant to be Tesla's fulfillment of their own prophecy that through an economy of scale production model and with the funds raised from Roadster and Model S sales, they would be able to produce a mass-marketable electric vehicle that was truly Tesla. This goal has been "met" but the vehicles have not yet hit the road. The Model 3 can achieve a 220-mile range and starts at $35,000 before federal incentives for electric vehicles (Tesla, 2017b). These numbers keep the vehicle competitive with other EVs in its class, but its branding may see it topple them.

Company Identities

This new identity of Tesla provokes an interesting economics case study that can be rooted back to Michael Porter's economic clusters. In his paper, Porter says that "Silicon Valley and Hollywood may be the world's best-known clusters" (Porter, 1998). Silicon Valley, in particular, is one of few clusters, in fact, that seem to suffer less from the pains of rigidities than others due to the nature of their businesses and products. Computer companies based here are normally "plugged into customer needs and trends with a speed difficult to match by companies located elsewhere," says Porter. He goes on to say that "The ongoing relationships with other entities within the cluster also help companies to learn early about evolving technology, component and machinery availability, service and marketing concepts, and so on." Martin Eberhard saw this first hand when working in the Valley through the lens of lithium Ion battery technology being developed for mobile electronics which he evolved into a working start-up. Tesla itself is unique in that it began as a technology company with the challenge of building hardware not yet mastered by Silicon Valley engineers, including those at Tesla. This allowed Tesla the freedom to stretch in Northern California free of local competition but with all the tech support it could possibly need. Tesla even boasted investment from Google co-founders Larry Page and Sergey Brin (Kolakowski, 2009). As the tech start-up evolved into a full-fledged automaker marked symbolically by its IPO in 2010, Tesla Motors came of age in a cluster that adored it and out of the reach of the one it was competitive with both geographically and technologically.

The Role of Competition

While the Big Three had the potential contend with Tesla technologically, it simply has not done on a large enough scale to bring down Tesla. It can be argued that this is because of complacency building profitable SUVs and trucks, and the ingrained flow of repetitive production techniques further sponsored by the theory of rigidities within clusters. The Big Three viewed Tesla as a boutique carmaker building only hobbyist vehicles, but when the Model S was introduced after the moderate success of the roadster they began to recognize Tesla as a formidable threat, but only in the future. Doing only the bare minimum of work towards EV programs in order to meet federal fleet emissions standards, when the major auto companies do produce electric cars they are lazy in design and “The automakers do almost no advertising for them, and most (not all) of their dealers do their utmost to steer customers away from them. Meanwhile, the companies continue to lobby to have fuel economy and emissions standards watered down” (Network, 2017). Against the odds, Tesla defeated the cluster system by innovating its way in the style of one cluster into the business of another, but it may have also opened the gates to competitors yet to be seen following their lead. This narrative, however, is not yet written but it will be important to keep an eye on the names Faraday Future, Lucid Motors, and Fisker in the near future.

There is the also an oversees influence on Tesla’s marketability. As I have attempted to keep this writing within the borders of the United States to the best of my ability, I would not be able to do the topic due justice without at least mentioning the influences of foreign autos in America. In 2016 both Toyota and Nissan have produced over 50% of their American sold vehicles in the United States. According to American University, Tesla is the only prominent automaker to build 100% of its vehicles in the United States (Johnson, 2017). Toyota has been at the forefront of hybrid automobiles for decades but does not “market fully electric passenger cars at the moment” (Reuters, 2017). Nissan was making headway with its Leaf, introduced in 2010 becoming one of the first major automakers in the world to debut a fully electric car without direct influence of government fleet mandates. The Leaf has recently fallen to the fourth bestselling plug-in electric vehicle behind Chevrolet’s Bolt, Tesla’s Model S, and its Model X SUV which debuted in 2015. The BYD e6, a Chinese built EV is predicted to have the best year financially over Tesla, and they are not alone atop of Tesla on the sales forecast “leaderboard.” Tesla was beaten by General Motors in the race of building a modern, affordable, long-range capable electric vehicle. GM's Bolt is on the road today and predicted to just edge Tesla's Model 3 in 2017 sales. For GM, however, the Bolt is only a "sign of its ability to innovate, and a tiny fraction of its total output" (Stewart, 2017). The two vehicles, and in reality, most vehicles compared to Tesla's cars, serve entirely different purposes, and should major automakers move entirely to EVs in the near future, as GM announced its plans to, then Tesla will continue to be a worthy and increasingly competitive adversary (Davies, 2017).

Tesla's Self-Preservation, The Modern Role of Elon Musk

A key to Tesla's success both present and future is its ability to stay ahead of the technology curve and keep up its reputation as an innovator. Even if competitors follow, as long as Tesla is consistently forward thinking and is careful with the reputation it crafts for itself, it has the potential to remain successful. Luckily this Is something that Elon Musk has exceled at. The South-African born CEO as he constantly proves his worth under immense pressure, and is proficient in making the impossible a reality. When interviewed, Musk likes to remind us that he is not a true businessman by trade and that he spends close to 80 percent of his time on engineering and design with his teams (Birsel, 2017). Tesla's investors are enamored with Musk and his hands-on approach to design and engineering the product he is trying to sell. Musk says that wants to solve problems, and not on a small scale, he is trying to change the world and if Earth is no longer a livable planet he has a plan for that too. Musk splits his time between several companies. SpaceX, a private space travel company engineering re-usable rockets for travel to locations around the world and to make humans the first interplanetary species has successfully launched vehicles and secured funding from NASA. Hyperloop, an 'enclosed train' system proposed by Musk is a hyper-efficient tube transportation proposal promising to have operational systems by 2021 (Hyperloop, 2017). The Boring company, another idea of Musk's, believes that

"To solve the problem of soul-destroying traffic, roads must go 3D, which means either flying cars or tunnels. Unlike flying cars, tunnels are weatherproof, out of sight and won't fall on your head" (Boring, 2017). As previously mentioned, Musk also plays a role in home solar company Solar City's operations and has made it a subsidiary of Tesla in order to blend technologies and provide consumers with a reliable renewable energy source to charge their vehicles with.

While Musk may portray that his time is split evenly across all of the responsibilities he has created for himself, Tesla and SpaceX are his largest and most time-consuming projects with good reason. This worries Tesla investors, but in the business, engineering, and environmental realms Musk has been dubbed a virtual superhero by his fans, one of his most common comparisons being to Tony Stark the billionaire, genius, and philanthropist that later became Iron Man. The comparisons people make of Musk to others do not stop at fiction either, as he is often held as a mirror image of Steve Jobs co-founder of Apple. This comparison is particularly potent considering how the auto industry has fully entrenched itself in the digital age of the 21st century. This story will be unpacked more in the next chapter, but it is important to know just how intertwined cars and computers have become over the years. As Cotton Seiler points out in his book *Republic of Drivers,* the internet is doing for people what the car did decades earlier, that is providing us with personal transportation to other places and technologies for work, education, and leisure (Seiler, 2008). Before the Tesla Model S, in-car technology was limited and a feature, for Tesla it became a core from which to build and pertinent to connect to the electric drive system. If the Roadster is Tesla's Apple 1, a project of one person pursued and sold by another, then the Model 3 could very well be Tesla's iPhone, a product for the masses of a technology they have may be purchasing for the first time marketed by a company with a leader who has become his own brand.

The Apple-Tesla- Jobs-Musk comparisons do not stop there, but the last one worth mentioning here is the following that these companies were able to create. When Apple unveils a new smartphone it may do so with a keynote speech which is followed by lines of customers camped out around its retailers to buy it. As Musk seized more control of Tesla over the years we have seen more and more of this method. Vastly improving his showmanship and speaking skills since the Roadster's debut, Musk is able to inspire and generate a sense of wonder and exhilaration for Tesla's vehicles. When unveiling the Tesla D, a supercar not ready for commercialization just yet, Musk said during his speech "This car is nuts," he said during the reveal. "It's like taking off from a carrier deck. It's just bananas. It's like having your own personal roller coaster." Musk and Tesla have become a household name with help from the media covering his and the company's revolutionary technologies and Elon's numerous and amazing side projects, Tesla has eliminated the need to advertise something that Apple has not accomplished. According to electric automobility researcher Alexander Edwards, Musk has "created the most-loved car in the nation from (Strategic Vision) data" (Reese, 2017). Tesla has a customer base not seen before in the automotive industry – moderately wealthy to extremely wealthy people who are conservative enough not to purchase other brands' luxury model because of the additional price, both economically and environmentally, of gasoline fuel.

Beyond developing the next generation of Tesla Vehicle, which will come into production after the Model 3, Musk has created a desire for electric vehicles rooted in environmental values insatiable to the point that other automakers have felt pressure to pursue them as well. When Tesla was first founded Eberhard and Tarpenning made it their goal to make electric vehicles fast, sleek, and even "cool" compared to the contemporary electric models that, in their opinion, needed to "apologize for being a car" from a design stance. When Musk was brought on as Chairman, he was seemingly convinced to back and join the venture because of the same principle. As time went on we can see the narrative change from a group of engineers seeking a cool new way to use an incredible technology to a brilliant scientific mind who is fixing major global issues by cleaning up a harmful technology in a beautiful way. This narrative transition was fueled, by actions of the company as a whole leading up to the year 2017, but also by Musk's own words. On June 9, 2017, Musk published the following publically through a series of tweets:

> Few people know that we started Tesla when GM forcibly recalled all electric cars from customers in 2003 & then crushed them in a junkyard
> This was done against the will of their owners, who held a candlelight vigil all night to protest the death of their cars
> Since big car companies were killing their EV programs, the only chance was to create an EV company, even tho it was almost certain to fail
> Nothing to do w govt incentives or making money. Thought 90% prob of losing it all (almost did many times), but it was the only chance. (Musk, 2017a)
> Long way to go, but we've convinced most of the auto industry to start EV programs & gave them all our patents to help, so that's something (Musk, 2017a)

A Greater Purpose

Perhaps these utterances about the origins of Tesla are true and the founders had an underlying desire to help mitigate the effects of climate change through the promotion of electric vehicles. The alternative to this is that Tesla made the goal to make “cool” electric cars, and now that it has succeeded Musk had to find a new way to promote his company. The latter is not as likely, but not sinister enough to be out of the scope of possibility. Musk’s commitment to human wellbeing through renewable energy and sustainable transportation is enough to rule out that he is trying to profit off of planetary disasters. Tesla is having overwhelmingly positive effect on the auto industry, and some may say that Musk has done “too good of a job” promoting electric vehicles as his competition has become more open to the idea, like GM who has planned 20 new electric vehicles for the next six years and Renault-Nissan who plan on 12 by 2022 (Dapena, 2017). This development of major automaker EVs is also predicted to put an end to Tesla’s profiting from the sale of zero-emission vehicle credit sales.

Musk has made the companies patents available for use by anyone and everyone. In a statement published on his Tesla blog, Musk writes:

> Yesterday, there was a wall of Tesla patents in the lobby of our Palo Alto headquarters. That is no longer the case. They have been removed, in the spirit of the open source movement, for the advancement of electric vehicle technology.
>
> Tesla Motors was created to accelerate the advent of sustainable transport. If we clear a path to the creation of compelling electric vehicles, but then lay intellectual property landmines behind us to inhibit others, we are acting in a manner contrary to that goal.

> Tesla will not initiate patent lawsuits against anyone who, in good faith, wants to use our technology.

In an interview with Stephen Colbert on the *Late Show*, when asked about the publicizing of patents for electric drive systems that have been crucial to the company's success Musk responded with the following: "If we're all on a ship together, and there's holes in the ship and were bailing water out, and we have a great design for a bucket; we should probably share the bucket design because we're all going to sink" (Musk, 2017b). Even though the Big Three and traditional automakers from oversees will continue to develop and market internal combustion engine vehicles, for the time being, a recent push in EVs from these companies sparked by Tesla is still a positive push towards a sustainable transportation future that should not go under-appreciated. Because Tesla is so far ahead of the renewable race, they must upkeep their innovative capacity in order to secure a place at the table when the other firms catch up.

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Chapter 3 - Conclusion

"The costs of creating the space for other technologies and other choices are so high that they are beyond the power of the market to overcome. All is not therefore lost, however. The implication rather is that the market *by itself* cannot move us onto a different technological path even if all the individuals in it want to be on that path. It needs the support of other institutions. It needs very large – all right, massive- public investment to disrupt and reorient our collective trajectory. This is not a bad thing." – *Erica Schoenberger, Nature, Choice and Social Power*

As Tesla became a popular living room discussion subject, expanding outward from its technological bubble of Silicon Valley, it brought with it excitement and cautious optimism for people from many different perspectives, or problems they wanted to be solved. Environmentalists saw an aesthetically pleasing electric vehicle capable of correcting or curbing public perception of electric vehicles. Economists and political theorists might have seen a lucrative opportunity for a firm to break the cluster-based motor vehicle industry model cemented in Detroit. Car buffs saw a potentially disruptive vehicle for automotive history that would be both fast and capable enough to compete in the market with the likes of any luxury sports car. The oil and auto industries saw something they long fought to suppress internally, something to be wary about. Truthfully, I cannot recall the first time I heard about Tesla or its cars. I set out to research for this project I had expectations and opinions on the matters I would be discussing, that were not necessarily biased or uninformed, but rather passive and without depth. Electric vehicles have always interested me but not as an environmentalist, or as an academic subject worth investing countless hours of time studying. However, I wanted to know whether America's love for the car could be successfully transferred into electric vehicles, and if the Tesla narrative was one that was repeatable. In short, the answers to these questions are yes, and no respectively but these answers were not my two biggest takeaways from this project.

On April 1, 2018, Elon Musk sent out a tweet that started with the simple phrase "Tesla Goes Bankrupt…" Elon's April fool's prank garnered an interesting collection of responses ranging from the displeased who chose to comment on Tesla's numerous recent shortcomings, fans of Musk applauding the joke, and some who seemingly took to the web to verbally joust with other users. After studying Tesla and Musk for the better part of two years, I found the tweet amusing, and a bit smug at the same time. But the part I found most interesting of the exchanges that were linked to Musk's ruse was between twitter users Francisco Quintero and Ryan Walkinshaw. Walkinshaw, a verified account holder "replied" to musk to saying:

> I like Tesla, but after 20 years it has failed to make any profit and looks very ominous for their future. Not to mention their USP, electrification, is being adopted by most auto manufacturers who seem a lot more capable of dealing with supply chain and production, than Tesla is (Walkinshaw, 2018)

To which Quintero replied:

> man, the whole point of Tesla is having others doing electric cars, reducing oil dependency for cars. See the big picture. Elon is changing the world. (Quintero, 2018)

Is the whole "point of Tesla" to create a pressure-based political war with American automakers? Maybe not, but certainly Tesla generates awareness, perhaps even fear, about where the evolution of energy and sustainability in business and society is leading the automotive industry. This is evident at the end of chapter two, in the discussion about the publicizing of Tesla patents by Elon Musk and his current team. While this internet interaction is hardly a scholarly source, quips like these have helped, to some degree, to shape the public perception and industry reputation of Tesla, Inc simply because of its creation and development in the age of the internet. What we now consider digital forms of communication give anybody with the economic means to get online a voice in a very crowded room.

This state of digital communication and connection gives the public agency in the decision of where automobility goes next. Until now, like I teased out in chapter one, the automotive industry and personal vehicles themselves have more or less 'naturally' evolved in a survival of the fittest (companies and cars themselves) model according to new industry standards and advancements in technology. Much like how humans have gained the ability to alter life in genetic labs and set new courses for long-term evolution through gene-drive technology and similar advancements, our digital present allows for the direct interface between industry and consumer which ultimately can lead the products they build in new directions.

I have learned from this project firstly that the automobile is far more than a technology or a physical possession and that since the first automobiles were operated on American streets they became ingrained in our cultural DNA. Cotten Seiler, an author I have referenced prior, writes in the introduction of his book, *Republic of Drivers,* "Readers expecting a travelogue, a polemic, a technical history of highway design, or a romp through "our love affair with the car" will be disappointed. . ." (Seiler, 2008). I found this to be true both of his book, and the examination of the automobile from any perspective. In so many ways the automobile has defined how we identify within given communities and with ourselves in our 'sovereign selfhood.' Our cities, homes, offices, schools, and "third places" are connected and designed around the automobile. It is a regret of mine that this project did not afford me the time or space to include an entire chapter on the highway system and the limits of automobile travel. Further, it would take a complete restoration of modern society to rid the country of the automobile as the premier mode of travel for individuals. This is why I see a future with fewer, but never an absence of cars on the road. As an environmentalist, I agree with the idea that there should be considerable efforts taken to increase the use of alternative modes of transportation in applicable circumstances. Increased bicycle and public transport infrastructure cannot be considered a bad choice; however, it cannot be the only choice.

What Tesla has done as of 2018 has shown that the previously inept business model of boutique automakers can work well in today's digital age when digital infrastructure and analog technologies find a nexus. At the same time, however, its relative success has lead to significant efforts by the existing oligopoly to chart a new course into building more sustainable vehicles in the style of hybrids and electric vehicles. This leads me to my second takeaway: The transition of society (at least in the United States) to all-electric vehicles may never happen in a way that one could predict.

By the time Ford was practicing mass manufacturing, and Taylor re-designed American factories, people had just begun to define what a car was. What followed, as explored in chapter 1, was a new development self-identity and understanding of the car was that became cemented into society as a permanent tenant. Over the decades that followed America witnessed the automobile's technological momentum as defined by Thomas P. Hughes in the late 1960's. Hughes' concept of the phenomena was a combination and synthesis of the theories of technological and social determinism. Hughes argues that young technologies begin in a state of social determinism where society determines the proper use and extent of it. If it ages well and matures, like technologies like the automobile, it enters a phase of technological determinism where society succumbs to the use of the tech and readily adapts other new technologies and societal trends to it. Once a technology enters the technological determinism phase it is said to be self-perpetuating and unavoidable (Hughes, 1994). The automobile is very clearly beyond a point of social determinism and is already often used as a perfect example of technological determinism in history of technology texts. We continue then to use knowingly harmful and unsustainable internal combustion engines for the exact reasons than that we will continue using cars. The technology within the technologically deterministic automobile was defined by society during its socially deterministic years to be a part of the definition of what a car is.

Consider two cars driving side by side, an original Tesla Roadster and a Lotus Elise. If painted the same red hue, and supplied with matching components like tires, rims, windows etc., the cars would look exactly the same and have the same fundamental purpose and function. Under one hood a petroleum-powered internal combustion engine, and under the other an electric motor powered by a battery (charged of course by predominately non-renewable power generation). Both are defined as automobiles but are vastly different. The difference between the two like the difference between analog and digital explored in both chapters 1 and 2. They exist at the same time, can be used by two people simultaneously, but hold many different qualities. Now, imagine two people writing a letter. One types on a typewriter, the other a MacBook. The font is exactly the same, the ink in the printer and the ink on the ribbon can be produced using the same chemicals, and of course, the letter can have the same content. The machines themselves are the fundamental difference here, one highly mechanical with several internal moving parts, the other more modern, sleek and capable of more. The MacBook is a product of a digital age, further, it is connected to a wider world via the internet and internal programming. Years ago, computers were simply not as capable as they are today even though they were early machines of an impending digital revolution. There was a point in time where both of these machines existed, yet when tasked with writing a letter a person would have chosen the typewriter as the more capable machine. Looking back at the two red coupes, it appears as though we are still at the stage of analog to digital transition where we would still, as a society, choose the type-writer of the pair.

When electric vehicles were first triumphed over by internal combustion engines in the early 1900's there were very few who imagined them coming back. Erica Shoenberger writes in *Nature, Choice and Social Power* "The history of gasoline-powered automobile in the US – and therefore the world – hinges on choices made that could have gone in other directions combined with unlucky timing. These choices were made permanent and essentially universal by the power of the market" (Schoenberger, 2014). It would appear as though the technological momentum of automobiles has reached a significant rift as electric drivetrains become increasingly more powerful and desired. The misconception being that the momentum has died, this is not the case. It is, of course, true, as Schoenberger points out, that the internal combustion engine car won out during its original stage of social determinism, however, and that it is now entered a stage of technological determinism. But as I stated previously the car is not itself alone "just a technology," and if the societal definition of what a car is continues to evolve there can come a day in which one of the subconscious elements of that definition is an all-electric drivetrain.

It is at this intervention point of the automobiles technological momentum that Tesla has done something special in planting the idea that an electric car is capable, efficient, and just as good looking as any other luxury gas-car on the market. It can be said then that the original founders and builders of Tesla, Eberhard, and Tarpenning, have done more to solidify electric vehicles in American society that Elon Musk and all the while not making the environment a primary focal point. Tesla built cars that themselves served as technological experiments for society to test. The automaker reintroduced society to the electric drivetrain in the modern day and thus re-entered it into a stage of social determinism which it has seemingly past due to its uncanny resemblance of what we believe a 'good car' should be. Moreover, Tesla played on, albeit without clear intention to do so, on being founded during what is described by Carol Wilder as the most digitally advanced age based on the sheer speed of advancement the technology industry has made in the past 20 years (Wilder, 1998). The fact that Tesla was born in the high tech economic cluster placed the young company at a significant advantage in preparation to introduce a disruptive technology. On a more metaphysical scale, Tesla has been intertwined with our 'digital' present by being more in line with the continually growing progressive environmentally focused public. In these ways, among others, the narrative of Tesla cannot be repeated. It is a watershed moment in automobile history, but I am still cautious to say whether it will lead to a complete transition to electric vehicles over internal combustion. By the time such a declaration could be made a new technology, supported and feared by many could come a long to push them away once again similar but never the same as Tesla.

It is my hope that upon reading my work or independently a future researcher or academic could re-write this thesis in what will then be considered the 'modern age.' Perhaps electric vehicles will become the norm in our society without compromising the standard nonrenewable power sources that are currently used for charging. Maybe Tesla proceeds forward with autonomous vehicle technologies and creates useable products for the aging vanguard of the automobile industry (The Big Three) to mimic in order to remain viable. Additionally, I am interested in what the next stage of the ongoing analog to digital transition could become. What will we consider digital in future decades? What is to come in a post-digital society?

This study has been a unique experience and has definitely presented me with answers to my original questions while also presenting me with questions I never anticipated. The weight of the topics that I was able to explore was immense and as I mention above, I hope that the work does not stop here. Thank you for taking the time to read and think about my work, and I look forward to seeing where these narratives go next.

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Appendix

The following writing, much like the preface, was researched and written for the initial proposal of this thesis project. I chose to include it within an appendix to the final product as a source of additional information on electric vehicles more generally for the benefit of future researchers and readers interested in gaining a more complete knowledge.

Types of EVs

The label “electric vehicle” has transformed over time into an umbrella term which encompasses battery electric vehicles, electric hybrid vehicles (HEVs and PHEVs), fueled electric vehicles (fuel cell), electric vehicles using supply lines, and solar powered vehicles (Larminie & Lowry, 2003). The electric vehicle classification can also be applied to multiple types of air, rail, and watercraft, however for the purpose of simplicity the appearance of "electric vehicle" or "EV" in this review will be applied only to road vehicles.

Battery powered electric vehicles have been written about the most. To be named under this classification, the vehicle must contain an electric battery, an electric motor, and a controller that allows for power distribution in order to move the vehicle either forward or backward. These vehicles have a main charging point that a charging cable will plug into in order to receive power from an external source. Battery powered EVs are the environmental purist's idea of an electric car and have been criticized by consumers often over the fear that the vehicle would not be able to hold up under the demand of a daily driving schedule. This concern is often addressed in EV literature and has been for some time. Even in 1977, author Ernest Wakefield wrote: "Not fully appreciated at present is the fact that the best battery-equipped electric vehicles are already adequate for many urban tasks." (Wakefield, 1977).

More popular in the consumer market in modern times are hybrid electric vehicles (HEVs). Hybrids are distinct from battery EVs in that they are powered by a conventional fuel source like gasoline and diesel in addition to power stored in an onboard electric battery (Pistoia, 2010). Standard hybrid electric vehicles are fueled like any other car equipped with an internal combustion engine, but they are never plugged in to charge their electric battery. They are instead charged through the storing of energy that is usually lost in braking by utilizing the generation power of the electric motor. Some newer hybrid electric vehicles have been engineered to be able to charge their batteries by plugging them into external power much like battery powered EVs, the distinction here being that these plug-in hybrids are still hybrids and contain internal combustion engines. Unlike normal hybrids, plug-ins allow for operation only using electric power when charged, once that charge is spent the internal combustion engine will take over control of the drive train, and the vehicle will run in the same way that a standard hybrid electric vehicle would (Development, 2017).

Fueled electric vehicles, also known as fuel cell vehicles, operate the same way as battery electric vehicles but by using fuel cells rather than batteries, which convert chemical energy from hydrogen into electricity to power the drive train (Hoyer, 2008). Fuel cell vehicles boast zero emissions and their fuel can ensure a range of driving comparable to that of a modern conventional car (Larminie & Lowry, 2003). While many automakers have tried their hand at developing a fuel cell model vehicle, very few remain on the road today. Public perception of hydrogen has remained mostly negative due to the popularity of extracting it via a process called "natural gas steam reforming," which recycles discharged methane by using a catalyst to create hydrogen and carbon dioxide (Spath & Mann, 2001). This method has garnered disapproval from environmental advocacy groups, for its unintended release of greenhouse gasses. The U.S. Department of Energy claims that the release of greenhouse gasses from the natural gas steam reforming process, which is necessary to create hydrogen fuel for fuel cells, will result in a reduction of greenhouse gas emissions (USDOE, 2017).

Literature concerning EVs that use supply lines is not nearly as extensive as that of the 3 types written about above. Supply line EVs use storage devices such as flywheels (mechanical spinning device which gains and distributes energy from braking) and super capacitors (chemical energy storage devices). They use energy efficiently but run into trouble storing that energy for long periods of time and require the supplementation of another fuel source making them essentially a modified hybrid vehicle. The cost of manufacturing and the potential maintenance issues that could arise from mass marketing of these types of EVs have lead automakers to steer away from supply lines, only to develop the occasional concept vehicle (Larminie & Lowry, 2003).

Finally, solar powered vehicles, while covered moderately by EV authors, have been mainly employed as racing vehicles and novelty items due to their impracticality. Although the technology of solar photovoltaic cells has been improving over recent years, fully solar vehicles suffer from several limitations including energy storage for driving at night and operating in intermittent and variable weather conditions (Rizzo, Arsie, & Sorrentino, 2010). While fully solar vehicles are not single-handedly changing the market for EVs, solar power has been noted for its contribution to the EV industry in powering charging stations and supplementing hybrids (Bhatti, Salam, Aziz, & Yee, 2016).

EV Incentives U.S. and Abroad

Authors who study electric vehicles and environmental consequences of transportation are generally in agreement that advocates of electric vehicles and a greater transportation overhaul, or switch to electric driven motor vehicles, claim that such a transition would be “mutually beneficial to transportation and electric power systems” (Sovacool & Hirsh, 2009). By mutually beneficial, these authors imply economic benefits.

In order for these benefits to be activated, electric cars must be purchased by consumers. For electric cars to be purchased, they must be desirable. To make even the most unattractive cars enticing to every day drivers in the United States, unattractive in the sense of low range, low capability, or aesthetics value, the different levels of government have pushed forward incentives for purchasing electric vehicles that are usually written in such a way that reminds the beneficiary that electric cars are a better choice for the environment. Authors Jenn, Azevedo, and Ferreira state that this federal and state promotion has been progressively increasing over the past decade, and that such promotion can usually be traced back to the Energy Policy Act of 2005 (Jenn, Azevedo, & Ferreira, 2013).

The Energy Policy Act of 2005 states in Sec. 1341 that it “allows a tax credit for investment in alternative motor vehicles technology, including qualified fuel cell, advanced lean burn technology, hybrid, and alternative fuel motor vehicles.” Some such incentives are federal tax credits. In the United States, electric motor vehicles and plug in hybrids that have been purchased in the year 2010 or later make their owner eligible for up to $7,500 in federal income tax credit based on the capacity of their battery. Incentives for EVs in the U.S. also exist at state and local levels, and vary drastically from location to location due to geographic challenges and population dynamics. On the state level, incentives may include voucher programs, such as the Alternative Fuel Vehicle (AFV) Voucher Program in Maryland that provides monetary rewards for the purchase of electric and alternative fuel vehicles, or traveling perks such as the High Occupancy Vehicle (HOV) Lane Exemption and Discount in New Jersey. In addition local incentives can also include Vehicle Purchase and Infrastructure Development Incentives, as well as parking incentives (Energy, 2017).

In Europe, electric vehicle promotional efforts have surged far beyond what the U.S. has done thus far, and has been developing since the mid 1990's according to Paul Hockenos of Yale Environmental 360 and The Guardian. Scandinavian nations have long been pioneers of EV adoption, and their numbers speak for themselves. Norway, the undisputed leader, boasts 100,000 electric vehicles with a population of just 5.2 million people (elbilforenig, 2017). Throughout Europe incentives for EVs include tax credits and exemptions in a similar fashion to the U.S., and in some regions consumers are eligible for bonus premiums for buying electric (EAMA, 2017).

With electric vehicles on the road, the next logical step is to integrate the utilities from which they get their power in a system that allows for the most efficient method of energy use possible. In the field, such integration is called vehicle-to-grid or V2G. The literature heavily favors PHEVs when discussing V2G integration, and states that vehicles need to meet 3 criteria to be considered eligible for a V2G configuration (Tomic & Kempton, 2007). Those criteria are " A power connection to the electricity grid, a control and/or communication device that allows the grid operators to access to the battery, and precision metering on board the vehicle to track energy flows" (Sovacool & Hirsh, 2009). Should this system be working in its full potential, utilities would have the opportunity to better manage electricity resources, and EV owners would have the opportunity to sell unused energy back to the utility for profit.

Barriers to Use & Modern Disapproval of EVs

Capability and Range Anxiety

Throughout their history, electric vehicles have always delivered with them a fear that they would not be able to stand up to the tasks and daily demands of a driver. Those demands include high speeds and long distances. The still prevalent and common fear that an electric vehicle could drain its battery fully miles away from home or a charging station has been dubbed "Range Anxiety" by professionals in the transportation field (Neubauer & Wood, 2014). This barrier to use technically only affects EVs in the battery powered classification, as hybrids (including plug-in hybrids) are readily fueled by gasoline. While range anxiety could apply to fuel cell electric vehicles, since a similar lack of hydrogen fueling stations exists, there are too few of these vehicles operational in personal or commercial use to find or come up with an accurate assessment at this time.

Researchers in several fields including sociology and psychology have looked into just about every aspect of range anxiety in hopes of cracking the case. One such study completed by Thomas Franke and Josef Krems in 2013, who have completed many studies on the topic with several research teams, found that for people who had initial hesitation when asked about their comfort with driving an electric car often cited "familiar combustion car range" when identifying how far they would feel comfortable knowing their EV could travel. That is about 400 miles with a full tank of standard gasoline. The group found that range preferences decreased significantly in those who had EV driving experience, and that experienced EV drivers cited average ranges for current model EVs when asked about what they felt would be a comfortable range for their EV to drive for them (Franke & Krems, 2013).

Dirty Batteries

The issue of 'dirty batteries,' the second barrier to use and/or adoption of electric vehicles is one that only appeared in recent years. As was outlined in the history section, the original electric vehicles ran on lead-acid batteries until recently when cars switched to lithium-ion based batteries a technology outlined by Whittingham and developed further for use in small electronics by developers in Asia. Lithium is highly conductive, highly flammable, and also highly reactive. In a partnered report led by the Environmental Protection Agency, the agency identified solvents used un the production of lithium-ion batteries for the use in automobiles to be a possible cause of cancer and neurological disorders (Amarakoon, Smith, & Segal, 2013). While efforts are being made by many small and some mid scale recycling plants specializing in taking apart EV batteries when their life cycle is up, more concern is found at the beginning of the process of building a battery. The construction of lithium ion batteries requires the mining of cobalt, which is often done in junction with copper mining. An issue that comes along with mining that is difficult to argue against is one that is much more human. Mining for these substances often time takes place in extremely impoverished places by people with little training or protective gear. One such example is outlined by the Washington post that details the hand-dug mines in Congo in which people search for low-cost cobalt to sell (Frankel, 2016).

Electricity Usage

Another barrier to electric vehicle adoption is one of the most common arguments posed by opponents of electric cars. That argument is that since most charging of personal electric vehicles will be done in one's home connected to the local power grid, should that power grid be in a location where fossil fuel burning is the main source of generating electricity, won't those electric vehicles be powered by fossil fuels? Furthermore, if a major influx in the use of electric vehicles was to happen, and more people were using more energy than usual to charge them, wouldn't the emissions created by the increased fossil fuel based electricity have a terrible effect on the environment? This idea has been called the "invisible tailpipe" of electric vehicles implying that while the car itself does not produce emissions, there are still emissions being produced elsewhere as if the vehicle were a conventional ICE car. While there are very few studies that have written at length on this topic, it has been discussed in hundreds of popular media and news sources. One study that does give this argument both validity and hopes that this barrier can be overcome by responsible charging methods, as well as a gradual transition to more renewable energy sources, was completed by the Union of Concerned Scientists in June of 2012.

> The U.S. electric vehicle fleet will only be as clean and sustainable as the power grid it ultimately plugs into . . . Because different regions of the United States receive their electricity from different mixes of power plant types, how good (beneficial to the environment and better than driving a combustion engine vehicle) depends on where the vehicle is charged. The use of coal-generated electricity releases significant amounts of global warming emissions, similar to those from an average gasoline vehicle (UCS, 2012).

Cost

The fourth and final barrier to EV adoption is cost. Not only do the vehicles themselves cost a lot to consumers due to the high manufacturing costs and low numbers of production, but as of today, there is obviously insufficient charging infrastructure for large scale adoption of EVs. This infrastructure issue is not one that those who drive combustion vehicles would want to pay for in taxes right now, and it is one that EV drivers can afford on their own in taxes given their comparative minority size to conventional drivers. Initiative in the charging infrastructure front from politicians is also lacking due to most sensible decision-makers' preference to support projects that will be completed and pay dividends while they are still holding their office. A report on electric vehicle barriers completed at Harvard University points out the interconnectedness of these barriers and notes that consumers needs and wants from a new vehicle are found more easily in cheaper ICE vehicles, rather than in costly EV. It makes perfectly good economic sense for someone to purchase a vehicle that they know will work for a cheaper price for a vehicle that they feel uncertain about (range, speed, durability). The Harvard study goes on to call for a role of the federal government to help lower the costs of vehicles by supporting research and development like it did in the late 60's and early 70's in order to "improve their performance and reduce their costs" as reduced costs would be an incentive for purchase (Pradhan & Patil)

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