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Disruption in the Automotive Industry

An analysis of the competitive forces that followed Tesla

Master's Thesis

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Abstract

In the 2000s the established industry had already tried electric vehicles. They found that the EVS were difficult to produce and sell, and ultimately would end up undermining their own business model. However, as climate change moved into the centre of social and political awareness, regulation was passed to enable electric vehicles to come to the fore. Over the last decade Elon Musk's Tesla has proven that there is both feasible technology and a considerable demand for BEVs. The macro-economic developments in Asia, have shifted the global market and production centres, and due to China's new legislation the automotive industry has to accept that the internal combustion engine is a thing of the past.

In this thesis we cover the disruption of EVs, in order to assess the research statement to which extent is the established automotive industry challenged by Tesla and the disruptiveness of electric cars. We examine the impact on the established industry, who had failed to market electric vehicles due to Clayton Christensen's innovator's dilemma. The thesis examines the global automotive industry at its current state, with particular focus on EV penetration and mainstream adoption. By building a combined framework of Michael Porter's Five Forces and the PEST analysis tool, the thesis examines the nine forces that shape the competitive environment of today's automotive industry, and what is to come.

Nomenclature

EV (Electric Vehicle) Generic term for vehicle powered partially or completely by electricity.			**Conventional Vehicles** Vehicles dependent on fuel to power motor (or charge battery)	
FCEV	**BEV**	**PHEV**	**HEV**	**ICEV**
Fuel-Cell Electric Vehicle	Battery Electric Vehicle	Plug-In Hybrid Electric Vehicle	Hybrid ICEV+EV	Internal Combustion Engine

Autonomous Driving:

In 2014, SAE (the American Society of Automobile Engineers) issued *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*, known as standard J3016, last update in July 2018. The taxonomy provides detailed definitions for six levels of driving, ranging from no to full automation (level 0-5). The key distinction is between level 2 and 3, where the system performs the entire driving task:

Human driver monitors the driving environment	
0	**No Automation**, the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems
1	**Driver Assistance**, the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task
2	**Partial Automation**, the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.
Automated driving system monitors the driving environment	
3	**Conditional Automation**, the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene
4	**High Automation**, the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene
5	**Full Automation**, the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver

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Chapter 1: Introduction

1.1 Motivation

When I first drove a Tesla S P85D in December 2015, I knew that car had the potential to disrupt the automotive industry. With its fully independent SAE 3 autopilot, sleek design, over-the-air updates, 400 km range, and noiseless acceleration from 0-100 km per hour in less than 4 seconds, it defied all prejudice and bias towards electric vehicles. It proved to me that this EV was ready to challenge the traditional industry head-on at full tilt. Consequently, the subject of my master's thesis is disruption in the automotive industry.

The automotive industry is a highly concentrated, labour and capital intensive industry with high global impact on multiple levels. Developments on the market structure are intimately tied to political, economic, socio-cultural and technological factors. New consumer demands for safer and greener cars (OECD, 2016) require deep transformations for automakers and suppliers alike, as well as for countries relying on foreign direct investment as the industrial development driver. Today's main enabler is digital transformation, which has opened up the industry to new actors. Whereas the industry stands to gain USD 0.7 trillion in 2016-2025 due to digitalization, the World Economic Forum (2016) estimates that the accumulated value created for society by autonomous driving and electrification of automobiles is likely to be higher than USD 3.1 trillion. This is the result of reduced total costs, fewer crash costs, lower insurance premiums, fewer road casualties and lower CO_2 emissions, in an industry that accounts for nearly 20% of global emissions. In August 2017, The Economist announced the death of the internal combustion engine on its front page. BCG (2018) welcomes this tipping point, writing that the dawning age of electricity is finally in sight, as the world transitions from an ICE-dominated market. PWC (2018) sees that the future of automotives is electrified, autonomous, shared, connected and yearly updated. From these statements, it looks like Tesla with all its advanced features is well poised to take over the entire industry from some of the world's biggest companies. However, looks can be deceiving. Is Tesla actually capable of sustaining its competitive advantages, is it big enough to make a difference against the giants it tries to topple - or is Elon Musk chasing windmills?

1.2 Current Outlook

In July 2018, Tesla reached a production capacity of 7,000 vehicles per week. Proudly thanking his employees in an internal email for this milestone achievement, founder and CEO Elon Musk wrote: " I think we've just become a real car company." (BBC, 2018) A wry retort aimed at the many critics, who have tried to humble the electric cars as a fad, and sowed disbelief in the company's ability to survive and thrive. Publicly, on the 1st of July 2018 at 10:26, Musk tweeted "7000 cars, 7 days ♥ Tesla Team ♥" to which, just 14 minutes later, Group Vice President of Ford EMEA Steven Armstrong replied: "7000 cars, circa 4 hours. ♥ Ford Team ♥". In many ways, this exchange highlights the current situation in the automotive industry, begging the question: are we about to witness a changing of the guards?

Tesla was founded exactly 100 years after Ford in 2003. In April 2017, just seven years after its initial public offering - as the first American car producer to go public since Ford in 1956 - Tesla's market valuation of USD 48.6 billion surpassed Ford's USD 45 billion value (Guardian, 2017). As a manifestation of the perceptions of value, market capitalizations are interesting. When comparing Ford's production in 2017 of 6.6 mio. vehicles, to Tesla's paltry 76,000 vehicles, in 2017, the valuation goes to show investors' extremely high level of trust in Musk and his mission, and not in the current capacity of the company.

The company is based in Silicon Valley, California, and follows Musk's so-called "secret master plan" to convince the mass market of the prowess of electric cars. Tesla's mission is "to accelerate the world's transition to sustainable energy", and as such, the company does not consider itself a mere car producer. In order to reduce dependency on the current electrical grid, it produces photovoltaic roof tiles and large batteries installed in homes and workplaces, all to accomplish the transition outlined in its mission.

Yet, last fifteen years down the road to here has not been easy for Tesla - or Elon Musk whose public persona has resulted in unwanted attention for the company thanks to a plethora of tweets and interviews with off-hand remarks. The much anticipated "Tesla for masses" Model 3 with a record of 500,000 pre-orders, was released in July 2017, but production has been notoriously delayed multiple times to the frustration of both buyers and investors (Bloomberg, July 2018). Tesla originally targeted 20,000 units a month by December 2017, which Elon warned was a brutally ambitious target (ibid), foreseeing the months of "production hell" that ended a year after the launch as reflected in the tweet above. Inside-EVs (2018) estimates that Tesla delivered 17,800 Model 3's in August 2018, thus stealing the previous best-selling EV in a month record from the Model S, resulting in a year-to-date sale of 55,882 cars. Nevertheless, Tesla is by no means in the clear yet.

By July 2018, the company had produced a total of 200,000 vehicles in an industry where the global output in 2017 was 73 million vehicles (OICA, see Chapter 4). The twelve biggest automakers produced 92% of that (ibid). There are currently 1.1 billion registered vehicles on the planet, but EVs account for just 4 million (See Chapter 4). Penetration is in other words, still low, but EV sales are at an all-time high and growing due to the changing market structure, which is the core subject of this thesis. However, IEA (2018) estimates that 125 million EVs will be on the market in 2030, and after years of inertia, the traditional automakers are now keen on conquering their market shares in this segment as well.

Regardless of Tesla's small footprint and recent problems, it has already had a considerable impact. Namely, that the traditional automakers have had their business disrupted, and only just recently have they begun the turn around due to organizational disbelief. In an interview, vice-chairman of GM Bob Lutz, told the New Yorker (2009): "All the geniuses here at General Motors kept saying lithium-ion technology is ten years away, and Toyota agrees with us—and, boom, along comes Tesla. So I said, 'How come some teeny little California start-up run by guys who know nothing about the car business can do this, and we can't?' That was the crowbar that helped break up the logjam." BMW's top management allegedly skipped the Paris Motor Show in 2016, the biggest industry gathering of the year, to discuss how to handle the threat of Tesla and revise the general strategy towards electrification (Reuters, 2016). According to Mark Matousek at Business Insider (February 2018), Tesla has the honor of changing the narrative in the auto industry and has influenced what kinds of cars its competitors make and how they look. The traditional automakers would eventually have figured out how to build self-driving technology, but Tesla accelerated those efforts, and now "The 10 most high-tech sedans you can buy" feature the same technologies Tesla introduced with the Model S (Matousek, April 2018). Volkswagen Group CEO Mattias Müller announced in September 2017, "The ideological trench warfare must cease … Our mission is to enable sustainable and affordable mass mobility. That is why – for the time being – we are working on the entire powertrain spectrum: from conventional to fully-electric. We are not being arbitrary. We are listening to the voice of reason." So how did Tesla manage to transform the age-old industry, how far has it come, and will it subsist?

1.3 Research Statement

The purpose of this thesis is to analyse the competitive environment in the automotive industry. Specifically, how the re-introduction of EVs has disrupted it, and how this has so-far affected the traditional ICEV automakers. With an innovative high-range battery Tesla demonstrated that EVs are competitive.

Tesla's market capitalization places the company in the global top 10, but its industrial output of vehicles is insignificant - especially in comparison with the three biggest carmakers; Toyota Motors Corporation, the Renault-Nissan-Mitsubishi Alliance, and Volkswagen Group. With the Tesla S currently thriving in the luxury segment against top-brands like BMW, Audi, Porsche, Lexus, Jaguar and Mercedes, and the Tesla 3 poised to go for the mainstream market, Tesla's primary challenge is to ramp up production and deliver - a problem the established industry with it gargantuan industrial capacity, does not have.

The traditional automakers, on the other hand, appear to have lost the lead in the category of EVs. ICE will not disappear, but its prominent position in the global fleet will be displaced over the coming decades. Therefore, the problem statement is:

> **To which extent is the established automotive industry challenged by Tesla and the disruptiveness of electric cars?**

By dissecting this question, some elements that need examination: What constitutes the established automotive industry, i.e. who are the traditional automakers? What constitutes a challenge in this sphere? What is meant by disruptiveness, and what kept the traditional automakers from producing EVs? In order to address them systematically, the thesis is structured in seven chapters, that use relevant theory and data to examine:

RQ 1: *What enabled Tesla to become a world leader?*
RQ 2: *What shapes the competitive environment in the automotive industry?*
RQ 3: *What is disruption, and what kept the established automakers from producing EVs?*
RQ 4: *What will enable and facilitate EVs in taking the mainstream market?*

The structure of the thesis gradually builds an understanding of the matter at hand, while addressing the research questions going forward. RQ1, RQ2, RQ3 and RQ4 will be answered partially via the Literature Review in Chapter 3. RQ2 and RQ4 are more complex and will be answered in part by the Literature Review, in part by the data collected in Chapter 4 and the analysis in Chapter 5. The analysis is built on a framework based on the covered theory, to examine the macro-environmental influence on the market forces and resultant structure. The discussion will evaluate the automotive industry as of 2018, and address the research questions with regards to the research statement. Finally, the thesis ends with a conclusion and a suggestion for future research.

1.4 Methodological Approach and Epistemology

Being a Master's Thesis written for the Cand. Merc Strategic Market Creation concentration at Copenhagen Business School, the research is conducted within the tradition of social sciences. Bryman (2012) writes that social research is necessary "because there is an aspect of our understanding of what goes on in society that is to some extent unresolved." What is "going on" here, is the impact of disruptiveness of EVs in the established automotive industry and society at large, and the purpose is to understand what is at stake, in addition to how and what may happen going forward.

Epistemology is the question of what is regarded as knowledge. As a consequence thereof certain standards arise with regards to methods, scope, and validity, so that a belief can be discerned from opinion - the latter is informed from evidence, whereas the first is felt. In other words, epistemology, is the relation between what is known and the knower, and here arise two schools of thought: empiricists and positivists. According to Chalmer (1978), both schools adhere to the foundational scientific approach, namely, that knowledge should be derived from observed facts. The distinction arises in empiricists maintaining that all knowledge should be derived from the mind by way of perception, while positivists have a more broadly oriented view of what constitutes a fact than just what is sensed. Positivists rely on logic and reason to interpret data. From this Chalmer (1978) distinguishes two methods in research, the deductive and inductive methods, with little regard for the latter.

Departing in laws and theories, the deductive approach gains its explanatory power in its ability to predict and explain. The inductive approach begins with observations to derive causal laws and theory. Bryman (2012) concurs, elaborating further that "just as deduction entails an element of induction, the inductive process is likely to entail a modicum of deduction." As such, deduction works its way from the general to the specific, why some refer to it as top-down. Following this method, research begins in the existing literature, and then a hypothesis, on the basis of theory, is designed to be tested via observations that yield data. Induction works in the opposite direction. It moves from the specific data and observations to generate broad conclusions, which are turned into hypotheses and tested.

Both methods are adequate writes Chalmer (1978), as long as they conform to criteria of objectiveness - and here inductionists are to be doubted as their understanding is limited by their observatory capabilities. Unlike trained doctors, laymen cannot make sense of an x-ray photo, why “attractive as it may have appeared, we have seen that the inductivist position is at best, in need of severe qualification, and at worst, thoroughly inadequate.” (Ibid) The research in this thesis rests mainly on deduction with a positivist reliance on quantitative data. Allowing insights from empirical data to weigh as much as theory, the purpose is to show how the world is predicted in theory.

1.5 Source classifications

Since the area of study for this thesis is relatively new, ongoing and constantly developing, a variety of sources of different quality are used to ensure all perspectives are covered. These are structured into three broad categories: scientific publications, expert reports, and media.

Category	**1**	**2**	**3**
Description	Scientific Source	Expert Report	Media
Scientific level	High	Medium	Low
Reliability	Medium	High	Low

Table 1: Source Classification

The automotive industry has been studied intensely for many years, and so has the impact of innovation in business. Current developments are covered by academia, professional consultancies, investors, and on blogs by professional and hobby experts - and by PR agencies, critics in media and observers, and in press releases by the companies.

A key number of sources for data are annual reports. These fall between category two and three, in the sense that the company publishes them and therefore serve in some sense as PR. However, they have been validated and checked by external auditors, which gives them a relatively high level of reliability. Lastly, because of the nature of business studies, a lot of sources with crucial information such as current price levels and product features must be found via non-scientific publications.

1.6 Delimitation

The automotive industry is vast. To grasp a manageable portion of it, we focus on the top twelve automakers. By selecting the biggest automakers in the past ten years, we gain an insight in the recovery from the financial crisis in 2008, and how it allowed a small outsider like Tesla to gain a foothold. As seen in the later examination of data, China has emerged as the leading car producer, the biggest market, and home of large automakers. Yet gaining access to information about this region is relatively difficult compared to acquiring information from the western hemisphere. The three main regions of study are defined as the United States, European Union and China.

A key distinction has to be made. By car we mean a four-wheeled motor vehicle capable of driving on the highway comprising one to eight passenger seats in addition to the driver - this is the M1 definition under EU regulation 2007/46/EC. Compared to American classifications, in which there is no particular logic which gives rise to many “cross-overs”, this is a relatively open definition, more or less excluding busses and motorbikes. Going through various data sets and annual reports, we use this definition to cover other definitions. For instance in America, pickups are defined as trucks and fall in the commercial vehicle category alongside small-busses because of their weight. In Asian countries, light vehicles are in high demand that would never be marketed in the western countries. These include motorbikes with three or four wheels and a cabin, which makes them look like regular cars, however without the speed to go on a highway. Similarly, we disregard off-road vehicles, duty vehicles etc.

Autonomous driving is a key innovation that will have an even larger impact on the EV. It will be taken into account because it is highly relevant for the analysis of the research statement, but will only be examined lightly as recent developments towards SAE levels 4-5 (see nomenclature) are primarily carried out by actors outside the automotive industry and have yet to fully materialize in the market. Similarly, the analysis of suppliers is given less attention, though the impact of electrification on their business surely merits its own study.

The “established automotive industry” we define as the global top original equipment manufacturers (OEMs). The selection criteria will be further explained in Chapter 2 and 4.

Chapter 2: Electric vehicles on the market

In order to give some context before we progress into the literature review, we begin with a cursory overview of EVs on the market. EVs are discerned from traditional vehicles by the ability to drive with an electric motor, and charge by plugging-in to the electrical grid. As such hybrids without a plug, are not considered EVs despite having an electric powertrain.

With 218,563 units sold by H1 2018, Tesla Model S is the second most common EV on the market (Table 2). An impressive feat, given that Renault, Nissan, Mitsubishi, Toyota, Chevrolet, and BMW are all global brands with long pedigrees, considerable organisational resources, not to mention a combined yearly output of 21 million vehicles. With 500,000 pre-ordered Tesla Model 3, and production numbers at 5,000 a week, and growing, it will only be a question of months before it overtakes the models below one-by-one, ultimately running past the Nissan Leaf as number one. This development is a landslide transformation of the EV landscape.

Top 9 EVs Accumulated sales

	Nissan Leaf	Tesla Model S	Chevrolet Volt PHEV	Mitsubishi Outlander PHEV	Toyota Prius PHEV	BYD Qin PHEV	BMW i3	BAIC EC-Series	Renault Zoe
2010	0	0	1,500	0	0	0	0	0	0
2011	22,094	0	24,000	0	0	0	0	0	0
2012	48,190	2,500	33,490	0	25,640	0	0	0	200
2013	96,340	25,670	58,420	18,590	44,950	0	1,700	0	8,050
2014	154,970	55,130	78,960	51,670	64,080	14,750	16,500	0	18,310
2015	195,170	100,440	95,880	91,450	66,470	46,650	38,580	0	35,830
2016	238,980	148,600	124,100	113,330	66,890	68,520	58,620	4,130	54,810
2017	282,530	193,660	148,820	135,170	95,820	89,260	83,870	82,210	80,760
2018 H1	331,949	218,563	164,960	155,133	124,016	116,293	102,207	122,616	100,491

Table 2: Based on numbers from ZSW from 2013-2017; 2010-2011, 2018 H1 from annual reports; and 2018 Global Top 20 - July 2018 EV-Sales

On the next page, we will take a closer look at the models. All the specifications are from the latest version of the vehicle, as described in EV-Sales large database. The BYD Qin PHEV and the BAIC EC-Series are only available on the Chinese market. The Qin is a 4-door compact sedan from 2014, ICE enabled with a 13 kWh battery and 70 km electrical range. Re-released as BEV in 2018, with 150 km/h top speed, 58 kWh battery and 420 km range. The EC from 2016, has a 120 km/h top speed, 22 kWh battery, 162 km range.

Renault-Nissan-Mitsubishi Alliance

The *Nissan Leaf,* a BEV from December 2010, is compact five-door car priced at USD 30,000. Its top speed is 140 km/h, all-electric with a 40 kWh battery and 242 km range in the newest 2018-version.

The *Mitsubishi Outlander PHEV* from 2013, is an SUV in the USD 35,000 range. Its top speed is 120 km/h, enabled by ICE, with a 12 kWh battery that gives a 35 km range.

The *Renault Zoe* is five-door supermini from December 2012. Only available in the EU, sells in the USD 30,000 range. It boasts a top speed of 135 km/h, holds a 41 kWh battery and a range of 277 km.

Tesla *Model S* launched in 2012, a luxury sedan now priced at USD 135,000. Going 0-100 km/h in just 2.28 seconds with a top speed of 250 km/h, with a 100 kWh battery and 504 km range.

GM's *Chevrolet Volt PHEV,* released December 2010 with a USD 35,000 price tag. 161 km/h top speed, enabled by ICE, with an 18.4 kWh battery that gives 85 km in range.

Toyota *Prius PHEV* released in 1997 in the USD 35,000 price range. Barely an EV, with 8.8 kWh giving a 40 km range.

BMW *i3* is a compact hatchback released in 2013 priced at USD 50,000. 160 km/h top speed, 33 kWh Battery and 180 km range.

Following this quick glance into the products offered by the automotive industry, we now examine the companies in order to ascertain what constitutes the traditional automakers. These twelve companies control 50 brands and 92.93% of global output (see Chapter 4).

2.1 The traditional automakers

In this subsection, we identify the traditional automakers. By using market capitalization as the first selection criterion, we find Tesla is in the top ten.

	Market Cap USD in Thousands	Revenue USD in Thousands
Toyota Motor Corp	174,050,214	265,761,872
Volkswagen AG	78,588,320	271,732,760
Renault-Nissan-Mitsubishi	70,214,226	196,089,899
Daimler AG	67,522,090	191,809,513
BMW AG	60,953,124	112,975,927
Honda Motor Co Ltd	50,536,321	140,263,331
General Motors Co	47,843,223	144,197,000
Tesla Inc	44,906,939	13,683,906
Ford Motor Co	36,947,685	158,656,000
Hyundai-Kia	33,733,034	130,694,844
Fiat Chrysler Automobiles NV	32,749,286	129,445,284
Suzuki Motor Corp	28,341,594	34,683,937
Peugeot SA	23,847,625	88,676,590

Table 3: Market Cap and Revenue as of September 10, 2018 from Gurufocus.com

Market capitalization, the total value of a company's outstanding shares, is found relatively easy with data from Nasdaq. It reflects investors expectations in future earnings, and thus taking the highest valued company serves as a proxy for leading actors. By examining the annual and quarterly reports, we find the production output, which we will return to examine in Chapter 4. Because Renault owns the controlling stake in the Renault-Nissan-Mitsubishi Alliance and therefore has the control over the two companies, we add them together to reflect that they are controlled by one board. Fiat similarly represents Fiat Chrysler Automobiles, and the same goes for the Hyundai-Kia Alliance.

Looking at the twelve companies, we find seven in the top ten by all criteria. Interestingly, we see a divide between luxury and high volume, low price manufacturers, when respectively Daimler and BMW, and Suzuki and Peugeot vie for top ten in revenue and production. Tesla's output is minuscule, but in terms of revenue and market cap, it is a global leader.

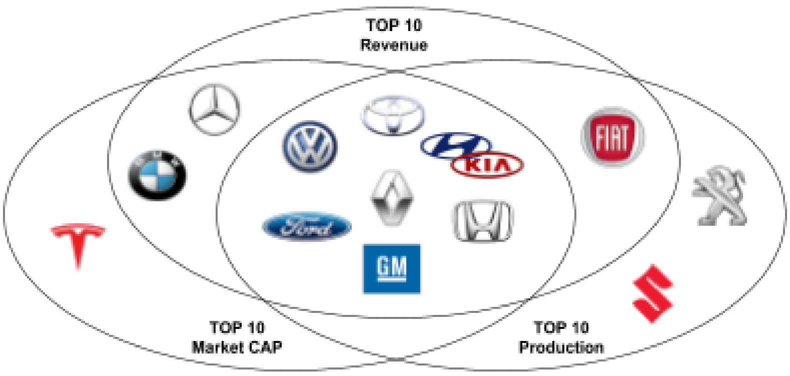

Figure 1: Tesla and the 12 traditional automakers

Chapter 3: Literature Review

3.1 Chapter Overview

In this chapter, I present the key literature that shapes the theoretical framework for this thesis. Having established in chapter 2, what constitutes the traditional automakers, we now turn our attention to the theories that will help us tackle the research statement.

The chapter begins by building an understanding of two perspectives within business strategy. Using selected case stories from GM and Tesla to showcase how business resources are put to use, we will understand from a theoretical point of view what shapes the competitive environment in the automotive industry. Afterwards, we examine the central theme of innovation in order to discuss fundamental theory on disruption and adoption, in order to comprehend what kept the established automakers from producing EVs.

There is one caveat before we go into the review. The unit of analysis is the fundamental problem with the definitions and models in this vein academia. The models presuppose that industries, consumers and technologies follow identical patterns, and consequently, the same conclusions may be drawn from varying levels of analysis – be it the adoption inside an industry of a given technology, or the diffusion in the market – even though very different forces are at play. The definitions are either very broad or very narrow, resulting in either too vague or too limiting interpretations of data. In most cases however, the insights offered yields explanatory power in the understanding of how things develop.

Figure 2: Theoretical links in literature review

The thesis includes a review of innovation and marketing to place emphasis on its central role in strategy, and its relation to the research statement. Taking off in Peter Drucker’s maxim “Because the purpose of business is to create a customer, the business enterprise has two – and only two – basic functions: marketing and innovation. Marketing and innovation produce results; all the rest are costs.” In this literature review, we explore key theory and the links between innovation, marketing and strategy.

3.2 Business Strategy

The literature on business strategy is considered with regards to the past, present and future of the automotive industry, to address the research statement, and in particular the research questions 1) what resources enabled Tesla to become a world leader, and 2) what shapes the competitive environment in the automotive industry?

Strategy is the core of business academia. According to Jay Barney (1991), one framework has formed the basis on which all research on business strategy since the 1960s has been structured. It is known by all as the SWOT analysis.

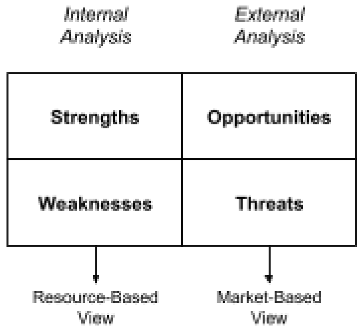

Figure 3: SWOT, RBV & MBV
Inspired by J. Barney's (1991) "Figure One"

SWOT provides the basis for two main schools: an internal analysis of organisational strengths and weaknesses, and external analysis of opportunities and threats in the competitive environment. This "out-side in" perspective can deemed the Market-Based View, and among others, the latter inspired Michael Porter's Five Forces Model (1979); whereas the "in-side out" perspective has led to the Resource-Based View. This part of the literature review examines these two approaches developed in the last fifty years.

3.2.1 The Market-based view

As assistant professor at Harvard, Michael Porter found it difficult to teach using the SWOT framework as it lacked rigour. In 1979, he proposed a framework in the Harvard Business Review article named "How Competitive Forces Shape Strategy" in which he offers a systematic way of thinking about an industry, now known as Porter's Five Forces. In order to analyze the attractiveness of an industry with regards to long-term profitability, one must carefully examine the factors that determine it, and then determine the relative competitive position one may attain within said industry. To Porter, it is not about who is the biggest, but who is the most profitable. The forces are "a reflection of factors over which a firm has little

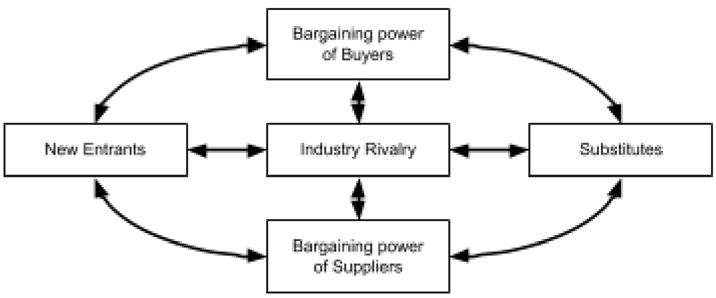

Figure 4: Porter's Five Forces

influence" while "competitive strategy has considerable power to make an industry more or less attractive" which is why it is "challenging and exciting." (Porter, 1985). In other words, the company's activity in the face of the strength of the five forces determines profitability.

Of these forces arising from competition, two are said to be vertical, stemming from the bargaining power of suppliers "behind" the industry, and the bargaining power of buyers in the market. Naturally, buyers are happier to get more and pay less, and likewise, suppliers prefer to deliver less but get paid more. The remaining three threats are horizontal: the threat of new entrants, the threat of rivalry, and the threat of substitutes. Substitutes meet the same basic needs but with a different product, and thus come from a different industry; new entrants, have eyed a way to compete in the profitable market; and intense competition will initially reduce all actors profitability, but may lead to competitors getting squeezed out. Thus every industry "has an underlying structure, or a set of fundamental economic and technical characteristics, that gives rise to these competitive forces … and are of greatest importance in strategy formulation" (Porter, 1979). A strong force lowers profitability, and if the combined forces are too strong, there is no profit at all.

Porter was asked in an interview (Argyres and McGahan, 2002), about adding other forces if he had to revise the model. He acknowledges two nominees for a sixth force, government and complementary goods, but disqualifies both as forces in their own right, because there is no "monotonic relationship" between their strength and profitability. "You can't say that "government is high, industry profitability is low," or "government is low, industry profitability is high." It all depends on exactly what government does. Also, there are many different parts of government, each with its own distinct impacts. And how do you assess the consequence of what government does? Well, you look at how it affects the five forces." In the following subsection, we build a framework for this.

3.2.1.1 Theoretical Framework: The Nine-Forces

In a framework called the Nine Forces, Fleisher and Bensoussan (2008) argue that a combination of the macro-environmental and the industry-specific analysis adds to the overall understanding for strategy formulation. Their framework departs in PEST and is followed by Porter's Five Forces. We have already covered Tesla's unique capabilities and the competitive advantages in the subsection about the resource-based view; with the nine-forces we may understand what shapes the competitive environment in the automotive industry (RQ2), and get an appreciation of whether the traditional automakers will prevail or succumb in a paradigm that favors EVs over ICE.

As such, the analysis in the thesis addresses three levels: the macro-environmental Political, Economic, Social and Technological influence, the industry interplay between buyers, suppliers, competitors, and the internal environment in Tesla. The coordination of strategic resources to capitalize are covered in the previous subchapter.

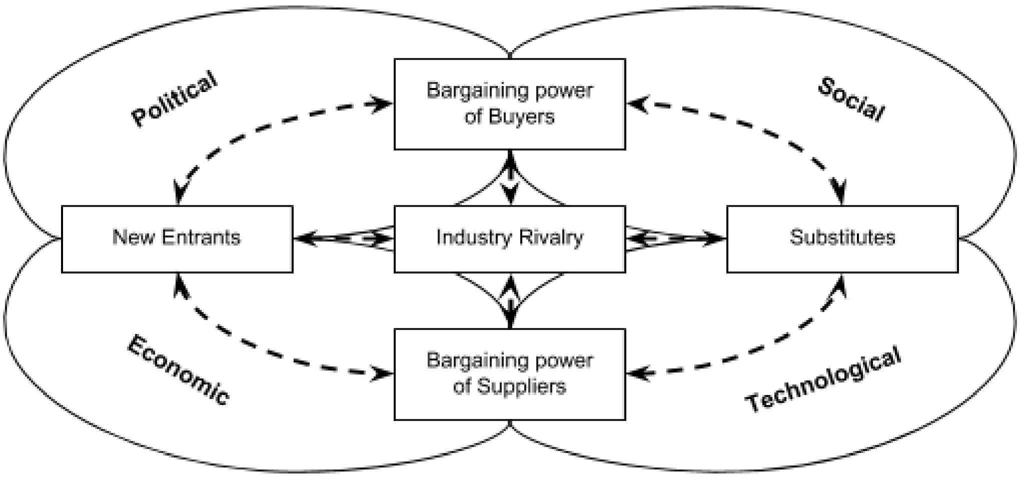

Figure 5: Porter's Five Forces superimposed on PEST

Knowing that the organisations operating within an industry, are significantly influenced by the macro-environment, this consequently has a deep impact on profitability. In order to assess the forces at play, we approach the industry holistically, and thus unite the results of the three perspectives in a powerful framework. Because the forces are interrelated to the extent that a change in one influences all others, the combined analysis allows identification of opportunities that arise as the industry structure or general environment changes.

This nine-force framework is the outline for the analysis Chapter 5 with the distinct purpose of answering RQ 2) What shapes the competitive environment in the automotive industry, and ultimately the research statement, and the research statement.

3.2.2 The Resource-based view

Birger Wernerfelt launched the resource-based view (RBV) in 1984, with the words “For the firm, resources and products are two sides of the same coin. Most products require the services of several resources and most resources can be used in several products.” After Wernerfelt's article, multiple scholars contributed to the approach such as Rumelt (1984), J.

Barney (1984) and Prahalad and Hamel (1990), who all find that success cannot be explained by external factors such as market structures, and must be due to reasons found internally, ie. the resources and their use (Wernerfelt 1984; Barney 1984).

In other words, RBV encourages organizations to look inward and find the source for competitiveness and drive that forward, rather than looking outward to align with market.

The key assumptions in RBV (Barney, 1991) is that organisations rely on tangible and intangible resources, that are heterogeneous and immobile, and hold VRIO attributes, which we'll return to after a brief overview:

- **Tangible assets** are the physical objects owned by a company. Land, buildings, machinery, personnel, capital and equipment, fall in this category. These resources are relatively easy for competitors to attain over time if need be - for instance factories can be acquired - so hinging strategy on these is of little use, as they offer only a small, futile advantage to the company.
- **Intangible assets** are all the objects that offer value but has no physical manifestation. Brands, reputation, heritage, processes, trademarks and intellectual property are not physical resources, take time to develop, and are not readily acquired. These, therefore often constitute the main source of competitiveness.
- **Heterogeneous resources** is the assumption that the combination of tangible and intangible assets mentioned above, in one company is different in another company. In RBV, firms achieve competitiveness by employing different resources differently.
- **Immobile resources** is the assumption that assets are not readily moved from one organisation to the other - at least not in the short run, where for instance both factories and brands can be bought. This immobility makes it difficult for competitors to replicate rivals, and difficult for new entrants to grow.

Automobile production is very capital intensive and requires large investments in assembly plants and equipment - in other words, tangible and immobile resources. These are required to achieve economies of scale, which makes it difficult for small scale companies to enter the industry. According to ILO (2010), a minimum production threshold of 4 million or more units are commonly quoted in the industry as profitable.

In RBV, the success of a given company can be tracked to the combination of resources within the specific company. According to Barney (1991) a competitive advantage may be attained, if the company resources hold the following characteristics: "(a) it must be valuable, in the sense that it exploits opportunities and/or neutralizes threats in a firm's environment, (b) it must be rare among a firm's current and potential competition, (c) it must be perfectly imitable, and (d) there cannot be strategically equivalent substitutes for this resource that are valuable but neither rare or imperfectly imitable." These go under the acronym VRIN - Value, Rarity, Inimitable and Non-substitutable. Companies make a profit by using valuable and rare resources they control, however, in order to sustain that competitive advantage, it must be difficult bordering impossible for competitors to acquire the same.

Because companies hold bundles of resources that are heterogeneous and immobile, the key to attaining a competitive advantage is to make the most of these. Strategy, to Wernerfelt (1984) is striking a balance between the exploitation of existing resources and the development of new ones. According to Teece (1980) the suggested approach is as follows: 1) identify unique resources; 2) decide in which markets those resources are most profitable; and 3) decide whether those assets are most effectively utilized by, a) integrating into related markets and selling directly to customers, b) selling the relevant intermediate output to firms related to that market, or c) selling the assets themselves to a firm in related businesses. This explains why companies focus their resources on a highly specific set of activities, why they benefit from supplying rivals in an industry, and why competitors business units are bought - mergers and acquisitions give control over supplementary and complementary resources, which enables the company's ability to carry out its strategy.

GMs EV-1 story highlights the importance of resource control. The 1997 version could travel 200 miles per charge at 35 cents per mile (Ovonic, 1998), thanks to EV-95 NiMH battery produced on license by Panasonic - a company that followed Teece's strategy of selling batteries as an intermediate good. GM Ovonic was formed via joint venture from 1994, giving GM control over the at the time best technology - in October 1997, a Solectria Sunrise powered by an Ovonics NiMH battery traveled 350 km from Boston to New York on a single charge (Ibid). However, GM also following Teece's approach, identified that the asset was best utilized outside the company and handed off the asset. On the 10th of October 2000, GM sold the division to oil company Texaco, and on the 16th of October, Texaco was acquired by Chevron in a USD 100 billion merger (EV1.org). Thus, the then most promising battery technology, the main component of an EV, was conveniently taken over by the oil industry, who naturally has no interest in its widespread adoption.

It thus seems plausible that the batteries were purposefully held back by the oil industry to hinder development of EVs; on the other, it is plausible, that they were not produced because it was deemed too risky based on the belief that the market base was too small. In an interview, The Economist asked Stanford Ovshinsky, the inventor of the nickel-metal hydride (NiMH) battery, about his perspective: "I think we … made a mistake of having a joint venture with an oil company, frankly speaking. And I think it's not a good idea to go into business with somebody whose strategies would put you out of business, rather than building the business." However, Ovshinsky did not subscribe to the idea that collusion kept the battery off the market; from his point of view, all that was needed was a cash infusion, and firm belief in the viability of the innovation, which he granted was too expensive.

3.2.2.1 Tesla's main assets

In the following, we examine two examples of how Tesla in the early stages, acquired and developed tangible and intangible assets following Barney (1991). We begin with the intangibles, the intellectual property and know-how that helped build the brand.

As an upstart company, Tesla naturally had few resources. Production of the Tesla Roadster began in 2008, and concluded in January 2012 - and the cars were put together in a garage. By December 2011, 2,150 had been sold in the US, while the rest had been shipped off to Europe and Asia (Tesla, Annual report 2011). Tesla did not have regular means of production nor the designs for all parts of a car, so the company sourced 2,500 Lotus gliders, car bodies without a powertrain - these, however, were developed and installed by Tesla. As Jonathan Musk (2016) - not related to Elon Musk - writes "Powered by thousands of laptop derived lithium-ion cells stuffed into the back of the car, the Roadster wasn't exactly what you might call engineered. Instead, it was designed and developed by a bunch of computer nerds, who each had more knowledge of their mum's PC than of motorcars." However dubious it may seem, Tesla managed to create an outstanding machine in that garage. That battery expertise gradually improved, and quickly emerged as the foundation of its key business, as written in the 2011 Annual report, "The electric powertrain we developed for the Tesla Roadster has provided the foundational technology for our Model S, our Model X crossover and our future vehicles, and for electric powertrain components and systems." The powertrain is Tesla's key intangible resource, and the root of its competitive advantage.

The powertrain as an intellectual property holds the VRIN attributes Barney (1991) identified. It is an asset that is difficult for competitors to copy and develop, but it is not unsubstitutable as others may develop similar or other technologies with the same effect: driving a car. Interestingly, Tesla released all their patents in 2014. Following the VRIN framework, Tesla had originally held their innovations in-house "out of concern that the big car companies would copy our technology and then use their massive manufacturing, sales and marketing power to overwhelm Tesla." (Tesla blog, 2014). In other words, the extreme resource heterogeneity between a small company and the traditional automakers frightened Tesla. But it did not happen. Musk continues "We couldn't have been more wrong. The unfortunate reality is the opposite: electric car programs (or programs for any vehicle that doesn't burn hydrocarbons) at the major manufacturers are small to non-existent, constituting an average of far less than 1% of their total vehicle sales." (ibid). In order to understand why this was the case, we need more theory about innovation and disruption, which is the topic of the next subchapter. Back to Tesla, we here see, as posited by Teece (1980) , that the development and use of the powertrain showcases how Tesla identified a unique resource, and how to make the most of it: "Our electric powertrain consists of the following components: our modular battery pack, our power electronics, gearbox, our motor and control and integration software which enables the components to operate as a system. We sell certain of these components to Daimler and intend to sell these systems to Toyota." (2011, Tesla Annual Report) Here we see Tesla following a mixed approach: both selling the core product directly to consumers, and as an intermediate to competitors. This makes sense on two levels: first, to generate credibility and cash for the expansion of the company, and second, it follows the mission statement of Tesla to expedite the transition to sustainable transport, also explains why the patents were released.

The Roadster was meant to be an exclusive, low-volume car designed to garner attraction for a more attainable EV. For Musk to accomplish this feat, Tesla would have to get hold of a factory - an expensive tangible and immobile asset. To raise the capital for this, Musk had to set up strategic partnerships to build additional revenue.

In 2007, Musk invited Daimler executives to demonstrate Tesla's powertrain (Davis, 2010). This resulted in the electric Smart car as well as an investment of $50 million for 10 percent of the company - valuing it at $500 million at the time. The ownership lasted until 2016 (Lambert, 2017). Musk also invited Toyota executives, who were so impressed with the technology, that Toyota invested $50 million in Tesla shortly after the IPO in June 2010 (Davis, 2010). This, in turn, convinced policymakers of Tesla's capability. One year later, Tesla received a loan of USD 465 million from the United States Department of Energy as part of an $8 billion program for breakthrough vehicle technologies (the established automakers absorbed almost all of the rest). This allowed Tesla to buy the NUMMI in 2010 plant from Toyota and the bankrupt GM, for a bargain price of USD 42 million - it was valued at USD 1 billion, and had a 450,000 unit output at the height of production (ibid). This gave Tesla its key tangible asset, the Fremont plant, which moved production out the garage, and would later allow the decisive high-volume output capacity.

So why did Toyota “give-away” the plant to Tesla? It never considered Tesla a potential rival. During the press conference at which it was announced, Reuters asked why Toyota chose to partner with Tesla, to which President Akio Toyoda looked over at Elon Musk and said: “Musk-Chan, I love him.” (Davis, 2010). The companies went on to jointly develop the RAV4 electric vehicle, which initially used the NiHM batteries from GM, but after Chevron acquired the patents, production had been killed. Akio Toyoda was impressed by the Roadster and Tesla’s start-up culture, which he hoped would inspire Toyota after a safety crisis that caused the recall of about 8 million vehicles in 2010 (Davis, 2010). The program ended in 2014, after which Toyota sold a portion of its stake with a healthy profit, because Toyota refocused its strategy to focus on FCEV, which is why Toyota is behind all automakers in EV production (Lambert, 2017). According to Reuters (2017) Toyota sold off its last Tesla shares in 2016.

The partnership with Daimler, the relationship with Toyota, and the US Government loan allowed Tesla to grow. With the Fremont plant, Tesla had acquired the key tangible, immobile asset to produce cars with its key intangible assets. This secured Tesla’s competitive advantage, and these partnerships are to a wide extent the result of Elon Musk’s persona.

3.2.2.2 Dynamic Capabilities and Competitive advantages

A firm’s sustained competitive advantage, according to Teece et al. (1997) depends on its dynamic capabilities. Dynamic capabilities, when combined with sound strategy (Rumelt, 2011), enable the enterprise to position itself for making the right products and targeting the right markets to address the consumer needs and the technological and competitive opportunities of the future. Strong dynamic capabilities are critical to success, especially when an innovating firm needs to pioneer a market or a new product category (Teece, 1980) In short, they determine the speed of which firm-specific resources are aligned and realigned to match requirements and opportunities to generate returns.

Bloomberg (2018) notes, that Elon Musk being the public face of the company has always been central to Tesla’s ability to raise money. This, in the framework of Teece (2012) is an aspect of a company's competitive advantage, because "Unlike ordinary capabilities, certain dynamic capabilities may be based on the skills and knowledge of one or a few executives rather than on organizational routines." Just like Apple had Steve Jobs, and Richard Branson is a locomotive in the Virgin Group, Elon Musk is in the centre of gravity for Tesla.

According to Burfield (2018) Musk "deliberately and audaciously cultivated a narrative of himself through years of carefully orchestrated media interviews and public appearances. His mystique grows with every new proclamation." This helps the company in all its interactions, because Musk is an expert in exploiting the attention, "He has become a master at leveraging the media to generate positive attention around each of his companies and pique the interest of investors, customers, and other key stakeholders." (Ibid) Journalist Peter Elkind wrote in Fortune magazine, that part of Tesla success is Musk's communication skills, "Musk took a process that typically plays out behind the scenes and made it public." The tweet mentioned in the beginning of this thesis is an example of this innovative approach, in which Elon takes an "Oz-like role as master orchestrator, sending signals through earnings calls and blog postings while keeping the states in the dark and playing on their fears of losing out. The combination of his strategy, the electric Musk factor, and the lure of 6,500 jobs inspired excited bidding among seven states and staggering leaps of faith." Getting the chance to meet Musk simply is impossible to refuse. Burfield (2018) agrees, writing that it makes everything easier when everyone "believes that you're genuinely trying to make life better for their citizens. Coupled with a track record of delivering success in the face of soul-crushing odds and a cacophony of naysayers renders it an especially powerful tool. That's why the legend Musk is so unmistakably important to his success across all his business ventures." As Burfield concludes, Musk's 'Ironman persona' is no accident, it is a carefully designed business tool.

Others believe in Musk's genius in the original sense of the word. If he succeeds with Tesla, he will be the man responsible for the biggest reduction in CO2 emissions. This is one reason for buyers and employers to flock towards Tesla. Another is Musk's reputation for going against all odds. When he founded SpaceX with the intention of colonizing Mars as a 31-year old software entrepreneur without any aerospace experience, he was mocked; the company now launches more rockets any other entity (Bloomberg, 2018), and the return of and simultaneous landing of two rockets in February 2018 certainly cemented his visionary skills. Similarly, when Musk in a tweet complained about traffic, and moments later came up with an answer for that issue with a tunneling entreprise called the Boring Company, people believed it was a joke. Now autonomous robot excavators, capable of repacking the dispersed earth onsite as bricks for house building (Collins, 2018), prepare to dig tunnels in Los Angeles, Chicago, and Baltimore with the prospect of connecting New York and Washington. The power of Elon Musk's rockstar celebrity builds Tesla's brand by creating a story a lot of people want to take part in.

Towering as he may be, Musk readily recognizes skill and ability in others. Peter Rawlinson, Model S lead engineer, came from Jaguar and Lotus. Manufacturing is led by Gilbert Passin, who used to run the NUMMI factory as a Toyota executive producing cars for GM, distribution is taken care off by George Blankenship, who set up the Apple stores (Liu, 2012). Franz von Holzhausen, produced GM's successful Pontiac Solstice and Saturn Sky, was lead designer of the Model S, and now serves as design chief (Bloomberg, 2018). The dynamic capabilities in Tesla are the synergy innovative teams in the organisation, and Elon Musk is the linchpin that keeps it all together.

3.2.2.3 Summary

Using the resource-based view, we have examined the key assets that enabled Tesla to take a world leading position in the automotive industry. This allows us to answer RQ 1) what enabled Tesla to become a world leader? Following Barney (1991) all companies hold a heterogenous bundle of resources from which their competitiveness stems. The asymmetry in resources between Tesla and traditional automakers, which hold massive tangible and intangible resources, is indisputable. However, Tesla's managed to build the company from scratch to its current position, because of the dynamic capabilities, that are embodied by Elon Musk and gravitate towards him in the shape of capable, loyal followers. From a RBV the tangible, immovable Fremont plant, and intangible resources battery design, brand, patents and other intellectual property, secured Tesla the strategic advantages, that has turned it into a top 10 automaker based on market capitalization.

3.3 Innovation

In the following, we examine how innovation shapes and threaten an industry. An appreciation of key theory is necessary to understand disruption and adoption as concepts. To answer RQ 3) What is disruption, and what kept the established automakers from producing EVs? We first define innovation and disruption and then examine how EVs and Tesla have acted as disruptors in the automotive industry.

Firms innovate to improve performance. Tidd and Bessant (2014) define innovation simply as the process of creating value from ideas. A new process or product gives the originator an advantage in the market, because these innovations reduce costs and-or increase demand, meaning lower price or better quality (Drucker, 1973). Larger sales volumes and increased productivity allows companies to market products with a higher markup, both resulting in higher profits. For automakers, large volumes are key to realizing profits. As a company develops, it specializes according to its marketing target, and while this becomes more tangible going forward, investment in research and development goes up until it reaches the point where new innovation becomes prohibitively more expensive.

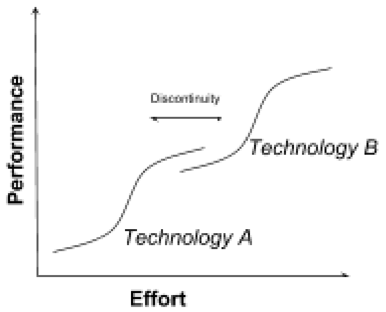

Figure 6: Foster's S-Curve

This is the idea in Foster's S-curve model (1986). Technological progress happens when a new concept is introduced, opening a path for future advancements, and this transition period with different competing technologies is termed a discontinuity. Since the effort needed to raise performance marginally gets higher as a technology matures, producers of new technology have an attacker's advantage. This is because the defender, in order to scale the production to mass-market, has covered the costs of multiple small, incremental innovations to contribute to lowering the price, and these developments, in turn, make the company lose flexibility as it is now dependent on high-volume production to cover the costs of getting to that evolutionary state. Abernathy and Utterback (1978) posit that the starting entrepreneur, and large corporations producing standard units in high volume, inhabit opposite ends of a spectrum that forms the evolution of a company. This is the case with Tesla and the established automakers.

At the onset of technological discontinuity comes an ambiguous period called the "era of ferment" (Abernathy, 1978). Here, producers are unsure about which technology to invest in order to serve the needs of their consumers, and consumers are sceptical about the performance of a technology. This creates openings for small companies, like Tesla, that have spotted what the large companies failed to capitalize on - unless the incumbent companies quickly adapt to the new paradigm. The "era of ferment" ends when a dominant design wins the majority of the market and sets the standard for the technology. This concept is relatable to many levels - it goes for specific components to the entire powertrain in all vehicles. Naturally, neither consumers or producers know which technology will prevail, and therefore betting on new technology is risky. Wernerfelt (1984) identified the disadvantage in moving first. While a successful innovation initially gives a head-start to create value, followers will often find that ideas are easier to reinvent than the one who originally found the invention. Therefore, one needs to keep growing the technological capability in order to protect one's position. However, this should be feasible given the head-start to profits, R&D and production learning curve - just like the tallest trees, he writes, gets the most sun. Prahalad and Hamel (1990) also liken the corporation to a tree, writing that judging another tree by its leaf says nothing about the strength of its trunk and roots, just like an end product will say nothing about a competitor. In Chapter 2, we saw that the traditional automakers had released EVs over the past ten years with success. Taking their size and resources into consideration, Tesla is a sapling in a forest of redwoods.

Mullins (1996) examined the influence of competency and prior performance under changing market conditions. If managers perceive their level of competence as high and prior performance as good, they tend to develop a "fat cat syndrome" where they feel invincible, perhaps even immune to changes in the marketplace. The attitude towards EVs is potentially rooted in the same perspective. For the fat cats in the automotive industry, maintaining the status quo means safeguarding profits.

3.3.1 Creative Destruction and Disruptive Technology

Joseph Schumpeter (1942) saw innovation as the fundamental driver that keeps capitalism in motion. In "creative destruction" the new ways take over by destroying the old, thus devastating the businesses that thrived in the former paradigm and the industry structured around it. When this happens, incumbent companies will cling on to the old paradigm, because of sunk costs and stranded investments made obsolete by the new. Clayton Christensen (1997) described how outstanding companies fail in the long despite "doing everything right" because of the Innovator's Dilemma. Namely, that those companies cannot capitalize on their successful innovations as these undercut their current business model.

Schumpeter distinguished five types of innovations: 1) Introduction of new products, 2) Introduction of new methods of production, 3) Opening of new markets, 4) Development of new sources of supply for raw materials or other inputs, 5) Creation of new market structures in an industry. Tesla does all five. Christensen further distills innovation in two types of technologies: sustaining technologies and disruptive technologies: Sustaining technologies improve product performance, whereas disruptive technologies "bring to the market a very different value proposition than had been available before." The main customer is on the fringe of the current market, and thus new, because these innovations are generally "cheaper, simpler, smaller, and, frequently, more convenient to use." (1997) Thus, disruptive technologies are innovations that result in worse performance for the incumbent companies. Large companies are familiar with innovations that involve improving a product that already has an established role in the market, and most large automakers know how to turn sustaining technology challenges into strategic advantages continuously. Christensen's claim is that large companies have problems dealing with disruptive technologies because they potentially end up ruining the large company by challenging their business model. In 1997, Christensen entertained the idea of EVs disrupting the market:

> "No automotive company is currently threatened by electric cars, and none contemplates a wholesale leap into that arena. The automobile industry is healthy. Gasoline engines have never been more reliable. Never before has such high performance and quality been available at such low prices. Indeed, aside from governmental mandates, there is no reason why we should expect the established car makers to pursue electric vehicles. But the electric car is a disruptive technology and potential future threat."

The implication of Christensen's Innovator's dilemma is that well-performing companies, in order to sustain themselves, paradoxically, have to disrupt themselves. For the traditional automotive industry, this means moving away from ICE to another powertrain.

The EV-1 from GM is a brilliant example of an innovator's dilemma. In 1987, after winning the trans-Australian race World Solar Challenge, with the unique Sunraycer, GMs CEO Roger Smith challenged the same design team to build an EV concept car called Impact on a USD 3 million budget (Paine, 2006). In 1996, the production version called GM EV1 appeared in California. It was quiet, fast, produced no exhaust and ran without gasoline – a distinct move away from GM's core business around ICE, and reception was overwhelming.

The timing seemed right. In response to the increasing environmental impact caused by CO_2 emissions from ICE, the California Air Resources Board (CARB) passed the regulation that required all automakers wishing to sell cars in the state to produce 2% of their fleet emission-free by 1998, scaling through to 10% by 2003 (Wade, 2018). And this is where critics eye conspiracy: emission-free was more or less the same as BEV, and GM allegedly produced the EV-1 to please CARB, and then prove that there was no demand for the vehicles, which is convenient, as that would have upended their business. In December 1999, GM bought Hummer and one month later the EV-1 production closed for good (Paine, 2006). The approximately 1,100 EV-1s were never sold, but leased to users, and all were taken off the roads when the leases ran out (ibid). Apart from a few deactivated cars now featured in museums, all EV-1s were destroyed.

3.3.2 The Innovator's Dilemma

The story of EV-1 obviously exhibits Christensen's characteristic of disruptive technology. Being electric meant being greener than ICE, which was a different value proposition, and that attracted customers on the fringe of the existing car market. Those users note that the range was sufficient for 90% of all trips and that charging at home was more convenient than getting gas at a station (Paine, 2006). By killing the EV-1, GM temporarily paused the creative destruction it could otherwise have caused, and perhaps even thrived in.

Christensen elaborates that resistance to disruptive technology is rooted in many levels in an organisation. From the top, Christensen's logic is aligned with Teece (1997), who wrote: "if the path dead ahead is extremely attractive, there may be no incentive for firms to shift the allocation of resources away from traditional pursuits." For GM, that path was ICE, not EVs which simply was not what the company based its competitiveness on. Going deeper into the organisation, Christensen notes that internal power struggle is ongoing. It might very well have been the case that division heads within GM are likely to have been upset by the EV production because it took focus from other activities considered more important. Prahalad and Hamel (1990) similarly identify that managers are unlikely to share their best resources, which are said to be imprisoned, and redeploy them for the better of the company under other managers, as it impairs their chances of promotion. Following this theory, the incentive to innovate and change on both the personal and the corporate level is nonexistent.

This is evident in an interview with GM board member Tom Everhardt from 1999-2002 (Paine, 2006). Everhardt supported the EV-1 initiative because it would give GM a two-three years leap ahead of the competition. At the board, he met stern opposition, as the consensus was that GM could not see a profit to be coming out of it. Everhardt says "It looks very schizophrenic, but when it started, we could show the people in California, that we could meet the zero-emission requirements - and later on, do we want to show them?" Basically, GM was not ready to go in that direction, because it meant all GM cars would have to follow the EV-1s example. As Everhardt concludes, "GM made a commitment to the

Hummer, because the Hummer could make them money." Christensen remarks that the descent into failure begins when successful companies aggressively invest "in the products and services that their most profitable customers want." Whether that decision alone set GM on the path to its bankruptcy in 2008, as Christensen alludes, is beyond the scope of this study.

Yet, the conspiracy theory about GM purposefully seeking to make a flop to convince policy-makers seems unfounded. Managers focus on things that are obviously profitable. Following the Pareto principle, this means 20% of all activities deliver 80% of the final result, and in the auto industry the all-steel bodies and engine design, account for 75% of the investments (Nieuwenhuis, 2007). This is the core product of the established automakers, and it seems like that mentality kept GM from seeing other opportunities in time. Managers wear "blinkers", write Prahalad and Hamel (1990), and in a large organisations like GMs it is not unlikely that multiple efforts are either counterproductive or wasted. But that does not mean that a conscious decision was made from the top to kill the EV-1, even though it is suggested by one of their board members at the time. Instead, it seems plausible that GM tried in earnest, but stopped when it saw that the path was not attractive. Maybe GM simply paused EV production from 1999 to 2007 (GM Conference Paper, 2012) until the market had become ready for the innovation, after which GM produced the Chevrolet Equinox FCEV, the Chevrolet Tahoe Hybrid, Chevrolet Volt PHEV, which is now a top three EV? As previously quoted, EV-1 battery inventor Ovshinsky, believed that it was the price of the technology that stopped the car. Even though CARB in 2000 reviewed progress in battery development, and found that what was originally estimated to have reached a price of USD 1,350 per unit, was likely to be closer to USD 20,000, it maintained the 10% ZEV requirement, but relaxed to standards include hybrids (Bedsworth and Taylor, 2007). Nevertheless, the large automakers filed suit in protest against the burdensome regulations, and following a settlement with CARB, an amendment came in 2003 which kept the target but allowed the industry to produce light-emission vehicles in an "alternative compliance path" (ibid). As such CARB, failed to turn the automotive industry, but managed to spur development of greener alternatives; and the EV-1 it inspired the Tesla Roadster.

In June 2017, Elon Musk tweeted: "Few people know that we started Tesla when GM forcibly recalled all electric cars from customers in 2003 & then crushed them in a junkyard" (Bihani, 2017). This statement supports Abernathy's conceptual "era of ferment" where producers' doubt about their ability to profit from a new technology, opens up a flank for small companies to enter, and eventually dominate. Therefore, “Major product change is often introduced from outside an established industry and is viewed as disruptive; its source is typically the start-up of a new, small firm" (Abernathy & Utterback, 1978). Tesla came from the outside of the automotive industry and was not bound by its ways.

3.3.3 Roger’s Diffusion Model

Understanding how new ideas and products spread in a social network is crucial to understanding how technology is adopted. A widely used definition of diffusion is Everett Rogers’ (1962) definition: “The process by which an innovation is communicated through certain channels over time among members of a social system. It is a special type of communication, in that the messages are concerned with new ideas.” Rogers’ adopter categorization builds on fundamental statistics. A bell curve representing the whole social network is divided by the mean and standard deviations, which results in standardized percentages that constitute the following:

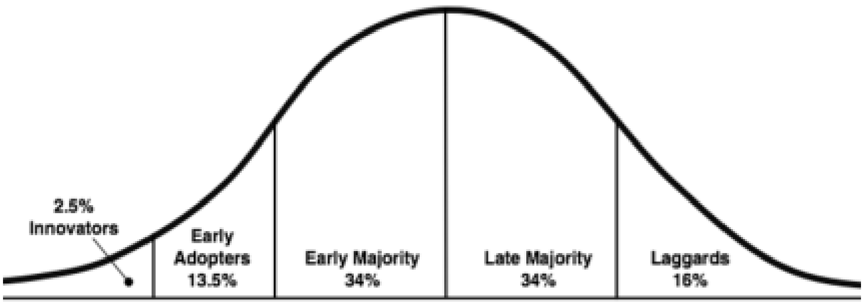

Figure 7: Rogers Diffusion Model

As seen in figure 3, the normal frequency distribution is divided into five adopter categories. Notice that the classification is not symmetrical: there are three adopter categories on the left, and two on the right, because Rogers regard the laggards as “a fairly homogenous category.” The so-called innovators and early adopters constitute a similar sized group and could be lumped into one, but Rogers keep them distinct because they have different characteristics. The five adopter categories are ideal types, meaning conceptualizations that make comparisons possible – their function is to guide research and serve as a framework. The dominant characteristics of each adopter category follow:

- **Innovators** are venturesome. They are eager to try new ideas, have the financial resources to absorb the loss of failed innovations, and are willing to accept a setback. Their salient value, writes Rogers, is the desire to take risk, and innovators get social capital when they launch new ideas into the social system. Furthermore, innovators are typically cosmopolites, whose attitude to a higher degree is share with a circle of like-minded people over a geographical distance.

- **Early Adopters** are respectable. They serve as role models to be consulted by others in society, and thus have the highest degree of opinion leadership. While the innovators are cosmopolites, the early adopters are locally integrated, and share their subjective evaluation of a new idea with close peers. If early adopters are convinced about a technology, and it is affordable enough, then it will be eventually hit the mainstream market.

- **Early Majority** are deliberate. They adopt new ideas before the average member of society "gets it" and provides the interconnectedness in a society. However, they are relatively risk averse as they do not have the funds to try out ideas that might fail; this is why they look to the early adopters for advice and track record.

- **Late Majority** are skeptical. They adopt new ideas after the average members have been convinced. This adoption may be in part an economic necessity, or due to network pressure. When the late majority gets the new idea, it has simply taken over what they were used to, and they are now forced to adopt.

- **Laggards** are traditional. Possessing no opinion leadership or funds to acquire brand new technology, the laggards are the last to adopt and enjoy new things. Their point of reference is the past, and decisions are made on the basis of what is known to work, why they come across as suspicious or against change. Their resistance to innovation is however rational, and Rogers means no disrespect with the term; he mainly posits, that their available resources are limited, and therefore must be "relative certain that the new idea will not fail:"

Thus, Rogers links socioeconomic status and innovativeness. Generally speaking, he proposes that affluent classes have more resources to try new things, and the robustness to withstand if the innovation falls through. By dividing the first 16% to adopt an innovation into two groups (2,5% innovators and 13,5% early adopters) Rogers posits that the latter will be the main determinant as to whether or not an idea will spread to the early majority, and thus whether the new idea will become a mainstream innovation. In other words, 16% is the tipping point for mainstream adoption. This is because early adopters are respectable role models whose opinion is valued in society, and because their lead into affordable innovations will attract the early majority. Following this, a mainstream market penetration is above 16% market share - and if this goes higher, according to the model, it is only a matter of time before the innovation will take over in the social system.

We see that there is a crucial gap between the early adopters and the early majority. Geoffrey A. Moore identified this 'chasm' and how to cross it. The first users are 'technology enthusiasts' and 'visionaries' who are willing to experiment, and reference each other when making buying decisions. The problem for full-scale diffusion is that the mainstream user - the 'pragmatists' - rarely communicates with these subsegments, or share their interests. Instead, "Pragmatists want to buy from proven market leaders." The mainstream user wants tried and tested products, and "they care about the company they are buying from, the quality of the product they are buying … and the reliability of the service they are going to get.” (Moore, 1999). Therefore Moore encourages companies to focus their marketing, "Target a specific market niche as your point of attack and focus all your resources on achieving the dominant leadership position in that segment." This is referred to as a beachhead; a prerequisite for later full-scale invasion. Adoption of EV hinges on garnering enough traction among early adopters to convince the pragmatic early majority. Elon Musk recognised this from the get-go, and devised a careful plan as we will see next.

3.3.4 Tesla’s Elon Musk’s Secret Master Plan

Elon Musk’s strategy from 2006 carefully follows Roger’s diffusion model. The Master Plan: “1) Build sports car, 2) Use that money to build an affordable car, 3) Use that money to build an even more affordable car, 4) While doing above, also provide zero emission electric power generation options.” (Tesla Blog, 2006). Here we see Musk outline three stages closely following Rogers diffusion model.

First, release a high-priced car to the super rich - *the innovators*. This ensured high-end positioning and cash to make a car worth the price. At the release price of USD 160,000 in 2008, the *Tesla Roadster* was in Porsche 911 Turbo territory (Roy, 2011). It was built on the Lotus Elise chassis, accelerated from 0-60 mph in 3.7 seconds, had a range of 244 km, and was widely welcomed by the predominantly cosmopolite Californians.

The second stage of the plan, is using the profits from stage one to fund and develop a medium volume, mid-high-end priced car targeting relatively affluent consumers. The aim here is to increase public acceptance of electric vehicles. Musk unveiled the groundbreaking *Tesla Model S* in March 2009 with a base price of USD 60,000, envisioned to go up against the likes of Mercedes, BMW and Audi. Once production ramped up, the car was the best-selling EV for two years in a row in 2015 and 2016 (Cobb, 2017). The reasons are manifold. For starters, an EV with a 300 km range, it was one of the fastest production cars and had semi-autonomous driving. The National Highway Traffic Safety Administration (NHTSA) awarded the Model S a 5-star safety rating in every subcategory without exception setting a new record (Tesla, 2013). Consumers loved it. In Consumer Reports (2012) annual survey of 350,000 vehicle owners, 98% of Model S owners would share that they would buy the same car again; and in their December 2017 study, the Tesla S came out among 500,000 vehicles as the most satisfying car to own. Thus Musk won over the *early adopters*.

In order to cross the chasm, and get the pragmatists on board, Tesla developed an SUV - the *Model X*. It holds seven adults, has all wheel drive, gull-wings, and as the only EV with a tow-bar, it has the world record of 5,500 pounds tow (CNN, 2018). In January 2012, Tesla started pre-orders, and when the first car rolled off the assembly line August 2015, an estimated 30,000 orders had come in (Pritchard, 2015).The third stage, is mirrored in the name *Model 3*. Tesla's first car for masses, is a low-cost car at a base price of USD 35,000. It launched in July 2017 with close to 500,000 preorders, but production has been sluggish which has frustrated fans. According to Bloomberg estimates (2018) Tesla produced some 40,000 in the first year, however those numbers have since picked up, and as of September 12 2018, has produced 90,800 Tesla 3s. This is where Tesla is right now.

Looking at the names Tesla S, Tesla 3, Tesla X and Tesla Y, does not give the impression of a specifically branded approach to the individual product; the names are generic, almost to a point of obscurity. However, observing that Musk's plan follows Roger's Diffusion Model (1962) starting with a pricy roadster to get the innovators, then field the luxury model S to get early adopters, followed by Tesla 3 to take the early majority, by using the X to get the pragmatist, and the unannounced, but much alluded to Model Y to get the late majority and laggards – one sees the product line is complete. And it is S3XY.

Christensen (1997) offered three foundational insights to a go-to market strategy for a would-be EV maker. First advice, is to disregard completely the positions occupied incumbent automakers. They will, he expects," focus precisely and myopically on the mainstream market" and thus have their sights "trained on the wrong target." Second advice is to discover an untapped market, and explore it with the customers - "The only useful information about the market will be what I create through expeditions into the market, through testing and probing, trial and error, by selling real products to real people who pay real money." Third advice, is to plan for learning, not making profits - and sticking to the fixed plan. Looking at Elon Musk's secret plan, with which he has arguably succeeded, Christensen was correct in all three point of his strategy.

The purpose of the second stage was to generate profits and invest in the facilities that would enable production of a high-volumes. As evidenced in Elon Musk's July 2018 tweet from the introduction, and the estimated Model 3 output 50,000 from that point, it seems that Tesla has become "a real car company." The purpose of the mainstream EV "is to encourage more traditional automobile manufacturers to invest in the electric car project, to stimulate competition, to promote the whole industry towards the direction of sustainable development.” (Musk, 2006). Whether Tesla and Elon Musk succeeds in this endeavour, hinges on convincing the mainstream consumer of EVs prowess.

3.3.5 Summary - Innovation

The purpose of this subsection was to examine innovation, disruption and adoption. Innovation is defined broadly as the creation of value from new ideas. In the automotive industry ICE has been the dominant design of the century. This dominance is now challenged by a radical innovation, the EV, which the traditional automotive industry failed to market due to the innovator’s dilemma.

As shown in the previous, major corporations have little interest in technology that will disrupt their business models. For the traditional automakers, the all-steel bodies and engine design, is the driver of profits, and therefore introducing a different powertrain was met with reluctance; furthermore, to managers it seemed nonsensical to invest in a technology that was much much too expensive to market, and at the same time made the core product look bad. This is why the established industry shied away from EVs, which answers RQ 3.

With the EV-1, GM tried to hit the mainstream market, but failed. For Tesla, following Rogers and Moores theorized recipe for diffusion, by beginning with a niche product for the affluent classes, was a sound strategy. It gave gradual access to funds, at low volume production, and raised awareness through the right channels while building capacity. This further underscores the answer given to RQ1 in the partial conclusion (Chapter 3.2.2.3), and partially answers RQ4. Given that the EV has now secured a foothold in the global car market, it seems that the gale of creative destruction has hit the established industry.
As for RQ3, regardless of whether, the traditional automakers were “fat cats” that simply failed to adopt the new paradigm ahead of time, or purposefully waited to see the first-movers try and fail, the industry now finds itself in an era of ferment following the technological discontinuity of ICE. The real question is now how the market reacts to the return of the innovation.

Following Cabral in an answer to RQ4, if EVs are convenient, smart and cheap enough to attract the right adopters in the right sequence, then EVs will cross the chasm and wide adoption eventually happens. However, this depends on the marketing efforts of the whole industry, as we shall see in the following.

3.4 Marketing

Lastly, we turn our attention to the influence of marketing in a marketplace, and how it is related to innovation. The marketing aspect is applied to answer to research question on how the mainstream market will accept EVs. To Drucker (1973), “The aim of marketing is to know and understand the customer so well that the product or service fits him and sells itself.“ Kotler et al (2008) build their definition on this premise - namely that the aim of marketing is to make selling unnecessary. They define marketing as a managerial process by which companies create value for customers, and build strong customer relationships in order to capture value from customers in return. If we compare this definition to Tidd and Bessant’s definition of innovation from the previous subchapter, as the process of creating value from new ideas, we see that the key difference between marketing and innovation is that the latter is about building a relationship with the customer. The very word simply means to bring those ideas to the market.

Kotler et al (2008) see marketing as a five step process for the company: first, understand the marketplace and customer needs and wants; second, design a customer-driven marketing strategy specifically tailored at getting, growing and keeping customers; third, construct a marketing programme that actually delivers superior value; fourth, build profitable customer relationships and create customer delight; fifth, reap the rewards by capturing value from customers. Marketing strategy is simply deciding what to sell to whom, and as we saw in the previous subsection concerning Elon Musk’s Master Plan, Tesla is very good at it.

Had Tesla instead gone directly for the mainstream market, it would not have had the benefit of a proven concept and brand to exploit. Moore (1999) writes that it is very difficult to break into a new industry by targeting the mainstream. Here early adopters are pragmatists, for whom “References and relationships are very important…Pragmatists won't buy from you until you are established, yet you can't get established until they buy from you.” This is a classic chicken-egg problem, which underlines the benefit of having track record and an established business platform to sell a new product from; for instance being an hallmarked American automaker like GM trying to launch an EV, BMW launching a MINI-E, Jaguar launching a new E-Type, or Volkswagen revamping the Minibus. Returning to RQ3 from the opposite angle, the automakers are in a strong position to release EVs.

In a study of some 450 EVs introduced to the US market from 2003 to 2011, van Wee (2012) find that startups generally targeted the small market segments where consumer demand was minimal. In the sports car segment, price is less of an issue and in other segments range and speed are of less importance, which allowed for low production volumes. The traditional industry exclusively went for the safer bets, and developed a number of models in the mini, small, compact, and sports car classes, thus leveraging the “references and relationships” that Moore observed. Innovative marketers, as noted by Kotler et al. (2008), continuously seek to improve these relations, since the company that mistakes new and better ways to satisfy demand, eventually lose customers to those who do. By creating superior value and satisfaction, the established automakers have acquired valuable customers, and ideally built relationships with that base going forward.

3.4.1 Consumer Choice

Cabral (2000) writes that consumer choice in the period following introduction of an new idea is crucial. Consumers arrive to the market sequentially - this is fully in line with Moore and Rogers. From microeconomic tradition, Cabral notes that consumers will derive utility individually from the choices available, and because these in theory provide a definite quantity, the one with the highest standalone utility prevails. In addition, there is the network related utility, whereby the choice that first gets the largest base, becomes most appealing. This network effect means consumer choice shapes subsequent consumers.

In other words, the process is self-reinforcing. Because the barriers that end up excluding other choices, are absorbing in the sense that once they are passed, the industry is locked-in with one of these competing technologies. Two implications are drawn from this simple model: 1) that an industry is pre-destined to become locked-in by a developed standard, and 2) that the best technology does not always win. As Cabral sums up “the eventual outcome, in terms of which technology the industry gets locked-in to, will depend on a limited, possibly small, number of initial adoptions.” Thus, the largest base of customers eventually get to decide for the rest. This is particularly relevant for RQ4. Cabral concludes, the particular historical details of the evolution of an industry may in some cases determine the long run market structure in ways that go beyond simple technology determinants. As we shall see in the following, this is apparent in the history of automotives; because ICE was the most convenient, versatile option, it became the dominant design.

The era of horseless transportation began in 1801, when Richard Trevithick built a steam-powered carriage. The first battery-powered EV was built in 1834, and in 1885 Karl Benz produced the first petrol-powered engine (Chan, 2013). However paradoxical, the winning solution was the most uncertain, the most polluting, the most criticized at the time, the most dangerous, and the most expensive - the internal combustion engine (Freyssenet, 2011). Around the turn of the 20th century, the most widespread technology in transportation was still the horse, but the nascent car industry in Europe and the US would soon take over.

Because Europe inherited the Roman network of roads that linked villages, townships and cities with well maintained highways, ICE was favoured from the get-go because it had range. Meanwhile, in the United States, EVs were widespread, as cars were mainly used within city limits due to the absence of rural and transcontinental infrastructure. In 1900, a total of 33,842 electric cars were registered in the United States, of which 40 percent were powered by steam, 38 percent by electricity, and 22 percent by gasoline (Chan, 2013). Thus for the American market, the first decades of the 20th century was an era of ferment. ICE became more competitive than EVs due to the innovativeness of mass production by Henry Ford from 1910; the invention of electrical automobile starters in 1912; the discovery and large-scale production of oil in Texas, and the extension of highways by 1920, (Chan, 2013). In 1912 an average ICEV cost $ 650 vs. $ 1,750 for an average EV (ING, 2017). Cabral's network effects multiplied as the innovations stacked up and captured market shares. In the automotive industry, ICE eventually came to dominate the market because it was the cheaper, practically adoptable and convenient technology.

3.4.2 Buyer Resistance

When it comes to new technology, consumers are usually reluctant. As we have covered in the previous subsections, Rogers and Moore offer an explanation for resistance based on the socio-economic characteristics of different groups in a social system. Their theories rest on the awareness and affluence of a person, and therefore willingness to try a risky purchase. Perceived risks play an important role in creating consumer resistance. Therefore, making the information readily available to consumers is important. According to Rogers (2003), neglecting the importance of consumer knowledge can induce a knowledge-attitude-practice gap. According to IEA (2018), the primary issue facing electric adoption is shorter driving range and higher vehicle cost, both caused by the battery.

EVs are currently sold at a higher price than ICEV. Kochhan and Hörner (2015) explore the Willingness-to-Pay (WFP) for an EV, and the effect of Total Cost of Ownership (TCO) of purchase. They find a mismatch. The total cost for buying, using and reselling an EV may be lower than ICEV, comparing electricity costs to fuel costs per kilometre. Yet a key reason for resistance is the limited flexibility because range is typically lower than a comparable ICEV, charging time to "refill" the battery is usually in the range of hours depending on the charging power, and the charging infrastructure needed to travel over far distances is still undeveloped. At least for now, "This makes BEVs only usable for short distances and cases where enough time for charging can be guaranteed." (Ibid) However, if the TCO - the cost of acquisition, operating costs, and end-of-lie value of the car - for an EV is lower than for ICEV, then the WTP should reflect this. Kochhan and Hörner conclude that the attractiveness of EV is improved on an infrastructure level, which is a long term investment, and not by the tax rebates, lower registration fees and other incentives that favor EVs, though they surely let more people get in touch with the new technology. This is in line with Rogers and Moore (1999) thinking, because the mainstream consumers require safety in purchase and derive little pleasure from a risky purchase. To mitigate that risk, brands may be seen as a promise.

3.4.3 Branding

Simply put, brands are consumed, and hold value beyond their utility because of the signals they exhibit - and thus allow the user to represent oneself. In the words of Grant McCracken, the cultural meaning of goods is in constant transit. This means that "goods are both the creations and the creators of the culturally constituted world." (McCracken, 1986) Culture is the lens through which the world is understood, and in continuation thereof, the blueprint that determines what is fashioned by human effort - "In short, culture constitutes the world by supplying it with meaning." (Ibid). This explains why certain brands gain strong support from different groups of people - it helps signal belonging. A strong foreperson like Elon Musk, allows Tesla users to associate themselves with his vision.

Naturally, brand awareness has a great impact on purchase decisions (Kornberger 2010). What makes brands magical is a long chain of cause-and-effect relations because brand value equals the sum of all intangible assets in an organisation that contribute to profit (Ibid). According to brands are imbued with personality. This helps marketers target their audience, and associate human characteristics with their offering, which is accepted or co-created to some degree by their users. Aaker's five core dimensions and their related traits are: 1)

Sincerity (down-to-earth, honest, wholesome, cheerful), 2) Excitement (daring, spirited, imaginative, up-to-date), 3) Competence (reliable, intelligent, successful), 4) Sophistication (upper class, charming), 5) Ruggedness (outdoorsy, tough). In the automotive industry each car brand has a carefully designed brand. Sports cars exude excitement, upmarket cars signal sophistication, and off-roaders ruggedness. The German automakers have long lived on signalling competence. Looking at the EVs on display in Chapter 2, it is clear to all that Tesla Model S is relatively more exciting than the competitors offering, but it also comes across as sincere, competent and sophisticated. Daniella Vlad (2014) made an interesting study about car brands' influence the consumer behavior. She found that owners of what is perceived German or Asian cars, have a strong preference for similar automakers; a BMW owner has little or no intentions of buying anything else than a Mercedes, Audi or a new BMW. In other words, well-branded products yield loyalty.

David Aaker (2007) examined how companies benefit from branding innovative products. He identifies three ways by which brands add value: 1) they differentiate from competition, 2) they create new subcategories, and 3) they affect the perception of the parent company. Pertinent to this case, is the ability to create a subcategory, and dominate it. Writing in 2007, Aaker's example of a "object typicality" in the subcategory of compact hybrid cars, is the Toyota Prius, which he deems "the first, and likely only model to come to mind." The greater the typicality of an object, the quicker and more precisely the connection to the category. Therefore "A branded innovation forming a new subcategory should attempt to achieve and retain the position of being the sole, authentic exemplar of the new product subcategory." (ibid). With Elon Musk's brand associated with the Tesla models, it is likely that consumers will associate Tesla with EVs in the same way as an iPod took over from Walkman as the standard in portable music players. "When a transformational innovation that creates a new subcategory is involved, a brand can help to define, position, and dominate that new subcategory." Aaker posits, that a vehicle perceived as the superior product, has a headstart in generating loyalty which will make it preferred over other products with similar typicality, and have the crucial top-of-mind position. Being perceived as the EV provider sine qua non, gives Tesla a strong competitive advantage.

Following Jennifer Aaker (1997), a Prius is not sophisticated or particular exciting, but does come across as sincere and environmentally friendly. An important aspect of the Prius offering is simply that "Every buyer was investing not only in a car, but in a company promising a better way." (Aaker, 2007). When Toyota had sold 10 million Priuses in January

2017, Chairman of the Board Takeshi Uchiyamada said : "When we launched Prius, no one even knew what a hybrid was. Those who drove it were called geeks or other names. Today, thanks to those early adopters who gave Prius a chance, hybrids have grown in popularity, and have ridden a wave of success out of the unknown and into the mainstream," (Toyota PR, 2017). David Aaker presumes that marketing a subcategory is easier than marketing a brand. This is in tune with Moore's theory about pragmatists favoring established offerings. These aspects give the traditional industry actors considerable leverage over new entrants.

3.4.4 Summary Marketing

RQ3 ask what facilitates EV adoption in the mainstream market. In this subchapter we have covered important insights. Historically, the adoption of cars is the result of an interplay between infrastructure and cost of technology, which ended up as the preconditions for the dominant design, ICE, which had the highest utility for majority of buyers. EVs are still a niche offering. The mainstream market demands flexibility, convenience and reasonably priced alternatives, and fear offerings that do not guarantee the utility they demand. Alleviating those fears and growing awareness will enable the EV to take larger market shares, by lowering resistance. To help consumers navigate and raise the profile of their own offerings, automakers spend a lot of resources on marketing and branding. Brands are consumed. Because they are used as an extension of the consumers self, the traditional automakers ideally create loyal followers that prefer their brands to others. By exuding sincerity and competence, Tesla managed to deliver the EV from the bias created by competition, and gain a footing in the well-off circles of society that want to appear green.

3.5 Summary

Business strategy is intimately tied to innovation management and marketing. So far, the Tesla models have been luxury cars aimed at the upper-income brackets. However, as seen in Musk's secret plan, this has always been the means to an end - a way to convince the market of sustainable transportation. Tesla ability to achieve its mission hinges on crossing the chasm, which means getting an EV market penetration over 16,5 percent. In order to do so, the EV must become more affordable, and its abilities must be communicated to new buyers that have not been in contact with current users because of social class. The top 10 producers have been providing affordable cars to the middle-class and lower end-incomes for decades, and possess the production capacity to market cheaper vehicles; however, they have not sought to speed up adoption as it would undercut the business model of ICE.

Chapter 4: The Automotive Industry in 2018

4.1 Chapter Overview

In the following chapter, we collect data and examine the automotive industry. In order to grasp its sheer size and apply the theory from Chapter 3, we take the following perspectives:

- Global production
- Regional vehicle fleets
- Regional sales and EV penetration
- Market concentration based on total output
- Global EV sales and market leaders

The global production, regional vehicle fleet sizes and sales, will give a insight in the sheer size of the automotive industry. Furthermore, this should give an impression of the internal resources required to attain and hold a leading position for the traditional automakers. Knowing the fleet size and EV penetration allows us to calculate current adoption. Following this, we compute market concentration based on total output in order to measure how strong the individual and combined production capacity of the industry actors is, and how this serves as an entry barrier for newcomers. After establishing the traditional automakers we turn our attention to global EV sales and market leaders to see how the industry has performed in this new segment. Finally, the examination of the geographic span of activity in the industry sets the foundation for the nine-forces analysis in Chapter 5.

4.2 Global production

In this subsection, we examine the global production of cars in 2016-2017. In this chapter, we process the actual numbers accumulated through 2017, using data obtained from OICA (2017). Global production has been combined into three world regions as follows:

- The Americas covers NAFTA and South American countries
- Europe covers the EU, Turkey, Russia and CIS
- Asia covers the rest. Africa accounts for 0.93% of world production.

Region	Asia	Europe	Americas	Total
2017 Output	44,964	19,595	8,190	73,456
Percentage	61%	28%	11%	100%

Table 4: Global output in thousands, OICA (2017)

World production is geographically placed in a handful of countries. Fully aligned with the Pareto principle, eleven countries out of 59 car producing countries manufactured 80.9% of the total 73.456mio vehicles in 2017.

Car Producing Countries

	China	Japan	Germany	India	South Korea	USA	Spain	Brazil	France	UK
2016	24,421	7,874	5,747	3,707	3,860	3,917	2,354	1,778	1,636	1,723
2017	24,807	8,348	5,646	3,953	3,735	3,033	2,291	2,269	1,748	1,671

Table 5: Country output in thousands, OICA (2017)

Of the the five biggest producers, all but one is located in Asia. With Germany as number three, China, Japan, India and South Korea, are the top five car producing countries. In total, the Asian countries produced 40.8 mio cars, which corresponds to 55.6% of the world output – while all the 14 car producing nations in Asia make 61%. The Chinese production capacity is fascinating; it produces more than the next top four countries put together, and only by aggregating the next five producing nations - respectively, the birthplace of the automotive industry, Germany, and the most important in recent production, Japan and South Korea - do we reach a number that tops it by just 300,000 vehicles. China alone produced more than 24 mio vehicles, i.e. a third of global production, for two years in a row.

The US is no longer a top 5 producer of automotives. Brazil manufactures 90% of all cars in South America, and together with the production in USA and Mexico, this corresponds to 88 percent of the 8.19mio cars produced in the Americas, and a regional contribution to global output of 11 percent. In Europe, the industry is still very localised. Though not featuring on the figure above, the Czech Republic, Russia, Turkey and Slovakia with their respective outputs in the range of 1.4 to 1 mio, make 6.7 percent of global output. While Germany, France and the United Kingdom only produce 53 percent of the 20.7mio cars in the EU, Turkey and CIS, this region accounts for 28 percent of global production. In other words, car manufacturing is much more spread in this region than in Asia. Naturally, because the production is highly concentrated in a few Asian countries, local legislation and government policy has a big impact on the industry. In addition to a large market size, as examined in the coming subsection, it becomes clear that Asian standards - particularly Chinese - might come to affect the global industry more than it already does.

4.3 Regional Vehicle Fleets

In this subsection, we examine the regional vehicle fleets. That is the number of registered passenger cars in the same three world regions, and Africa, which we will use later to measure EV adoption.

REGIONS	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Europe	277	283	286	295	298	303	310	315	321	327	334	351	369
Americas	203	209	214	220	221	222	226	224	228	233	238	250	261
Asia&ME	157	167	181	191	206	226	248	270	292	318	344	384	425
Africa	17	20	21	22	23	24	25	26	28	29	31	32	33
Total	654	679	702	727	748	776	808	835	869	907	947	1.017	1.087

Table 6: Development in regional vehicle fleets in millions. Compiled from OICA ”Sales: New Registrations 2015-2017” and ”Passenger Vehicles in use 2005-2015”

Two things in particular, are interesting in numbers above: the world fleet crossed 1 billion registered vehicles in 2016, and there has been significant growth in Asia. While the fleet in the Americas over the decade from 2007-2017 has risen from 203mio to 261mio, in Asia it hiked from 157 to 425 million. Africa almost doubled its fleet in 12 years, while the European market has grown 33% from 277 to 369 million. This is naturally reflected in the global sales numbers summed up in the next table:

Sales	EUROPE		AMERICAS		ASIA+ME					World Sales
2005-2017		EU 15		USA		China	Japan	India	S. Korea	
CAGR	0.01%	-0.13%	-0.21%	-1.74%	7.94%	15.19%	-0.60%	8.58%	4.04%	3.48%
Growth	0.17%	-1.70%	-2.73%	-20.42%	169.94%	528.61%	-7.52%	191.60%	67.41%	56.04%

Table 7. Development in regional vehicle fleets in millions. Compiled from OICA ”Sales: New Registrations 2015-2017” and ”Passenger Vehicles in use 2005-2015”

Over the thirteen year period from 2005 to 2017, world sales have increased 56.04% corresponding to a yearly combined aggregate growth of 3.48% The bulk of this growth is due to China, with an impressive rise in sales in India and South Korea as well. The American market has decreased by -20.42% which is a reflection of the high consumption prior to the financial crisis in 2008. The European market has remained stable, with a small increase of 0.17% in the region, though the EU 15 countries have seen a decline by -1.70%

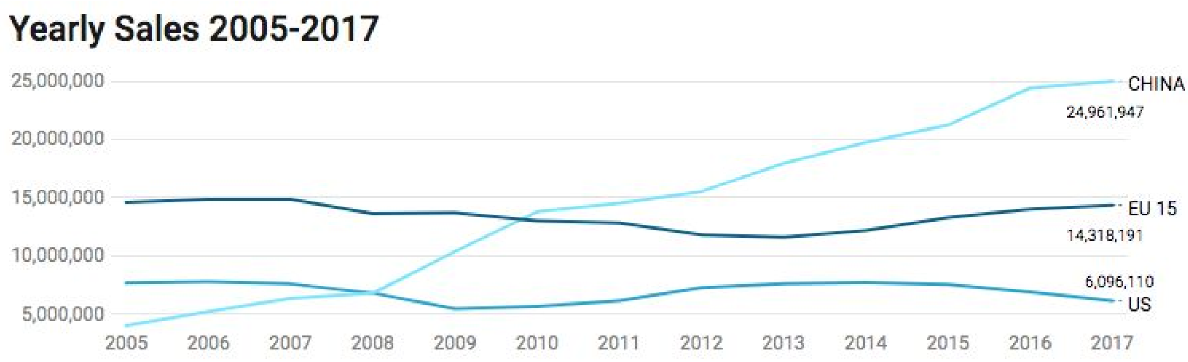

Figure 8: Yearly sales in the US, China and 15 “old” members of the European Union.
Data source: OICA ”Sales: New Registrations 2015-2017”

In the graph above, we see how China eclipsed US sales in 2008 by hitting 6,5 million, and, how China eclipsed sales in the EU by reaching 13 million in 2010. In 2014 it almost eclipsed the two big markets combined, and in 2014 it surpassed them by 4 million. In 2017, the Chinese car market was four times bigger than the American. Obviously the Asian hike evidenced in table 6 is due to the booming home market in China. This is in contrast to the sales in Europe and the US, that have remained relatively stable, with a dip in the years after the 2008 recession. In contrast, China has increased sales by 628 percent from 2005 to 2017. Clearly, the market has relocated, and consequently Chinese policy has an influence on automakers as important as the European Union and US Government, if not bigger.

4.4 Global Electric Vehicle Fleet

Now that we have looked at the global production and car fleet, we can finally turn our attention to the EVs. By definition, EVs comprise all cars with an electric powertrain, including hybrids as long as they also have plug-in charger. Different technologies are in use, and OECD’s IEA (2018) estimates that BEVs make up some 60% of the global EV fleet, which surpassed 3 million in 2017, and must by now have crossed 4 million in 2018.

However how large these numbers seem, they are but a drop in the ocean of 1.1 billion vehicles. Their growth and penetration of global vehicle fleet:

Global EVs	2012	2013	2014	2015	2016	2017	H1 2018
Total	210,250	431,050	759,320	1,309,060	2,052,960	3,222,300	3,972,030
Penetration	0.025%	0.050%	0.084%	0.138%	0.202%	0.296%	0.342%

Table 8: Sources ZSW 2013-2017, EV-Sales Global Top 20 - July 2018,
and EV-Sales Monthly Plug-in Sales scorecard

On a global scale, we see that EV penetration of the car fleet has risen tenfold from 0.03% in 2012 to 0.3% in 2017. Assuming that the industry now has production capacity in order, and the market is ready, that number will continue to grow exponentially and eventually crowd out ICE. IEA (2018) estimates that the EV fleet will number 125 million in 2030 , and when the EVs eventually beat ICEVs on price and quality the transition will happen very fast. ING (2017) estimates that all new vehicle sales may be EVs already by 2035.

On a global scale, EV penetration is still very far from the 2.5% threshold Moore and Rogers theorized as prerequisite to getting the early innovators; but is important to note that the theory is applicable to a much smaller social system, more like US or EU state level, and that markets for any specific good is segmented. In other words, simply looking at the Global Fleet EV ratio says little about its penetration and trajectory. Like Moore encouraged, managers must secure a beachhead and then follow up with an invasion; as EV production has increased 18 times from 210,250 in 2012 to 3,9 million in H1 2018, it is safe to say that the invasion is building.

That is of course, if the EV automakers can cross the chasm. To get that critical mass, the auto industry has to convince the venturesome innovators in a social system, that make up 2.5% and then attract the visionary early adopters, who make up 13.5% Refocusing our global lense to a local state level, and taking the eight countries with the highest number of EVs and divide that by country fleet, we get an impression of local penetration:

Country	2018 Fleet	2011	2012	2013	2014	2015	2016	2017	H1 2018
CHINA	1,615,794	0.01%	0.02%	0.03%	0.09%	0.23%	0.41%	0.69%	0.77%
USA	899,555	0.00%	0.02%	0.06%	0.14%	0.24%	0.33%	0.12%	0.15%
JAPAN	217,604	0.01%	0.03%	0.07%	0.12%	0.17%	0.21%	0.87%	1.10%
NORWAY	195,133	1.11%	0.29%	0.63%	1.40%	2.67%	4.15%	6.07%	6.37%
UK	149,402	0.01%	0.02%	0.03%	0.07%	0.14%	0.24%	0.34%	0.36%
FRANCE	147,740	0.01%	0.03%	0.06%	0.10%	0.17%	0.25%	0.33%	0.39%
GERMANY	169,112	0.00%	0.01%	0.03%	0.06%	0.11%	0.15%	0.21%	0.31%
NETHERLANDS	129,888	0.01%	0.08%	0.35%	0.53%	1.05%	1.28%	1.31%	1.36%

Table 9: Top EV countries with yearly penetration. Sources ZSW 2013-2017, EV-Sales Global Top 20 - July 2018, EV-Sales Monthly Plug-in Sales scorecard and IEA EV Global Outlook 2018

As seen in table 9, the national penetration in the countries with most EVs is still low. In fact, so low it does not makes sense to map them on Rogers Diffusion Model. Norway and the Netherlands lead the adoption with 6.37% and 1.36% EVs in the national fleet, pursued by Japan and China with 1.1% and 0.77% The UK, France and Germany have penetrations ranging from 0.31% to 0.39% We see that China and the US, despite having the nominally largest EV fleets, have relatively low penetration because their total fleets are the world's biggest. That Norway and the Netherlands feature highest based on EV penetration, comes as no surprise. Both countries are affluent, social equality is high, and populations are small and dense, which means they communicate easily with each other, which spreads adoption quickly. In 2017, EVs accounted fo 39% of new sales in Norway (IEA, 2018). However, one has to wonder why other small, rich European nations, without an automobile industry to show consideration for, such as Denmark, has failed to secure a similar position.

4.5 Market Concentration

We now turn our attention to the automotive industry. By examining the quarterly and annual reports of the top twelve companies, we estimate production in the past 12 months up to August 2018. This allows us to calculate market concentration. Using the 2017 global output of 73.4 mio vehicles as the total, we calculate global market shares, assuming output equals demand, and has not risen radically seeing that output in 2016 and 2017 are quite similar. The top twelve companies control 92.93% of global output, and some 50 brands.

Company	Production	Marketshare
VW	11,038	15.04%
Renault	10,600	14.44%
Toyota	8,923	12.16%
Ford	6,621	9.02%
Honda	6,215	8.47%
Fiat	4,855	6.61%

Company	Production	Marketshare
GM	4,157	5.66%
Peugeot	3,997	5.45%
Suzuki	3,727	5.08%
Daimler	3,279	4.47%
Hyundai-Kia	3,375	4.60%
BMW	1,423	1.94%

Table 10: Top 12 with estimated production in the past twelve months, and market share of 2017 global output

Naturally, the biggest market shares by this definition belong to to the largest producers. This method is taken from the industrial organisational analysis tradition (Cabral, 2010), and though it lacks the price-cost margins, that would have allowed us to calculate market power, we accept the results as adequately valid for our analysis of the automotive industry, because the two are causally related. Though market power is more accurate, this method would have required much more data. In order to gauge market concentration, we sum the market share *ms* of the companies:

$$C_4 \equiv \sum_{i=1}^{N=4} ms_i$$

$$C_4 = 15.04\%_{vw} + 14.44\%_{Renault} + 12.16\%_{Toyota} + 9.02\%_{Ford} = 50.66\%$$

$$C_{12} = 15.5\%_{vw} + 14.9\%_{Renault} + 12.5\%_{Toyota} + 9.3\%_{Ford} \ldots 1.94\%_{BMW} = 92.93\%$$

Following the suggestions of Naldi and Flamini (2014a) with a C4 index over 50%, the global automotive industry must be considered a loose oligopoly. The theory is that the higher percentage of the market these top four firms control, the less competitive the market is, and over 80% is approaching a monopoly. However easy to calculate and use as a token for competitiveness, there is a distinct problem with the four-firm concentration ratio. Namely, that one firm, or that the four biggest actors, could be significantly larger than all the rest. To account for the relative size distribution of the firms in a market, we must use another index.

The Herfindahl-Hirschman Index is often used to assess competition and market structure. Here *N* companies operate, and by summing the squared market shares *ms* of *i*-th company, we get the Hirschman-Herfindahl Index:

$$HHI \equiv \sum_{i=1}^{N} ms_i^2$$

The HHI increases both when the number of firms in the market decreases and as the range in size between those firms increases. Thus, when a market is occupied by a large number of firms of relatively equal size, the HHI approaches zero, and conversely it reaches its maximum of 1 when the market is controlled by a single firm - a monopoly. Competition authorities use HHI as a screening tool ahead of mergers to avoid harmful competition. The US Department of Justice (2010) multiply the HHI with 10,000 to get a range. An HHI between 1,500 and 2,500 points is considered moderately concentrated, while markets exceeding 2,500 points are highly concentrated. Such industries are almost impossible to penetrate, because the production capacity held by the oligopolists blockades entry. Cabral (2010) concludes that at intermediate entry costs, incumbent actors should seek to build large enough capacities to induce potential entrants to give up any attempts to enter. As we have established with the C4 and C12 indices, the mature companies that make up the traditional automakers seem to have heeded Cabral’s advice.

The Herfindahl-Hirschman index thus offers a more telling image than the four-firm ratio, but it is more difficult to attain. It requires complete knowledge of all market shares in a market. Because we only know the data points from twelve companies in the industry, we cannot calculate the HHI; unless we estimate the residual market share and number of actors, *Q*. Obviously, the market shares of N companies total 1. Therefore, the residual market share can be calculated by subtracting C_{12} = 92.93% from 100%, which results in *R* = 7.07%, and given that the actors will either have market share equal to or lower than the smallest actor, BMW, (1.94%) we can derive both the lower and an upper bounds, as inspired by Naldi and Flamini (2014b) to give an interval. In the case of the lower bound, the number of actors must in theory be finite, but to a degree of having no market power:

$$HHI_{lower} \equiv \sum_{i=1}^{10} ms_i^2 \quad | \quad HHI_{upper} \equiv \sum_{i=1}^{10} ms_i^2 + Qms_{10}^2$$

The calculations follow:

$$HHI_{lower} = \sum_{i=1}^{10} s_i^2 = 15.5\%_{vw}^2 + 14.9\%_{Renault}^2 + 12.5\%_{Toyota}^2 + 9.3\%_{Ford}^2 \ldots 1.8\%_{BMW}^2 = 917.09$$

Since the lowest known market share $ms_{10} = 2\%_{BMW}$ and the residual market share is R = 14.3%, and we assume that the unknown number of companies are equal to or smaller than BMW, then we may calculate the upper bound: Since $Q = R/ms_{12} = 3.64,$ the upper bound is:

$$HHI_{upper} \equiv \sum_{i=1}^{M} ms_i^2 + Qms_{10}^2 = 911.06 + 13.71 = 925.38$$

This gives an interval estimate of the HHI in the automotive industry:

$$911.06 < HHI < 925.38$$

Though the C4 ratio alluded to the industry being a loose oligopoly, our HHI calculation shows that it is far from being even moderately concentrated by US Department of Justice standards. Assuming that the number of automakers is approximately 40, the concentration is significantly closer to the lower bound. That being said, the twelve actors in the traditional industry manufactures 92.93% of global output, which gives them significant clout in bargaining with regulators, suppliers and buyers.

4.6 EV Sales

Global OEM EV Sales		YTD 2018	Share
1	Renault-Nissan-Mitsubishi *	97,696	10.78%
2	Tesla	91,201	10.07%
3	BYD **	90,436	9.98%
4	BMW *	71,185	7.86%
5	BAIC **	67,552	7.46%
6	SAIC **	66,207	7.31%
7	VW *	65,847	7.27%
8	Geely **	53,795	5.94%
9	Hyundai-Kia *	38,371	4.24%
10	Chery **	30,973	3.42%
11	GM *	29,570	3.26%
12	Toyota *	28,195	3.11%
13	Daimler Group *	25,785	2.85%
Traditional Automakers in top 20		356,649	39.37%
****Chinese Automakers in top 20***		308,963	34,10%
Others		150,040	16.56%
	World Total	905,958	100.00%

Table 11: Source, EV-Sales: August 31, 2018 Global Top 20

In Chapter 2, we examined the nine best-selling EVs. In a previous subsection, we analyzed the global EV fleet and penetration, which is increasing due to growing sales. Global automakers engage in asymmetric competition. This means that actors are not equally interested in the same markets, why competition for various segments differs, and local presence of all brands is not given.

Looking at the EV sales of 2018, the traditional automakers delivered 39.37% of all EVs, while Tesla alone delivered 10.07% Just seven of the top twelve automakers are represented in the top twenty global EV sellers. They are displaced by the Chinese automakers, who have sold 308,963 vehicles corresponding to 34.1% of global EV sales. The Renault-Nissan-Mitsubishi Alliance is the best-selling OEM, just barely outperforming Tesla in H1 2018 global sales. These numbers however are bound to change soon as the Model 3 exits production lines in droves.

BMW comes in on a top 4. A strong position for a carmaker with a 1,4 million output relative to VW who sold almost the same number of EVs out of a total production of 11 million cars. In January 2017, Toyota announced that it had sold more than 10 million Prii; however, the bulk of them are hybrids without a plug, which disqualifies them as EVs. The PHEV version is the fifth best-selling EV of all time, but so far in 2018, sales of EVs have landed Toyota a position as 12th best selling OEM despite producing almost 9 million vehicles in total. This position is in fact, just above Daimler group, who has produced just 3,2 million.

This goes to show that the luxury marquees (BMW, Daimler and Tesla) have been capable of securing a solid foothold, much larger than the more pragmatic automakers focused on the mainstream market (VW, Hyundai, Toyota). This supports Moore and Rogers theory about affluent buyers relatively higher propensity to try and buy something new.

4.7 Summary

Current production of and the market for cars is dominated by China. Consequently, local legislation and government policy has a big impact on the industry, and Asian standards - particularly Chinese - might come to affect the global industry more than it already does.

The penetration of EVs is still low. Rogers and Moore theorize that 16% market share is the tipping point for mainstream adoption, and that is still years away - however, due to exponentially growing sales, and hospitable pockets in the global marketplace, the EV dominating future might come soon. Coming back to RQ4, more EVs on the road help convince other consumers about the benefits of switching, and gradually requires the improvement of necessary infrastructure, which conversely facilitates higher sales.

The traditional automakers produce 92% of all vehicles. This gives them ample control and power. Competition is sound, with no single entity is dominating the other. The market concentration is loose, but industrial output is massive and should put off potential entrants. Nevertheless, in the niche of EVs it is clear that Tesla has a distinct advantage over the established industry. With the latest sales number from August (Loveday, 2018), it is clear that Tesla is in the lead for EVs.

Chapter 5: Nine-Forces Analysis

In this chapter we analyse the present state of the automotive industry in order to answer the the research statement. We begin with the macro-level impact of political, economic, social and technological pressure on the market structure, and the challenges it imposes on the established automotive industry. Particular focus is given to the political and technological developments as they have enabled the current era of ferment. After this analysis, we consider the five-forces laid out by Michael Porter in an industry level analysis.

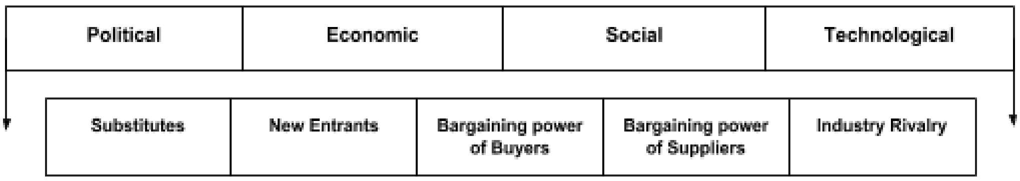

Figure 9: PEST and Porter's Five Forces

5.1 Macro level: the PEST-Analysis

5.1.1 Political

In this subsection, we examine the macro political attitude towards zero emission vehicles (ZEV), and transition to sustainable transport. Because the political responses to climate change have had a crucial effect on the feasibility of developing BEVs, we need a detailed overview of how the world leaders have acted and reacted. We begin at the global level, and then dive into the regional levels with focus on American, Chinese and European policy. This approach allows us to include and compare the salient characteristics across regional competitive environments.

Naturally, global warming is a international political issue. A recent study by Aengenheyster et al. published in August 2018, on when we at the latest have to start ambitiously to reduce emissions, the conclusion is that time is dear: if we are to limit global warming to 1.5°C in 2100, we have already passed the point of no return if the share of renewables in the energy mix continues to increase by the current 2% a year - and we only have until 2027, if we increase that to 5% a year. This results in direct pressure on the automotive industry to deliver cleaner cars. According to data collected by the International Energy Agenture (2017), three sectors produced nearly 85 percent of global CO_2 emissions from oil, gas and coal in 2015: electricity and heat generation generated 42 percent, transport 24 percent, and industry 19 per cent. Road vehicles, and therefore ICE, accounted for 5,695 of the total 11,169 mio tonnes oil-based CO2 emissions in transport (IEA, 2017). With the automotive industry directly responsible for 50.1 percent of emissions from oil, and 17.6 percent of the total 32,294 mio tonnes CO2, ICE is a key to limiting emissions. However, despite 30 years of global political attempts to curb the impact of greenhouse gas emissions, progress has been slow. The goal of reducing emissions, according to PWC (2007), must be balanced between maintaining industry competitiveness, maintaining social acceptability of products offered, and maintain tax revenues for governments. Economic growth trumps environment.

5.1.1.1 The international community

In 1992, the United Nations adopted the Framework Convention on Climate Change. An international environmental treaty, with the objective to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC). The foundational Kyoto Protocol was been widely criticized (Schiermeier, 2012), mainly for being unambitious; and for putting the onus on the rich, developed countries, with no obligations for the less developed countries. Kyoto Protocol adopted in 1997, came into force in 2005, requiring the developed countries to reduce their 1990 level greenhouse gas emission by 5 per cent from 2008-2012; this led to the trade of emission permits, which was intended to stimulate green investments. However, meanwhile the regional emission of CO2 had changed dramatically.

In 1990, the developed nations including the United States were responsible for 60 percent of global emissions - a decade later, the less developed nations including China accounted for more than 50%. Already at the original negotiations in Kyoto, President Bill Clinton said that the US would not ratify the pact unless China and other developing countries accepted the pledge. This caused the US senate to vote against ratification (Schiermeier, 2012), meaning the US did not accept the obligation to cut emissions; and caused Japan to do the same, as it would put them at a disadvantage relative to their biggest competitors. Pursuant to the meagre support for Kyoto, and the failure to reach an agreement in at the COP15 in Copenhagen in 2009, 195 national governments finally came together in 2015, and adopted the first-ever universal, legally binding global climate deal. At COP21 in Paris, the countries agreed to limiting global warming to 1.5°C; keeping the increase in global average temperature to well below 2°C above pre-industrial levels; the need for global emissions to peak as soon as possible, and to undertake rapid reductions (EU, 2015). According to World Resource Institute (2017), emissions had peaked in 49 countries by 2010, including the EU and US, corresponding to 36 percent of global emission; Japan has made unconditional commitment to peak by 2020, and China has implied that it will peak before 2030, which corresponds to 60 percent of global emissions. Obviously, the delays in emissions peak require larger future decarbonization reduction in order to stay within the 1.5–2˚C target. However stumbling the efforts of the international community, there is a globally agreed upon aim at reducing emissions, and this pushes the automakers change their ways.

5.1.1.2 United States

Being the world's largest economy, the birthplace of modern automobiles, and previously the largest market, the American policy has had and continues to have a huge impact on the automotive industry. Regulated by both the federal government and states, the primary incentives are financial, including tax credits, for lowering the up-front costs of EVs. In 2009 (EERE), President Obama set the goal for the US to be the first country to have a million EVs on the road by 2015. With a USD 2.4 billion in federal funding for advanced batteries, related components for EVs, and deployment projects, the president sought to promote environmental sustainability and boost employment.

In order to promote ZEV, the US Federal Government initiated a tax credit for PEVs purchased after December 2009. Depending on battery capacity, passenger seats and total weight, the credit ranges from USD 2,500-7,500 until the manufacturer sells its 200,000th EV, after which the credit is scaled down to half for the next six months, and then halves again for six months before expiring. It also implemented a tax credit of USD 50,000 for businesses that installed charging equipment, and 2,000 for individuals. Tax credits are much larger incentives than tax deductions. Since American citizens pay about a third of their income as federal taxes, the buying power of a credit is about three times higher. This has led many observers (Howard, 2018) to speculate that Tesla has deliberately waited for their production capacity to intersect with the 200,000 sales target, as it would give their buyers an advantage both parties can exploit. Others (Stewart, 2018) however point out that the timing is terrible as the federal help artificially closed the gap between ICEV and EVs for consumers. In March 2018 (Yingling), the 36 largest energy providers asked Congress to keep the tax credit, as it is essential to foster rapid adoption of ZEV. This comes at a time, they wrote, when market is just about to take off as consumers are given a wider range of choices - and naturally, it would be beneficial to the American energy industry. Tesla's Elon Musk has remained remarkably quiet on the matter, presumably because it gives an advantage to other EV manufacturer that Tesla is no longer eligible for (Stewart, 2018). According to Inside EVs (July, 2018), GM should be close to the 200,000 vehicles limit and credit phase-out, followed by Renault-Nissan-Mitsubishi provided the sales of the Nissan Leaf picks up again.

Nevertheless, the US market failed to reach Obama's one million EVs by 2015. In November 2017, the Republican party announced that it would roll back Obama's pro-EV and sustainable energy policies. This led General Motors (Blanco, 2017) to release a statement, encouraging Congress to reconsider: "Tax credits are an important customer benefit that can help accelerate the acceptance of electric vehicles. Because General Motors believes in an all-electric future, we will work with Congress to explore ways to maintain this incentive." When the bill was passed, the incentives for EVs remained in effect.

In the US, California has always led the pack on the green path. As previously described in the story about GMs EV-1, since the early 1990s the California Air Resources Board (CARB) has worked towards ZEV, requiring automakers to produce 2% of their fleet emission-free by 1998, scaling through to 10% by 2003 (Wade, 2018). With California being the world's fifth-largest economy, its comprehensive approach to to eliminate emissions set the standard. In 2015, California passed a bill for 50% by 2030, and after that, New York and New Jersey followed suit with similar mandates, with Oregon implementing a slightly less aggressive 50% by 2040 policy (Roselund, 2018). In August 2018, the California Assembly passed the SB 100 bill, which mandates a state move to 100% zero-carbon electricity by 2045 (Ibid). Currently, eleven states have adopted the California ZEV requirements. In 2018, California Governor Jerry Brown signed an executive order calling for 5 million ZEV by 2025 (IEA, 2018). Because the Environmental Protection Agency (EPA) has relaxed emissions standards, IEA (ibid) finds the EV adoption on a national scale will falter. Their report warns that as some states follow California's lead and others do not, the EPA's new policy could effectively divide the US into two markets.

According to Cohen (2017) the "Can't do"-approach prevalent in US automakers, will not serve them well. They know, he writes, that the disappearance of ICE is a matter of when, not if. In this race, the companies that build the best EVs will win market dominance, and obviously no-one wants to hand over that that business to manufacturers in Europe or Asia. In an attempt to create jobs and protect the US automakers, President Trump is trying to recreate an industrial past that is gone for good (ibid). Trump considers renewable energy "very, very expensive" and "not working on a large scale" according to Stewart of the New York Times (2018). To Trump, a wind farm in California looked like a "junkyard" that kills birds in vast numbers. Not surprisingly, the president withdrew USA from the Paris Agreement. This means that the world’s largest economy no longer seeks to reduce emissions in concert with the international community - as the only country in the world. Though production is low, the US automotive industry is still very influential on a global scale, so the impact of the limited political pressure will be interesting to follow in the years to come.

5.1.1.3 China

Over the past decade, as we have seen in Chapter 3, the main production and markets have relocated to Asia. China is one of the most profitable markets, and no automaker can afford to be shut out of the country, why all have to abide by their rules (Perkowski, 2018). The competitiveness of the Asian industry stems from the large size of their home markets, and dominant high market shares, which serve as a platform for overseas sales. However, whilst Japan's and Korea's automobile industries are highly competitive, Chinese manufacturers have been excessively dependent on the Chinese domestic market (Shioji, 2012). In 2017, according to China Association of Automobile Manufacturers (Marklines, 2018) a total of 639,000 passenger vehicles were exported. Thus at the moment, Chinese automakers pose no threat to the Japanese, US and EU manufacturers; furthermore, they are primarily focused on low-end segments in developing countries.

A particularly outstanding feature of the Chinese industry is the central government’s considerable support and control. At the entry of the People’s Republic of China into the World Trade Organization in 2001, many domestic automakers feared that the local industry would be wiped out by the regional and global competition (Harwit, 2001). That did not happen. Understanding why that was a concern, and why it did not happen, requires a quick go-through of the communist influence on the industry (recap of Niewenhuis & Lin, 2015). The Chinese automotive industry dates back to 1952, from which it was subject to the first five-year plan; in 1979, the state nationalized all companies, and organized them in a monopoly; in 1986 the industry was named a pillar industry, and direction of production was switched from trucks and busses to ordinary passenger vehicles. However, technological know-how was almost non-existent, so the government opened for international joint ventures. In 1988, the government enacted a new strategy: it set up high tariffs to protect is domestic industry, raised entry requirements for manufacturers, and focused on joint ventures to acquire know-how (ibid). From 1988, it supported six companies, that would go on to set up joint ventures, such as: Peugeot Beijing Jeep, Tianjin FAW Xiali, SAW, FAW-Volkswagen, Shanghai-Volkswagen, SAIC-Volkswagen, Guangzhou-Honda. In 2001, when China entered WTO, the central government relaxed entry restrictions to domestic private companies, and granted permission to four indigenous firms: Chery, Geely, Hafei and Brilliance. In the early 2000s more joint ventures followed: Changan-Ford, Beijing- Hyundai, Brilliance–BMW, and Dongfeng-Nissan. In 2003, BYD started making cars in addition to its main business, batteries; it is now the top six best-selling EV automaker (Chapter 2 and 3).

However successful the strategy was in enabling the production surge covered in Chapter 3, it failed in acquiring the high-tech innovations, and because of the state-owned companies, competition failed to develop new technology (Niewenhuis & Lin, 2015). Nevertheless, as a result, the development in the Chinese automotive industry over the past ten years, has been nothing short of remarkable.

Now, China's EV adoption rate and nominally highest fleet and production is also the result of other policies. In the tenth Five-Year Plan from 2001-2005, the national policy on New Energy Vehicles (NEVs) began with a number of pilot cities chosen for steered adoption (Niewenhuis & Lin, 2015). It focused research on three powertrain technologies, pure EVs, hybrids and FCEVs, and the critical components the three have in common, controller system, motor and battery. In the eleventh Five-Year Plan from 2006-2010, emphasis shifted to the component side, and in the twelfth Five-Year Plan from 2010-2015 (ibid), it was specified that pure EVs were the preferred technology.

From this followed a wide scale deployment of charging infrastructure within the successful pilot cities, government centres and capital. Furthermore, the central government required that the pilot cities and regions had to purchase a minimum 30% of non-local vehicles, and removed permissions to restrict non-local vehicles in order to break local protectionism (ibid). With its exemption from the Kyoto protocol, China had little incentive in the 2000s to focus on green energy to enable the rapidly expanding economy. In order to combat pollution and traffic congestions, China imposed vehicle registration quotas, from which EVs are exempt and with a sway of other incentives China aims for EVs to take 12% of the market share by 2020 (ICCT, 2017). China's central governments paid a generous subsidy of up to USD 10,000 for the purchase of a BEV depending on the range of the vehicle (Perkowski, 2018). That subsidy has just been redrawn, and instead of letting the government take the brunt of costs associated with making EVs attractive, China has now shifted the cost of procuring cheaper EVs to manufacturers.

In April 2018, China's New Energy Vehicle (NEV) mandate, based on California's ZEV mandate from CARB, came into effect after its announcement in October 2016 (ICCT, 2018). This has given the automakers short time to adjust. With the aim of introducing greener vehicles into the fleet, manufacturers producing or importing more than 30,000 vehicles, are required to offset the corporate average fuel consumption (CAFC) by a target growing 2% yearly from 8% in 2018 by generating NEV credits. Surplus credits may be carried over to the next year, or bought and be sold off to other companies to help them meet their CAFC requirements (Ibid). Credits are awarded for the combined sales volume of an individual car's performance in electric range, energy efficiency, and power of fuel cells. A BEV or FCV with a 350 km range earns 5 credits, a 250-350 km range earns 4, and PHEVs with a 50 km range earn 2 credits (ibid). Thus, a Mitsubishi Outlander PHEV get 2 credits, whereas the Tesla Model S BEV gets 5 credits. The penalties for failing to comply with NEV are harsh, ultimately leading to the denial of approval for a given vehicle to be sold in China, and the suspension of total production until CAFC has been recalculated and becomes compliant (ICCT, 2016). In order to understand the pressure NEV places on manufacturers we calculate an example.

Given that Renault-Nissan-Mitsubishi has a combined output of 10.6 million vehicles (Chapter 3), with a CAFC target of 8% in 2018, the alliance needs to earn 848,000 NEV credits. Assuming that their yearly EV production is 180,000 (equal to 15,000 vehicles a month), shared between their three bestselling models, Nissan Leaf, Mitsubishi Outlander and Renault Zoe, in an order similar to 2018 sales respectively of 55%, 22% and 22% then calculations are as follows:

$$108{,}000*3 + 36{,}000*2 + 36{,}000*3 = 504{,}000 \text{ NEV Credits}$$

This results in a deficit of 344,000 credits, which Renault-Nissan-Mitsubishi either has to buy from another manufacturer, or earn itself by revising the production line. The first option thus incentivises manufacturers to produce more EVs to earn excess credits, and gives pure EV manufacturers like Tesla a distinct advantage as it can sell all its credits. The second option encourages automakers to improve on the EVs range, with a preference for BEVs. If for instance the Nissan Leaf improves its 242 km range to 250 km, it would earn 1 extra credit for every unit in the whole production, resulting in a total of 612,000 credits. Relative to the costs of upgrading battery capacity, the interest in paying a competitor to do so, must be small - but it might prove necessary to meet CAFC target. With electrification and upgrades across the whole production Renault-Nissan-Mitsubishi will come closer to the mandated number of credits in 2018. However in 2019, as the CAFC increases to 10%, the company will need to buy excess credits from other producers, for instance the new all-electric Chinese manufacturers. The NEV thus marks a decisive turning point for the traditional automotive industry, and a key impact on the strategic allocation of resources. China is the most important market for automakers, and it the strict influence of government regulations are bound to have a high impact on their general strategy.

5.1.1.4 European Union

In 1998, the EU signed a voluntary agreement with the European Automobile Manufacturers Association (ACEA) that required a 25% reduction of CO2-emission from the 1995 level of 186 g/km to 140 g/km in 2008. Back then, Europe was the biggest market, and however, ambitious the plan, the industry failed to deliver. The European Commission compromised to an average of 130 g/km in 2012, which came about after fierce lobbying as the original target was 120g, according to the New York Times (2007). FIAT’s chairman Sergio Marchionne argued that the regulation would add EUR 3,650-4,800, to the average retail price of a new car, and move thousands of jobs overseas. Spokeswoman Sigrid de Vries of ACEA summed the crux of the matter for policymakers: "The risk is that it will lead to a loss of jobs and production in Europe, while making cars more expensive for consumers" which of course is difficult for any politician to tolerate.

The disclosure of VW Group’s scandalous tinkering with diesel emission numbers, shook the industry, national governments and the population in EU. According to Bloomberg (September 2018) “VW knew by 2008 that they wouldn’t be able to meet US pollution standards,” and consequently installed software that could detect and cheat authorities. As the world’s number one producer with a brand rooted competence, the repercussions estimated by Bloomberg in the order of USD 10 billion, are beyond the scope of this thesis, but it is safe to say that the on-going trial and reputational damage has not only hurt the reliability of a national symbol of pride, it has also caused diesel in particular, and fuel in general, to fall out of favour. Now diesel cars are being banned in cities like Hamburg (Meyer, 2018), and in all of UK and France from 2040.

The EU remains firm in decarbonizing transport. In September 2014, the European Parliament passed the Directive for Alternative Fuel Infrastructure. It stipulates that member states must ensure enough charging points for EVs and compressed natural gas cars to circulate in cities and suburban areas, and that charging must follow the same standards to secure interoperability (DAFI, 2014). Since September 2017, the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) has been used to test CO2 emissions, which has established the 2021 EU fleet benchmark at 95 g/km. In July 2018, the European Parliament adopted new post-2021 CO2 targets, whereby it expects to reduce CO2 by 179 million tonnes from 2020-2030 resulting in better air quality, create 70,000 additional jobs and strengthen the competitiveness of the EU automotive sector, and use and import less oil, hoping to save 380 million tonnes of oil from 2020-2040 worth around EUR 125 billion (EC, 2018). The target going forward is a reduction from the benchmark of 15% in 2025 and 30% in 2030. In order to make the industry comply with the rules, the Commission will penalize the automaker by EUR 95 per g/km exceeding targets for each newly registered vehicle. To support a gradual and fair transition, the target is an average of the whole production, with ZEV given more weight to incentivize investment (EC, 2018). According to ACEA (June, 2018), hybrids make up 67% of all electrified vehicles sales in Europe, but naturally only BEVs and PHEVs are recognised as ZEV. All in all, this will cut EU emissions 40% of 1990 levels, thus meeting the targets of the Paris Agreement.

5.1.1.5 Global EV Capitals

Although most regulations to facilitate the transition to sustainable transport is made on international and national level, metropolitan policy also shapes development. Cities complement higher level policy with local understanding. Clean vehicle policies help reduce CO2 emissions, pollution and smog which increases air quality. Naturally as the bulk of population is centered in cities, and EVs have a limited range, the majority of charging infrastructure is also found here, where it enables the market.

In 2016, 20 cities accounted for 40% the world’s EV stock, and 43% of global sales (ICCT, 2017). The bulk is found in Asia, being Tokyo and seven mega-cities in China; in America, Los Angeles, San Francisco, San Jose, and New York ; and in Europe, the mega-capitals Paris and London, in the Netherlands, Amsterdam, Rotterdam, Utrecht, and in Scandinavia, Oslo, Bergen and Stockholm. The highest concentration of public charging points are found in the Netherlands and Norway. Each city has carefully tailored regulations to facilitate ZEVs in the local context.

All cities are gradually implementing and electrifying municipal fleets, busses and car-sharing programs, and opening special lanes, parking spaces and charging infrastructure. According to the ICCT (2017) the different cities have pursued a mix of strategies to facilitate adoption. In Norway, EVs were initially exempt of tunnel and ferry tolls, charging and parking is free, and drivable in the bus lanes, allowing the user to bypass traffic - all have gradually been scaled back as EV volume grew. In some Chinese cities EVs are allowed to drive on days where ICE is banned from driving. In China and Japan, some cities supplement national incentives for new energy vehicles, by implementing valuable tax exemptions. This happens in Europe as well, for instance Rotterdam has a rebate for BEV in addition to Dutch government's incentives. In other cities, those who trade in an old or polluting vehicle are given benefits for their next car. Thus, cities speed up the transition to electric transportation.

5.1.1.6 Summary

The global political climate is gradually implementing harsher regulations to cut CO2 emissions. In in order to reach the Paris Agreement target, the automotive industry is forced to eventually phase ICE out of production. Much like the original 1990s CARB sought to compel the American industry to incorporate ZEVs in their fleets, the EU post 2021 targets obligates the European industry to either drastically reduce ICE-emissions or increase the portion of EVs. The Chinese NEV mandate clearly prefers BEVs, and because the Chinese market continues to grow the automakers have to abide by the policy.

The political climate has opened an era of ferment, where competing technologies offer the same solutions to transportation. As a response to climate change ZEV policy made EVs possible to produce and attractive to purchase. Conversely, it has cut short long-run interest in further developing ICE as it is bound to one day become obsolete. This has placed ICE at the end of its S-curve, and reshaped the beginning of the EVs S-curve. Following Cabral, the technology that gets the biggest base first, gets the lock-in advantage which sets off a virtuous cycle, that quickly lowers costs due to economies of scale and gives the producer a distinct advantage; and makes competing innovations superfluous. Answering RQ4, the overarching political influence on the socio-economic and technological level, is an inseparable condition for the widespread adoption of EVs.

In the first decade of the 21st century, China became the world's biggest car producer, with the world's largest car market and the world's biggest EV fleet (Chapter 3). This is due to centrally planned government intervention and protection. If Cabral is right, China will not only be able to adopt EVs with all the local benefits that follow, it will also dictate EV standards globally. An possible implication of this is that Tesla as such is not the disruptive force with regards to the global automotive industry, and because of the five-year plans; EVs would eventually have arrived.

5.1.2 Economic and Social

The automotive industry has a high impact on growth and development. In this subsection we briefly examine the macro-economic environment and social impact which in this case are so closely interlinked that we fit them in one subchapter. First, we glance at the prospects of growth, and in the following we quickly examine employment and mobility.

5.1.2.1 Global macroeconomic outlook

In the current UN ”World Economic Situation and Prospect” update from mid-2018, the short-term prospect for the global economy is continuing to improve. Unless otherwise stated, all references to economic factors and percentages are taken from said report. World GDP is expected to grow 3.2% in 2018 and 2019, an uptick from the forecast in 2017, because of the expected growth in developed economies, mainly the US.

The rising macro-economic conditions presents the opportunity to achieve a number of the Sustainable Development Goals because the raise in living standards; however, with that economic growth comes an environmental cost as well. According to the UN report (2018), global CO2 emissions increased 1.4% in 2017 due to economic growth despite the Paris Agreements efforts to decouple the two. This is because the cost of fossil fuels is still relatively lower than other sources of energy. The forecasted emissions growth is 0.4% annually between 2016 and 2040, compared to 2.2% between 2000 and 2016, mostly owing to EV deployment and renewable energy (ibid). The latter alone decreased total carbon emissions in 2017 by 5.5% and now produces 12.1% of global power generation. According to the UN, China at 45% is now the largest investor in global renewables; a title previously held by the EU since 2004.

The EU area is projected to expand by 2.1% in 2018 and 1.9% in 2019. The young members in the Baltics and Eastern Europe are expected to have higher growth rates than the old members. According to ACEA (2018) motor vehicles account for EUR 413 billion in tax contributions in the EU15, and the automobile industry generates a trade surplus of EUR 90 billion for the EU. However, the region as a whole is still in a period of uncertainty due to the exit of the United Kingdom. Asia’s regional GDP is set expand 5.8% in 2018, and 5.7% in 2019. The locomotive is still China. With a 6.9% and in 2018 and 6.5% growth in 2018 and

2019, policy makers need to find ways to maintain growth while ensuring the long-term sustainability. As we have seen in the previous subsection, China is actively seeking to reorient the automotive industry. Rare earths extraction and refineries are concentrated in China, and used in batteries and for the magnets in electric motors. This partially explains why China has chosen BEVs as the pet tech in the NEV mandate: The appreciation of EVs will result in higher demand for these materials, at which China stands to gain a considerable profit and control through its nationally controlled industry.

This shapes the whole industry. A key implication of widespread EV adoption, is then that the energy dependence of oil from primarily middle-eastern countries, might very well shift to a resource dependence of materials from China. This partly explains Toyota and other Japanese automakers focus on PHEVs and FCEVs (RQ3). Cheaper batteries will obviously facilitate the EV on the mainstream market (RQ4) and clearly the Chinese dominance will influence the market structure as a whole (RQ2) as the competitive force of suppliers rises.

5.1.2.2 Employment

Estimating the work force of the global automotive industry is not straightforward. According to OICA, auto manufacturing required 8,397,451 in 2017. Unsurprisingly, with China as the biggest producer, employs the largest workforce of some 1,605,000 individuals, while the US employs 954,210, and the EU+CIS and Turkey 3,227,432 (ibid). According to ACEA (2018) 13.3 million or 6.1% of total EU employment, work in the automotive or related industries, and the those in manufacturing represent over 11% of total EU manufacturing employment. According to the American Automotive Policy Council (AAPC, 2017), automakers, suppliers, dealerships and local shops comprise 7.25 million U.S. jobs, which in total contributes 3% to GDP. A similar figure for the Chinese automakers and related industry could not be found. Regardless, no other manufacturing sector generates as many jobs, and if the global automotive industry was an independent country, it would be the sixth largest economy (OICA, 2018). As automation takes away jobs in manufacturing, and the transition to autonomous, sustainable transport takes off, employment will be severely affected. Because the production and maintenance of EVs is less labour intensive, than ICE due to lower complexity and fewer parts, the societal impact will be tangible; however, EV production requires high-skill labor so efforts may be channelled in this direction.

5.1.2.3 Transportation

ACEA calls the new EU post-2021 CO_2 targets and policy unrealistic. Their June 2018 study outlines three barriers: affordability, infrastructure and investment. Currently, the EVs are only sold in the EU countries above the average GDP of EUR 34,000, which means 85% of all EVS are located in just six Western European countries. Due to this imbalance, 50% of all cars sold in Western Europe would have to be EVs to reach the required EU average of 30% in less than 12 years. According to ACEA (June 2018), at the current pace, the market share of EVs will be 3.9% by 2025 and 5.4% by 2030. This results in a clear split between the North-Western versus the Eastern and South-Eastern European countries.

The main purpose of a vehicle is naturally transportation. In cities, simple walking and mass transit lowers the demand for vehicles. According to the UN (2018), 55% of the world's population lives in city areas today; that proportion will increase to 68% by 2050. The world's urban population is highly concentrated within a few countries. Currently, 82% of the US population and 74% in the EU live in cities. While 90% of the world's rural population is currently found in Africa and Asia, the growth in India, China and Nigeria is expected to account for 35% of the growth in the world's urban population by 2050, as India which has the largest rural population (893 million), followed by China (578 million), will see and increase of 416 million and 255 million urban dwellers. Their needs for transportation are difficult to foresee, but air pollution is easy to remove entirely thanks to ZEV. Arguably, the 250 km range of common BEVs (Chapter 2) should be enough to cover daily distances.

Sprei, Jakobsson and Plötz (2017) studied the average vehicle kilometres (VKT) travelled in Western Sweden, Winnipeg Canada and Seattle USA with GPS and habits in Germany with a questionnaire, covering a total of 190,000 driving days and 9.5 million VKT. The averages in Sweden and Canada are 22 km and 35 km and 38 km in USA and Germany, and the corresponding 0.75 percentile is 72 km, 40 km and 62 km 65 km. Though their measurements are state of the art using GPS, and the samples are representative in car size and fuel types, there is a slight overrepresentation of senior-citizens due to an age-criterion. Their conclusion is that the users will be able to use their EV as they would use ICEV.

Regarding the way cars a used, one innovation in particular will have a huge impact on the social sphere: the autonomous car. After a transition period in which both human operated and autonomous vehicle drive on the road together, the latter will come to overshadow the first, and that prospect is like reading a fantasy: “Passengers, responsible only for choosing the destination, would have the freedom to do what they please in a vehicle. Disabled, elderly, and visually impaired people would enjoy much greater mobility.” (OECD, 2018). Governments will be relieved of traffic police costs, due to no ticketing and alcohol-impaired driving, traffic will be optimised when the vehicles can communicate which will increase throughout on roads and highways, simultaneously ”easing congestion and shortening commuting times” and inadvertently the cars will last longer as collisions become a thing of the past (McKinsey, 2014). This in turn will affect insurance companies, who will lose the market related to highway incidents, but retain policies for theft and vandalism. Obviously companies will be attracted by autonomous driving before consumers, as pay for human operators, i.e. drivers make up the bulk of costs in logistics. In the first instances, one operator will be able to drive a line of individual trucks that communicate together, in a relatively environment such as a highway. This will have a huge economic impact by considerably lowering prices on all goods, but it will also have social costs going forward because the chauffeurs will be put out of work. This is yet another example of how low-skill workers will be displaced by automation.

5.1.2.4 Summary

Following the UN prospect, the economic growth in China and Asia will continue to increase demand for vehicles. A key insight is that EVs are cheaper to manufacture and thus sell, which is a boon to consumers as transport levels rise, and the air in the cities will become cleaner without exhaust, and quieter without the sounds of pistons. This has huge implications for the automakers and their suppliers, as demand for their ICEV gradually disappears (RQ2). However, for society at large, this also means that jobs will be reduced, as the industry as a whole is disrupted.

This is why the political level has difficulty in dealing with obvious solutions to ending emissions - the economic growth and social-wellbeing in many ways depend on reliable transport. The social impact of EVs and automation, is difficult to foresee. On one hand a utopian future comes in view with driverless transport, on the other hand layoffs in the manufacturing and transport industry spells a significant social challenge.

5.1.3 Technology

The automotive industry is in a technological discontinuity between ICE and EV. As previously covered, EVs went head to head with ICEV in the early 1900s. The latter ultimately prevailed because of electric starters, cheap fuel and readily available infrastructure that enabled long-range travel. By the 1990s the EV returned, and over the past three decades the political, economic and social development has made EVs competitive again, which is why we now see an era of ferment (Abernathy, 1978). Besides the battery other alternatives for propulsion have made their way into cars.

In the following we consider four propellants: diesel, natural gas, hydrogen and battery, and the weight and volume of the system (and fuel, or cells) required to drive a distance of 500 km. A key difference is the refuelling time versus recharging. We see in the table below, that 33 L of diesel in tank with a total weight of 43 kg, provides the same propulsion energy as an 830 kg lithium-ion battery system. In other words, the systems give equal range, but the BEV is nearly 20 times heavier than the ICEV. In comparison, natural gas requires a heavier system than diesel, but a comparable fuel quantum, while hydrogen has a system three times heavier than a regular ICEV but a fuel requirement of only 6 kg. Naturally higher mass requires more energy to move, takes longer time to stop – which gives a theoretical advantage to lighter systems, however in practice, as we have seen in previous, according to Cabral (2008) the most convenient system will prevail.

	Diesel *Fuel*	**CNG** Compressed Natural Gas *Fuel*	**CGH** Compressed Hydrogen *Fuel*	**Battery** 100 kWh Lithium-ion *Cells*
Weight	43 kg (33 kg)	170 kg (37 kg)	125 kg (6kg)	830 kg (540 kg)
Volume	46 L (37 L)	200 L (156 L)	260 L (170 L)	670 L (360 L)
Refuelling	Less than 5 min			App. 8 hours

Table 12 : Weight and Volume comparison of 500-km range energy storage systems.
Source: GM's Conference paper, Vehicle Electrification – Quo Vadis, 2012

If range and speed of fuelling is the most important, the CNG and CGH is the most best system. Yet, ICE and BEVs have one distinct advantage compared to CNG and CGH - the supply infrastructure is in place. ING (2017) agrees noting that BEV will beat FCEV because the latter is too complex, very expensive and have limited infrastructure, and production facilities. Brownfield investments in old gas stations and logistics may repurpose them for carrying gas and hydrogen, but the electric grid is already in all homes and workplaces, and simply needs a plug to charge vehicles. In addition, the very way the individual cars are put together places BEVs at an advantage - they are the simplest to manufacture. According to ING (2017) the BEV powertrain consists of a motor and a battery package, comprising a total of 200 parts; by comparison, conventional powertrains consist of a the engine, transmission and exhaust, comprising a total of 1,400. In addition to these follow other crucial systems, for instance the fuel system. The problem with is the costs of having two systems in one vehicle, and making them work seamlessly together, which adds weight, thus lowering efficiency, and complexity which raises costs - and since neither systems is capable of going up against their purebred cousins, and the overall fuel economy is just a little better than ICE, hybrids are an inferior innovation. ING (2017) foresees that the breakthrough point for BEVs will come in 2024, when they expect the pieces of the "puzzle" to come together, namely range, price, infrastructure and TCO.

5.1.3.1 Well-to-Wheels

Besides being cheap, fossil fuel has one overarching advantage when it comes to producing energy; it is dependable. A conventional coal fired plant runs regardless of bad weather, be it lack of sun or wind. The problem with fluctuating renewables is that a 100% reliable mix is more costly to acquire, operate and maintain, unless a way to store excess energy is found. This is where hydrogen has an opportunity.

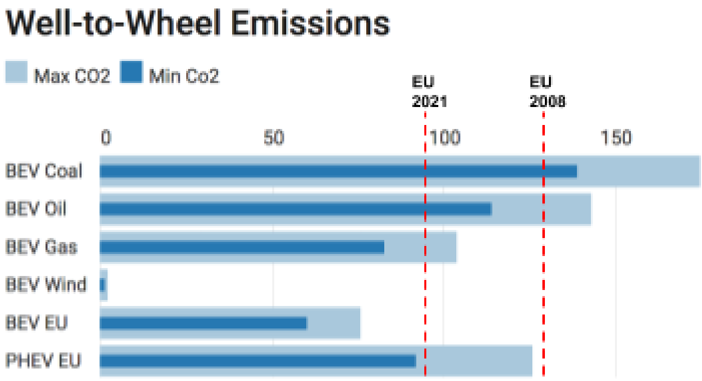

Figure 10: Adapted from figure compiled by Nördelof (2014) based on calculations by Edwards et al (2011) and Donnes et al. (2008)

EVs are only as clean as the source. Naturally, as a ZEV pollution will not happen in vicinity of the vehicle, but the same amount of CO2 will be released regardless of where a litre of fuel is burnt. Yet even in the scenario where EVs are charged by fossil fuels we see an alleviation in the fact that a single engine is an inefficient means of converting the chemical energy from fuel. According to PWC (2017) 62% of the potential energy is lost in a typical vehicle. The advantage of burning said litre in a highly efficient power plant is that less energy is lost in transition, and that the excess can be used for heating. In the figure above we see well-to-wheel emissions from BEVs powered by fossil fuels, wind and a BEV and a PHEV charged with the European electricity mix in 2008. The key is that BEVs charged with energy from coal do not meet current requirements, and BEVs powered by oil fail to meet the 2021 requirements. The EU energy mix has improved since 2008, so at maximum emission PHEVs will probably fit the 2021 regulation, just like BEVs powered purely by wind or the 2008 EU energy mix will. As that mix is reorients towards renewables, the combined emissions also decreases.

In order to meet the criteria, the traditional industry is downscaling ICE. Fuel economy on ICEV is improved via a number of initiatives, such as downsizing motors, lowering weight, improving aerodynamics to reduce drag, and autonomous driving to name a few. One R&D effort for reducing car emissions is cylinder deactivation or variable displacements, presently employed by Honda, GM, Chrysler and Mercedes-Benz (PWC, 2018). The principle is simply that under partial loads a vehicle does not need the excess 30% power for forward motion, why closing the intake and exhaust valves, yields an improvement in fuel efficiency and CO2 emissions of around 20% on the highway. But the investments might soon prove fruitless as the Chinese NEV mandate comes to put pressure on ICE. Following Foster (1986) ICE may soon cross the point where new investment to gain tangible performance enhancements relative to EV is feasible.

5.1.3.2 Improved batteries and the cost of EVs

Batteries currently make up 50% of the price on an EV. According to ING (2017) battery costs have fallen from an average $1000/kWh in 2010 to around $300 in 2016, and current leaders are moving towards $150 per kWh. In the years going forward, according to IEA (2018) the combination of improved chemistries, increased production scale, and larger unit capacity, will result in higher battery performance and lower price. This is exactly as envisioned by Foster's S-curve.

Currently, the core battery elements are lithium, nickel, and cobalt; but properties of other materials are incessantly researched. The IEA report (2018) notes that cobalt supply in particular, is subject to risks as nearly 60% of the global resources are concentrated in the unstable Democratic Republic of Congo; and furthermore, China controls 90% of the refining capacity. ING (2017) estimates that an EV powertrain costs around EUR 1,500, which is about half the average cost of an ICE powertrain. Nevertheless, with battery packs making up 35-50% of the total costs, the costs currently rise above those of an ICEV. This is why government incentives are important to facilitate adoption, which sparks a virtuous cycle following Foster S-Curve to invest in battery technology. This will at some point in the future decrease battery costs to a point where ICE becomes on par with ICE. Additionally, due to the political intolerance of emissions, stricter regulations according to ING (2017) may add EUR 1,000 to the cost of an ICE after 2020.

5.1.3.3 Infrastructure

EVs are spreading fast, and causally, charging infrastructure has grown enormously. In 2017, the number of private chargers at homes and workplaces is estimated at almost three million worldwide by IEA (2018). In addition, there were about 430,000 publicly accessible chargers worldwide in 2017, a quarter of which were fast chargers (ibid).

The US, has an estimated 16,000 public charging stations, and nearly 43,000 individual charging points (Coren, 2017). By comparison, there are 112,0000 gas stations. China is naturally the world leader due to its policies. In 2016, the country had 150,000 charging stations (Xinhua, 2017), and with the thirteenth Five-Year-Plan (2016-2020) aiming to power the demand of 5 million EVs by 2020, the plan is to build 800,000 charging points. In the EU there are approximately 150,000 charging points (EAFO, 2018), of which 76% are located in just four countries - 28% in the Netherlands, 22% in Germany, 14% in France, and 12% in the United Kingdom (ACEA, June 2018). By comparison, gas stations in the EU number 121,000 (ING, 2017). Again, because of the issues with affordability and infrastructure investments, the Eastern and South-Eastern European nations have hardly any EVs or charging points. Naturally the charging stations gravitate around population centres and key highways, but gradually, as battery range is extended and prices for EVs go down, the charging points will expand to other areas as well.

As previously mentioned, Toyota and the Japanese automakers prefer FCEVs to BEVs. According to Reuters (March, 2018) the Japanese government plans to have 160 hydrogen stations and 40,000 FCVs on the country's roads by March 2021; and by 2030, it wants 900 stations to service some 800,000 FCVs. By then, the government expects the price of hydrogen to fall from USD 0,9 to USD 0,3 per normal cubic meter, resulting in a USD 20 for 500 km range as per table 11. With the significant output of the combined Japanese industry, and Toyota's world leading position, the era of ferment regarding the future propulsion is not easy to foretell. It might be the case that FCEVs will be limited to Japan, while BEVs take over the rest.

5.1.3.4 Summary

The impact of technology cannot be understated. As we have seen, ICEV is nearing the end of its life cycle. We are in the early stage of a technological discontinuity, because the market structure due to restraining policy, higher oil prices, and increased demand for greener transportation, transfigures EV as the more feasible technology. The transition from oil is an incremental innovation to an existing system, which has made charging infrastructure development worthwhile, and caused falling battery prices in tandem.

Self-driving cars will radically alter the societies in which they drive, and this radical innovation will disrupt the automotive industry. Industry rivalry as a result is intense, in short because getting there first will mean all the difference. ICE will not disappear overnight, but gradually see itself crowded out by EV.

5.2 Industry Level: Porter’s Five Forces

In the following we examine the pressure of the five competitive forces. We begin with the horizontal forces, the threat of substitutes and new entrants, and then analyze the impact of the vertical forces, the bargaining power of buyers and suppliers. Finally, we examine the internal rivalry.

5.2.1 Threat of Substitutes

Substitutes are products and services that offer the same or similar benefits, in this case of a car, the threat is the risk level automakers face from replacement of a substitute. Throughout this thesis we have examined how the EV acts as a substitute to ICE in the powertrain of a car, but we have not looked at cars in general. These are easily substitutable.

If we define transportation as carrying people or goods over a distance, obviously a number of things may do the trick. On a spectrum, we have large ships, trains, planes and other systems to take loads of people and goods over a long distance, and in the opposite we find skateboards, bikes, animal carriages, and wheelbarrows, that will only be able to bring a person and small load over a short distance. From a western point of view, the latter part of the spectrum may come off as unserious, but in the developing economies these contraptions fill market gaps, enabling social and economic interaction to a very high degree.

Acting as the missing yet affordable transition between an bike and a car, micro-EVs are not required to meet the same crash tests as cars, cost a fraction, and may be operated by minors - and as automation matures, disabled, elderly and obese citizens will turn to these vehicles just like we already see small BEVs operated in airports and golf clubs. Harrop (2018) estimates the market for these vehicles to reach USD 41 billion in 2028, with Southeast Asia as the main market, where the ubiquitous ICE-tuktuk and rickshaws will be replaced by micro-EVs in millions to reduce emissions. Following China's policy to end pollution in cities, which banned motorcycles and scooters with ICE, all two-wheel vehicles are now BEVs. According to Wang (2017) there are already some 200 million electric bikes in the world, mostly produced and sold in China. A further disruption scenario concerning these low-range vehicles, is that they do not require long charging sessions, and even more futuristic, some might even operate independent of the grid via on-board solar panels.

Yet, micro-segmentation of transport is not the only threat of substitution to cars as we know them. Autonomy will play a key role in disrupting the world as we know it. In February 2017, (Ford Media) Mark Field, CEO of Ford Motor Company, stated that the company is transitioning to become an automaker, and a mobility company . This entails a particular focus on autonomy, and the company plans to deliver the first high-volume driverless car in 2021. To do so, Ford has created the independent company Argo AI with a leading team former Uber and Google employees, and the plan is to develop a software based product that can be licensed to other companies (Ford Media, 2017). Alphabet, the parent of Google, has another subsidiary Waymo, who is one of the leaders in automation. It has signed a contract with Avis to automate their global fleet, and recently announced that they would supply automation systems to 20,000 cars from Jaguar Land Rover and another 62,000 from Fiat, beginning fall 2018 (Lee, 2018). Waymo has already driven 9 million miles of driverless transport on the public roads of California (Herger, September 2018) and is widely considered the forerunner. GMs is a serious contender with its autonomous driving program Cruise, which has driven some 100,000 miles, and will be released already in 2019 in a Chevrolet Bolt at SAE level 4 without steering wheels and pedals (Hawkins, 2018). Non-automakers, but transport and mobility operators like Uber and Lyft, who have recently turned global taxi services upside down using their proprietary apps, similarly plan to offer autonomous driving at SAE level 4-5. How many miles Uber accomplished before a fatal crash forced them pause their program (Lee, 2018), and how many miles Teslas fleet of 200,000 auto-piloted models have driven, is unknown. But the four are the world leaders.

Lastly, new business models have emerged as automakers reinvent themselves as mobility service providers. BMW has made a clever move with DriveNow - a pay-to-go system using BMW i3 vehicles within a city zone, which at the same time shows customers that EVs are capable of fulfil demands at a very low price, and prepares an organisation in advance for an autonomous fleet operator. Roland-Berger (2018) estimates that vehicle sales for new mobility services will exceed 10% of new car sales by 2025 in the US and the EU.
As stated in the beginning, transportation can be viewed on a spectrum. Naturally, the disruptive innovations in automation and BEV, will spill over in the large vehicles too. In fact it already has, as their operating environments are much less complex - airplanes have autopilots that take over in march height, transport vessels navigate using GPS on legs, and trains in metros have been without operators for years because the tracks are sealed off. The impact on a global scale of these innovations cannot be understated. It will send ripple effects through our global supply chains, employment and manufacturing, and just as Schumpeter envisioned, from this creative destruction a new paradigm will rise.

5.2.2 Threat of New Entrants

What enable Tesla to grow from a hand-built, low volume producer was the acquisition of the Fremont plant - a tangible resource that gave Tesla the ability to churn out cars in higher numbers, even though it has yet to reach the capacity of the established actors. This was a coincidence of Musk's charm on Toyota and good timing, as GM bankruptcy forced it to hand off the site. For a new new entrants to get hold of a similar site, an enormous amount of cash would be necessary. The industrial capacity and output of the world's automakers is impressive. With a combined market share of 92% the top twelve have a strong advantage over potential entrants. OICAs world map (2018), shows 750 production plants. In other words, the tangible resources in the industry lifts the entry barrier up very high.

Tesla has managed to emerge in this environment for a number of reasons. Primarily because it saw an untapped market, and had the strategic resources to capitalize here against all odds. Others have tried to follow Tesla, and previous employees - even founders of the company - have tried to copy the same recipe for success, but most have failed, and the ones that still exist have too little output and market cap to be studied in this thesis. In a study of some 450 EVs introduced to the US market from 2003 to 2011, van Wee (2012) find that startups generally targeted the small market segments where consumer demand was minimal. In the sports car segment, price is less of an issue and in other segments range and speed are of less importance, which allowed for low production volumes. The traditional industry exclusively went for the safer bets, and developed a number of models in the mini, small, compact, and sports car classes, thus leveraging the “references and relationships” that Moore observed.

However, as seen in the literature review, innovation tends to come from the outside of the industry because automakers are myopically focused on what they do best. This makes them susceptible to changing business models, which opens the door to new entrants. As seen in the previous subsection, automation will shake up the world of transport. Just like the mobile phones became “smart phones” in the course of 2000s, the cars of the 2010s have been digitalized. A modern premium vehicle, according to Roland Berger (2018) has software spanning 100-150 million lines of coding, which is about 2-3 as many lines as Microsoft Office 2013, and 5-8 times as many lines as a Boeing 787 control system, and the autonomous vehicles will require even more. SAE level 5 vehicles do not need a driver to go from a to b, which means well-planned use of the vehicle may extend the usability of the car from one owner and household, to multiple users. This will disrupt private car ownership, as seen in the previous subsection, the software giants of Silicon Valley have set their targets on autonomous driving. They for sure have the strategic resources to secure a beachhead and land an invasion following Moore’s theory.

5.2.3 Bargaining Power of Buyers

Currently, buyers are individual purchases that buy a single vehicle at a time. This results in low bargaining power. Had the main buyers been primarily large volume government and corporate fleets, then they would have been better able to negotiate prices with the industry. Nevertheless, the propensity to consume is what drives the market. Since all cars have the same fundamental utility as a transport provider, switching costs are low, and as EVs become cheaper, demand grows. However, strong brands create loyalty, and risk averse behaviour in the mainstream segments, may serve to the advantage of the traditional automakers. However, as soon as the EV crosses the chasm, and the base of users becomes big enough to lock-in, the mainstream will have no choice. Consequently, the collective bargaining of buyers is low, to a point where it does not threaten industry profits.

In 2011, Deloitte surveyed 13,000 individuals in 17 countries between November 2010 and May 2011, and revealed that the majority of consumers would either be a first mover in the adoption of an electric vehicle or at least willing to consider purchasing an EV. Deloitte found that their first mover respondents are upper or middle-class urbanites or suburbanites, generally well-educated, with a higher-than-average number holding post-secondary degrees. They view themselves as environmentally conscious, tech savvy, trendsetting, and politically active. To this segment, the EV spells “coolness,” convenience, safety, stylishness, and good value. On this latter point, potential first movers are sensitive to government incentives, fuel efficiency, and the cost to charge a battery. They are appealed by the perception that these vehicles are cleaner, more environmentally friendly, and more efficient than traditional ICEV. Of the drivers surveyed by Deloitte, 80 percent typically drive less than 130 kilometers per day, but consumers expect EVs to travel considerably farther. Obviously, only a few consumers would be willing to pay a premium for an EV. In the US 78% would pay less than USD 30,000 and 34% would pay less than USD 20,000. Deloitte see the key factors to EV adoption as range, charging convenience, and TOC.

Following ACEA, European consumers are sending a clear signal: there are still too many barriers – such as lack of infrastructure, affordability and range – for electrically-chargeable cars to replace diesel or petrol vehicles (ACEA, June 2018). The European car industry welcomes financial incentives, and acknowledge that EVs make an important contribution towards sustainable transport. From their point of view, tax measures help shape consumer demand towards fuel-efficient cars, and facilitate a market for breakthrough technologies, in the crucial breakthrough phase, as innovations generally first enter the market in low volumes at a significant cost premium. Positive policies offset this premium and fosters demand, they write (ACEA, April 2018). However, ACEA also reminds policy makers that ICE necessarily will play a dominant role for years to come, and the policy must factor in other emission effective technologies.

5.2.4 Bargaining Power of Suppliers

Suppliers have a crucial role in the automotive industry. The value chain is located in several locations across the globe, where a multitude of different companies and clusters specialise, and operate as first, second and third tier suppliers. Because the suppliers obviously manufacture the components that go into the finished cars, and thus also the spare parts that account for 40% of the overall industry profits alone, thanks to the aftermarket (ILO, 2010). These suppliers are now at a crossroads between producing parts for ICEVs and EVs, because when the first becomes obsolete, the suppliers go out of business. There is therefore considerable pressure on suppliers, which means their bargaining power is low.

The biggest threat against them is the shift to electric powertrains, as almost a third of the value of the automotive supply chain is powertrain related (ING, 2017). The implication of an impending creative destruction on the automotive industry is a paradigmatic, and suppliers in the value chain for the old paradigm will have to follow Teece’s (1980) advice on how to best utilize their resources, leading to divestment of infeasible assets. Oil infrastructure will become obsolete, which means gas stations and oil tankers will disappear. Multiple jobs in manufacturing will be outsourced (ING, 2017), as powertrain development and production shifts from car manufacturers to generic suppliers and/or battery suppliers. Currently, because few automakers have in-house specialty in the EV arena, they rely on suppliers to a higher degree, and most BEV models have battery packs from major suppliers such as LG, Samsung and Panasonic (ibid). Estimating how this development impacts bargaining power is difficult: on one hand the key suppliers are concentrated in the EV arena, but the other compenent supliers within chassis, body, interior and exterior design will be unaffected. However, the ICE powertrain suppliers will have to adjust, quickly.

While the family name behind the brands run with the attention, the unsung heroes of the automotive industry are in many cases component suppliers. While the Benzes, the Renaults, the Citröens, the Daimlers, the Fords, the Rollses, the Royces, the Ferraris, the Toyodas, the Hondas (Maxton, 2004), and now the unaffiliated Teslas, are for good reasons considered the stars of the industry, most of the innovations that add value to their products have come from outside their organizations. Historically, almost all activities were in-house, because, in short, “vehicle manufacturers could not keep up with the technological, financial and managerial burden of looking after all the functions of the vehicle.” (ibid). This means much of the R&D in key components happens in the supplier side of the value chain.

Figure 11: Breakdown of industrial value-adding activities Source: Maxton & Wormald, 2004

Because the automakers face competitive pressure to satisfy the new paradigm, they try to squeeze suppliers. As seen in the figure above, the automakers only add about a quarter of the entire value, and thus squeezing is short sighted, as suppliers have to maintain profit margins to invest in R&D in order to respond to the needs of car manufacturers. Roland Berger (2018) examined the valuation spread between OEMs and suppliers, and report that is currently at an all-time high, with suppliers nearly at 2x the valuation of OEMs. Their conclusion is that OEM valuations appear to have factored in risks from disruptive trends in contrast to supplier valuations, where investors have not seen what is coming.

Furthermore, the increased software reliance opens up for new suppliers: the tech giants from Silicon Valley, where Tesla was born. Here the scale of a platform, again following Cabral, is crucial as the highest network will have the lowest marginal cost to develop and service. Consequently, the big software producers will seek to build a operating system, much like the ones we see in Google and Apple smartphones. For instance Apple CarPlay (2018) is already in most of the established automakers vehicles from 2016 and going forward. As the suppliers take over consumer experience design, they gradually push the automotive industry “backwards” in the value-chain, and become the service providers themselves - in such a scenario, the automakers become suppliers to mobility providers.

5.2.5 Internal Rivalry

The intensity of rivalry shapes the profit potential of the automotive industry. As seen in Chapter 4, the traditional automakers are not equal in size, and the growth rate of car sales means that the companies fight intensely to get new and retain old customers. As seen in the industry concentration analyses, the traditional automakers dominate the global output. The vehicles on offering are highly differentiated, but designed to compete for the same broad segments, yet the excess capacity of industrial output, means that any traditional automaker can quickly follow up demand for successful models. Competition however is not bitter, and we do not see any actors actively cutting prices at the expense of margins, to take market shares from another automaker. This tacit collusion keeps the potential profits high.

In the following table, we summarize the current strategies of the traditional automakers:

Company	Electrification Strategy	Source
VW	“Roadmap E” - 80 models (50 BEVs + 30 PHEVs) in 2025	VW Mag, 2017
Renault	“Drive The Future” - 8 BEVs and 12 EVs by 2022	Groupe Renualt, 2017
Toyota	“Vision 2050” - 5.5 mil sales all electrified - focus on FCEVs	Toyota Newsroom 2017
Ford	No formalized strategy - 40 EVs by 2022, including 16 BEVs	Ford Media, 2018
Honda	“Vision 2030” - 66% EVs - focus on FCEVS	Honda, 2018
Fiat	Five year plan - increase EVs and phase out diesel by 2021	Manthey, 2018
GM	All electric future - 20 EVs and FCEVs by 2023	GM Newsroom, 2017
Peugeot	All electric from 2025	Reuters, 2018
Suzuki	No formalized strategy - 13% of global sales HEVs	Suzuki, 2017
Daimler	No formalized strategy - 10 EVs by 2020 - focus on PHEVs	Daimler, 2017
Hyundai-Kia	No formalized strategy - 38 eco-friendly models by 2025 -	Hyundai, 2018
BMW	BMWi subbrand - 25 EVs including 12 BEVs by 2025	Reuters, 2017

Table 13 : Electrification strategies in the established automotive industry

From table 13 it is evident that the established automakers have realigned their corporate resources to produce EVs. There is a clear orientation towards BEVs, but many also focus on FCEVS. Some actors retain the hybrids in the product lines, and others like Daimler and BMW will remain ICE producers alongside the EV production. Others like GM and Peugeot have wowed to go all electric. This underscores that the technical discontinuity of ICE is well under way, and that Tesla has succeeded in its mission to speed up the transition to ZEV.

5.3 Summary Nine-Forces

In order of magnitude and impact, the increasing global political pressure, technological maturity, economic feasibility and social acceptance, mean that EVs will take over from ICE within the coming years. The latter will continue to dominate the landscape for at least a decade, but EVs monthly market shares will soar exponentially because of the macro-environmental pressure analyze here using the PEST model.

The market structure outline in the Porter's Five Forces framework, causally related those developments. Consideration for suppliers feeds back into the political pressure, while the impact of new entrants in the marketplace for cars is causally related to the technological influence. Likewise the bargaining power of buyers is shaped by the socio-economic progress, which will either encourage or stop potential substitutes.

Political	Economic	Social	Technological
Very High	**Medium**	**Low**	**High**
- Paris Agreement - NEV Mandate	- Growing demand - EVs are cheaper than ICEV	- Employment - Transportation	- Battery developments - Infrastructure

Substitutes	New Entrants	Bargaining power of Buyers	Bargaining power of Suppliers	Industry Rivalry
High	**Low**	**Low**	**Medium-Low**	**High**
- Software = Low entry barrier	- Output = High entry barrier	- Switching costs	- Disrupted	- Intense competition

Figure 12: Key factors in PEST and Porter's Five Forces

Following Porter, it is important to remember that these two frameworks work in different ways. The PEST forces have an influence on all the five forces simultaneously, but cannot be said to monotonically impact the profitability of an industry. Strong industry forces lower profitability, and if the combined forces are too strong, the is no profit at all.

As we have seen in the previous, political influence is high, but that may affect the automakers in many different ways. Here we label it as very high, because the global Paris Agreement and Chinese mandate, puts strict regulation on the industry. Technology likewise has a high influence on the market, naturally, as it enables it. The impact of social transformation we deem as low; naturally, the political level will have to take unemployment into consideration, but added benefits outweigh the disadvantages. Economy similarly has a lower impact than the techno-political pressure that enables it, but its deemed medium as demand for vehicles is growing, and EVs are cheaper which will attract automakers.

We now turn to the five forces. The impact of substitutes is considered high, because the whole notion of car ownership is likely to be disrupted, as software enables mobility as a service. The threat of new entrants is considered low, as industrial output is a high entry barrier. However, that being said, beginning as substitutes new suppliers may potentially transform into new entrants as the market structure changes. The bargaining power of buyers is considered medium, as their willingness to buy vehicles regardless of technology, is what drives the market - however, switching costs are relatively low, as any car holds the same fundamental utility. Bargaining power of suppliers is deemed medium-low, because that side of the industry is under considerable pressure from the social-economic and technological changes. Finally, industry rivalry is considered high, as the competition for market shares are intense (see chapter 4).

Chapter: 6 Discussion

In this chapter, we answer the research questions, before we progress to the conclusion, and discuss limitations to the study and future research. This thesis aimed to examine the extent of challenges facing the traditional automotive industry posed by electrification and Tesla. The main focus has been on the strategic use of innovation management, technological change, and marketing to gain a competitive advantage. In order to investigate the matter, we have examined the current state of the automotive industry, and impact of the nine forces outlined in PEST and Porter's Five Forces, which has presented some key issues and opportunities related to the potential transition from ICE to EV – and Tesla's role in the industry going forward.

Global political consensus favours EV as a driver in the legally binding Paris Agreement on CO2 reduction. The economics of EV production and adoption are feasible thanks to increasing fuel prices, tough regulations to cut emissions, and marginally lowering prices as battery technology increases in tandem with adoption. From a social point of view, EVs will yield a double dividend of cheaper and greener transport; hopefully creating employment in the creative destruction that follows. The technological level in BEV is currently at the cusp of overtaking the lead in most common scenarios from ICEV, as prices go down while performance soars – already, the EVs outmatch ICE when it comes to acceleration. The lateral power of suppliers and buyers, and the horizontal power of new entrants, substitutes and industry rivalry is increased by regulatory incentives, socioeconomic costs, and the technological maturity which lowers uncertainty for producers and consumers alike.

At the moment, the traditional industry seems well equipped to handle the gale of creative destruction unleashed by the disruption of EVs. Tesla has accomplished its mission to accelerate the global transition to sustainable transportation. It now stands to reap the first-mover advantages from both the buyers in marketplace, and as a supplier to the traditional industry that seeks to win market shares in the same arena. Regardless, of which scenario becomes the most relevant, Tesla has unique and rare resources, that combines into a high potential to take significant market shares. However, even at the current rate of production the company's output cannot compete with the volumes of Toyota, Ford, General Motors, Volkswagen, Peugeot and Renault, for a large scale mainstream takeover. Here the traditional industry has the upper hand. Thus, in its current state, no established actor in the automotive industry is not threatened by Tesla, though all have had their business disrupted.

Calling the automotive industry “fat cats” in the vein of Mullins, seems unfounded, although there is some truth to in conjugation with the Innovator’s Dilemma. Perhaps, the industry simply waited for the market to ferment, before betting company resources on new technologies in vain. Toyota’s Prius, GM’s Chevrolet Volt and particularly the Bolt, and the Nissan Leaf, show that the largest automakers have been engaged in ZEV manufacturing in anticipation of a market uptake; but it also shows that their safe-bets on the pragmatists, was not the key to unlocking the mainstream market - instead, that part was performed out by the cool high-end Tesla. Now, because of the macroeconomic developments in Asia, the global car market has shifted, and because of the clout the Chinese government has due to its political influence on the domestic industry, the global car fleet of the future will be different from today. The NEV mandate will force the traditional industry to change their fleet mix.

RQ 1: What enabled Tesla to become a world leader?

Tesla’s combination of strategic resources enabled it to become a world-leading EV automaker. The intangible powertrain designs and brand, which materializes in the Model S, 3, X, Y from the Fremont plant, alongside Elon Musk and team’s relentless dynamic capability, is what enabled Tesla to pursue the clever secret plan that ensured EV adoption. Though not a world leader in terms of output, Tesla is setting standards for the rest.

RQ 2: What shapes the competitive environment in the automotive industry?

The competitive environment is to a very large degree shaped by the political will to curb CO2 emissions, and the technological possibility to have ICEVs substituted by EVs. The socio-economic impact of this transition keeps the development in a limbo where global politicians have to balance growth, employment, social-wellbeing and the climate, all while the technological development on a daily basis makes the transition easier and cheaper at an exponential pace. Furthermore, the intense rivalry for market shares, in an industry that will see itself disrupted by digitalisation, puts a strain on suppliers.

RQ 3: What is disruption, and what kept the established automakers from producing EVs?

As discussed above, the innovator’s dilemma held back the established automakers. Why did Tesla succeed when GM with EV-1 failed? Musk made a plan in 2006 and stuck to it learning with the customers as he has progressed. Musk focused on a small untapped market with the Roadster, and built a beachhead with that for the Model S and X to follow, and pave the way for the Model 3 to take the mainstream market. The combination of resources within Tesla gave it the decisive competitive advantage, as Musk fully disregarded the traditional automakers' positions of strength, and instead focused on hitting the right market segments in the right order following Rogers and Moore. GM followed its instincts, and soon found itself trapped in the innovator's dilemma. What kept the automotive industry from producing EVs was in part the lack of interest, as it the macro-level climate was not ready to support the technology, and in part due to the fear of disrupting its own business.

RQ 4: What is the expected outcome of EVs attempt to take the mainstream market?
As regulations, technology, economics and consumer preferences align, OEM inertia towards electrification disappears. When the industrial production capacity switches, due to strict demands from primarily Chinese regulations, the mainstream markets will soon have no other choice than EVs.

This study has a number of limitations. First, it explores the automotive industry and competitive positioning of companies on a global scale; despite operating in a global market, the companies face asymmetries on the local scale, and particularly Tesla has proven adept at targeting, winning and exploiting a low volume niche to build its capacity to expand into the mainstream. Second, the study remains focused on the top ten automakers that have a combined 2017 output of 92% and just one EV automaker with less than a per mille of the global production, without considering the many Chinese EV automakers in detail. It would be interesting to explore their capacity, domestic and regional market shares, and lastly future ability to export their cars. An interesting future study could be focused entirely on the Chinese EV automakers. Certainly, the shaping impact of Chinese policy merits study.

Concerning future research, it will be interesting to revisit this turning point in the automotive industry five and ten years from now - indeed, just a couple of weeks from now, as it becomes apparent whether Tesla's Model 3 succeeds or not. This would allow an ex-post analysis of the potential paradigm shift. While it is safe to say that the global consensus is focused on reducing CO_2 emissions, the EU and China stand without American presidential support for regulation to change the industry. Finally, another path for future research is to compare the price development of battery-powered vehicles, to other industries within electric manufacturing that have experienced similar cost-reductions. At some point soon, the digital alternative inherent in EVs will crowd out the analogue status quo maintained by ICE. This would allow observers to define clear-cut strategies for better performance in the marketplace, and the dissemination of best practice for coming startups in industry.

Chapter 7: Conclusion

The extent to which the established automotive industry is challenged by Tesla and the disruptiveness of EVs is a matter of interpretation. On one hand, Tesla has disrupted the ICEV by innovating the concept of a car; on the other, no established automaker has been put out of business yet, as their strategic skill and dynamic capabilities appears to have been capable of re-aligning the industry before it succumbs in creative destruction, so it would be a far stretch to conclude that Tesla is a threat. Rather it seems that the upstart company will coexist in a beneficial competition with the established industry. This conclusion, in turn, challenges the notion that Tesla is a disruptive force - perhaps, the EV is simply an incremental innovation, and the prerequisite foundation for the disruptive force of autonomous driving.

Tesla is not capable of producing EVs in a volume that can challenge the traditional industry. Even though demand for EVs is high and growing, at present Tesla cannot realistically serve the market. The traditional automakers will reorient their production to exploit this opening. Already, the established industry’s yearly EV production outperforms the total production by Tesla after 14 years. Nevertheless, Tesla has challenged the “fat cats” and made them change their business. Granted, the first mover advantage Tesla secured, gave the company a short lead, but the gigantic resources in the traditional industry have gradually been realigned to pursue and overtake market shares in the EV niche. Tesla has a considerable share of the EV niche already and sets the standard here for the automakers to follow.

As such Tesla is not a direct threat to the industry as a whole. How the Model 3 will fare is not yet possible to say, but it is very likely that it for a period will dominate the EV segment for the masses, and consequently set the standard again.

Due to China’s strong influence on the macro-level of the global market structure, BEVs have a distinct supporter, and this has lowered uncertainty for producers and consumers alike. Because of this influence, the global emission targets are likely to be met. This is the main “challenge” or perhaps rather, the main opportunity that faces the automotive industry.

References

Academic sources

Aaker, L. J., 1997, Dimensions of Brand Personality, Journal of Marketing Research Vol. 34, No. 3

Abernathy, W. J., 1978, The productivity dilemma: roadblock to innovation in the automobile industry, Johns Hopkins University Press

Abernathy, W. J., and Utterback, J. M., 1978, Patterns of industrial innovation, Technology Review, vol 80

Aengenheyster, M., Qing, Y. F., Ploeg, F., and Djikstra, H. A., August 2018, The point of no return for climate action: effects of climate uncertainty and risk tolerance, Earth Syst. Dynam., 9, 1085–1095 [Online]
https://www.earth-syst-dynam.net/9/1085/2018/esd-9-1085-2018.pdf

Argyres, N. and McGahan, A., 2002, An interview with Michael Porter, Academy of Management Executive

Barney, J., 1991, Firm Resources and Sustained Competitive Advantage, Journal of Management, vol 17

Bryman, A., 2012, Social Research Methods, Oxford University Press

Bedsworth, L., Taylor, M., 2007, Pushing technology when it pushes back: learning from California's zero-emission vehicle program, Public Policy Institute of California.

Cabral, L. M. B., 2000 Introduction to Industrial Organization, The MIT Press

Chalmers, A. F., 1978, What is this thing called science? Queensland

Chan, C. C., 2013, The Rise & Fall Of Electric Vehicles In 1828–1930: Lessons Learned, Proceedings of the IEE, vol 101

Christensen, C. M., 1997, The Innovator's Dilemma, Harvard Business School Press

Drucker, P, 1973, Management: Tasks, Responsibilities, Practices, (Reprint 1986), Truman Talley Books, United States

Foster, R. N. 1986, Innovation: The Attacker's Advantage, MacMillan, London

Freyssenet, Michel, 30 november 2011 ”The start of a Second Automobile Revolution Corporate strategies and public policies”, ERIEP, Number 3, The challenges facing the European automotive industry, The start of a Second Automobile Revolution Corporate strategies and public policies, [online] http://revel.unice.fr/eriep/index.html?id=3301.

Harwit, E., 2001, The Impact of WTO Membership on the Automobile Industry in China, The China Quarterly No. 167 (Sep., 2001), pp. 655-670, Cambridge University Press

Henderson, R. M, and Clark, K. B., 1990, Architectural Innovation: The Reconfiguration Of Existing Product Technologies and the Failure of Established Firms, Administrative Science Quarterly

Kotler, P., Armstrong, G., Saunders, J. and Wong, V., 2002, Principles of Marketing. 5th European Edition, Prentice-Hall, London.

Kochhan, R., and Hörner, M., 2015, Costs and Willingness-to-Pay for Electric Vehicles, in Denbratt, 2014, Sustainable Automotive Technologies, Springer

Kornberger, M., 2010 Brand Society: How Brands Transform Management and Lifestyles. Cambridge University Press.

Kleijnen, M., Lee, Nick., Wetzels, M. (2009) An exploration of consumer resistance to innovation and its antecedents. Journal of Economic Psychology 30 (2009) 344-357.

Maxton, G. P., and Wormald, J., 2004, Time for a Model Change: Re-engineering the Global Automotive Industry, Cambridge University Press

McCracken, ,G., 1986, Culture and Consumption: A Theoretical Account of the Structure and Movement of the Cultural Meaning of Consumer Goods, Journal of Consumer Research Vol. 13, No. 1

Moore, G. A., 1999, Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customer, HarperCollins Publishers, New York

Mullins, J.W., 1996, Early Growth Decisions of Entrepreneurs: The Influence of Competency and Prior Performance Under Changing Market Conditions. Journal of Business Venturing 11, 89-105

Naldi, M., and Flamini, M., 2014a, The CR4 index and the interval estimation of the Herfindahl-Hirschman Index: an empirical comparison. HAL Archives Ouvertes

Naldi, M. and Flamini, M., 2014b, Interval Estimation of the Herfindahl-Hirschman Index Under Incomplete Market Information, IEEE Computer Society

Nieuwenhuis, P. and Lin, Xiao, 2015, China's Car Industry, in The Global Automotive Industry, Wiley

Porter, M., 1979, How Competitive Forces Shape Strategy, Harvard Business Review [Online] https://hbr.org/1979/03/how-competitive-forces-shape-strategy

Porter, M., 1985 The Competitive Advantage: Creating and Sustaining Superior Performance. NY: Free Press

Rogers, E. M., 2003 Diffusion of Innovation, The Free Press

Prahalad, C. K., and Hamel, G., 1990, The Core Competence of the Corporation, Harvard Business Review [Online] https://hbr.org/1990/05/the-core-competence-of-the-corporation

Rumelt, R. P., 1984, Towards a Strategic Theory of the Firm, in Competitive Strategic Management, Prentice-Hall

Schiermeier, Q., 2012, The Kyoto Protocol: Hot air, Nature: International Weekly Journal of Science, Vol. 491 [Online] https://www.nature.com/news/the-kyoto-protocol-hot-air-1.11882

Shioji, H. , 2012, Competitiveness of the Japanese, Korean, and Chinese Automobile Industries, The Kyoto Economic Review, Vol. 81, No. 1 (170), SPECIAL ISSUE: The Competitive Advantage of Regions (June 2012), pp. 48-63

Sprei, F., Jakobsson, N., and Plötz, P., 2017, On the distribution of individual daily driving distances, Transportation Research Part B: Methodological Volume 101

Teece, David J., Pisano, G. and Shuen, A, 1997, Dynamic Capabilities and Strategic Management, Strategic Management Journal, 18:7, 509-533

Tidd, J., and Bessant, J., 2014, Strategic Innovation Management, Wiley

Vlad, D. S., 2014, Modelling Research on Consumer Attitude Toward Car Brands, International Journal of Sustainable Economies Management

van Wee, B., Sierzchula, W., Bakker, S., and Maat, K., 2012, The competitive environment of electric vehicles: An analysis of prototype and production models, Environmental Innovation and Societal Transitions 2 (2012) 49–65

Wernerfelt, B., 1984, A Resource-Based View of the Firm, Strategic Management Journal, Vol. 5,

Experts

AAPC, 2017, State of the U.S. Automotive Industry, [Online] www.americanautocouncil.org/sites/aapc2016/files/2017%20Economic%20Contribution%20Report.pdf

ACEA, June 2018, Making The Transition To Zero-Emission Mobility [Online] Https://www.Acea.Be/Uploads/Publications/Study_Ecv_Barriers.Pdf

ACEA, April 2018, Negative job impact of forced electric car push underestimated by European Commission, report shows, [online] https://www.acea.be/press-releases/article/negative-job-impact-of-forced-electric-car-push-underestimated-by-european

BCG, 2018, The Electric Car Tipping Point [Online] https://www.bcg.com/en-nor/publications/2018/electric-car-tipping-point.aspx

Cohen, S., 2017, The “Can’t-Do” Approach of the American Auto Industry, State of the Planet, Columbia University [online] https://blogs.ei.columbia.edu/2017/03/27/the-cant-do-approach-of-the-american-auto-industry/

Deloitte, 2011, Unplugged: Electric vehicle realities versus consumer expectations [Online] https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_us_auto_DTTGlobalAutoSurvey_ElectricVehicles_100411.pdf

European Alternative Fuels Observatory (EAFO), 2018, Number Of Publicly Accessible Charging Positions [Online] www.eafo.eu/europe

European Parliament, Directive for Alternative Fuel Infrastructure (DAFI), 2013/0012(COD) - 22/10/2014 Final act, [Online] www.europarl.europa.eu/oeil/popups/summary.do?id=1368222&t=f&l=en

EU, 2015, Climate Action, Paris Agreement https://ec.europa.eu/clima/policies/international/negotiations/paris_en#tab-0-0

EERE, Energy Efficiency and Renewable Energy (US Department of Energy) March 19, 2009, President Obama Announces $2.4 Billion for Electric Vehicles [Archived, Online]http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=152

EERE, Energy Efficiency and Renewable Energy (US Department of Energy) 2018, https://www.energy.gov/eere/electricvehicles/electric-vehicles-tax-credits-and-other-incentive

EV-Sales, August 2018, 2018 Global Top 20 - July 2018 www.ev-sales.blogspot.com

International Energy Agency (IEA), 2018, Global EV Outlook 2018, https://www.iea.org

ICCT, International Council on Clean Transportation, November 2017, Electric vehicle capitals of the world: What markets are leading the transition to electric? [Online] https://www.theicct.org/sites/default/files/publications/World-EV-capitals_ICCT-Briefing_08112017_vF.pdf

ING, 2017, Breakthrough of electric vehicle threatens European car industry, [Online] https://www.ing.nl/media/ing_ebz_breakthrough-of-electric-vehicle-threatens-european-car-industry_tcm162-128687.pdf

ILO, International Labour Organization 2010, The Global Economic Crisis - Sectoral Coverage Automotive Industry: Trends and Reflections [Online] https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_161519.pdf

International Organization of Motor Vehicle Manufacturers (OICA) www.oica.net

Marklines, China - Flash report, Production volume, 2017 [online] https://www.marklines.com/en/statistics/flash_prod/productionfig_china_2017

McKinsey, 2014, A road map to the future for the auto industry [online] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/a-road-map-to-the-future-for-the-auto-industry

Roland-Berger, 2017, Global Automotive Supplier Study 2018, Lazard

ZSW, Center for Solar Energy and Hydrogen Research Baden-Württemberg, Numbers 2013-2017 [Online] https://www.zsw-bw.de/en/media-center/data-service.html#c6700

PWC, 2007, The automotive industry and climate change [Online] https://www.pwc.com/th/en/automotive/assets/co2.pdf

PWC, 2018, Five trends transforming the Automotive Industry [Online] https://www.pwc.com/gx/en/industries/automotive/publications/eascy.html

UN Dept. of Economic and Social Affairs, May 2018, 68% of the world population projected to live in urban areas by 2050, says UN, [online] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

UN, 2018, World Economic Situation and Prospects 2018

U.S. Department of Justice, Aug 2010, Horizontal Merger Guidelines, [online] https://www.justice.gov/atr/horizontal-merger-guidelines-08192010

World Economic Forum, 2016, Electricity: uncovering value through digital transformation, [online] www.reports.weforum.org/digital-transformation/electricity-an-industry-ready-for-digitization/

World Resources Institute, November 2017,, Levin, K and Rich, D, [online] https://wriorg.s3.amazonaws.com/s3fs-public/turning-points-trends-countries-reaching-peak-greenhouse-gas-emissions-over-time.pdf

Media

AutoGuide, Nov 2015, Tesla Model X Wins 2016 AutoGuide.com Reader's Choice Green Car of the Year Award, AutoGuide (online)https://www.autoguide.com/auto-news/2015/11/tesla-model-x-wins-2016-autoguide-com-reader-s-choice-green-car-of-the-year-award.html

BBC, July 2018, Elon Musk calls Tesla 'a real car company' [Online] https://www.bbc.com/news/business-44680021

Blanco, S., November 2017, GOP's Move To End Electric Vehicle Incentives In Tax Plan Could Not Come At A Worse Time, Forbes[Online] https://www.forbes.com/sites/sebastianblanco/2017/11/02/electric-vehicle-tax-credit-gop/#671c6e457cb7

Bihani, S., 2017, Here's why Elon Musk started Tesla, Times of India [Online] https://timesofindia.indiatimes.com/auto/miscellaneous/heres-why-elon-musk-started-tesla/articleshow/59071716.cms

Burfield, 2018, Elon Musk's "Iron Man" persona is no accident — it's an incredibly useful business tool [Online] https://www.linkedin.com/pulse/elon-musks-iron-man-persona-accident-its-incredibly-useful-burfield/

Collins, T., September 2018, Elon Musk reveals plan to build a medieval watchtower for the Boring Company headquarters constructed entirely with 'lifesize LEGO-like bricks' made from leftover dirt from its underground tunnels, [online] https://www.dailymail.co.uk/sciencetech/article-6167509/Boring-Company-build-watchtower-lifesize-LEGO-like-bricks-dirt-tunnels.html

Consumer Reports, December 2012, Would You Buy Your Car Again? Consumer Reports' annual car owner satisfaction survey (Online) https://www.consumerreports.org/cro/2012/12/owner-satisfaction/index.htm

Consumer Reports, December 21, 2017, The 10 Most Satisfying Cars: The models that bring their owners joy (Online) https://www.consumerreports.org/car-reliability-owner-satisfaction/10-most-satisfying-cars-owner-satisfaction/

Coren, M. J., 2017, There are now 16,000 public electric vehicle charging stations in the US (and China has way more), Quartz, [Online] https://qz.com/1007304/there-are-now-16000-public-electric-vehicle-charging-stations-in-the-us-and-china-is-way-ahead/

Davis, J. 2010, How Elon Musk Turned Tesla Into the Car Company of the Future, Wired

The Economist, August 2017, The death of the internal combustion engine [Online] https://www.economist.com/leaders/2017/08/12/the-death-of-the-internal-combustion-engine

Edwards, O., June 2006, The Death of the EV-1, Smithsonian Magazine, (Online) https://www.smithsonianmag.com/science-nature/the-death-of-the-ev-1-118595941/#LMLeftdZJucEOi8O.99

Elkind, P., 2014, Inside Elon Musk's $1.4 Billion Score, Fortune, [Online] www.fortune.com/inside-elon-musks-billion-dollar-gigafactory/

EV-1.org, no date, Chevron and EVs [online]www.ev1.org/chevron.htm

The Guardian, 2017, Tesla charges ahead to overtake Ford in market value [Online] https://www.theguardian.com/technology/2017/apr/04/tesla-charges-ahead-to-overtake-ford-in-market-value

Harrop, P., 2018, Micro EVs, e-Bikes, e Scooters, e Motorbikes, Mobility for Disabled [online] https://www.idtechex.com/research/reports/micro-evs-e-bikes-e-scooters-e-motorbikes-mobility-for-disabled-2018-2028-000572.asp

Hawkins, A. J., 2018, GM will make an autonomous car without steering wheel or pedals by 2019, the Verge [Online] https://www.theverge.com/2018/1/12/16880978/gm-autonomous-car-2019-detroit-auto-show-2018

Herger, M. 2018, The Short Nose OR The Exponential Gap To Waymo, [online] https://thelastdriverlicenseholder.com/2018/09/10/the-short-nose-or-the-exponential-gap-to-waymo/

Howard, B., February 2018, Tesla to Hit 200,000 Sales This Year, Could Limit Model 3 Tax Credits, Extreme Tech, [Online] https://www.extremetech.com/extreme/264629-tesla-hit-200000-sales-year-limit-model-3-tax-credits

Lambert, F., 2017, Toyota cut its last tie with Tesla as it launched its own electric car effort, Electrek [Online]https://electrek.co/2017/06/04/toyota-tesla-electric-car/

Liu, A. 2012, Elon Musk Will Usher in the Era of Electric Cars [Online] https://motherboard.vice.com/en_us/article/kbbbwy/elon-musk-will-usher-in-the-era-of-electric-cars

Loveday, E., July 2018, Update – 5 Automakers Closest To Losing The Federal Tax Credit Inside EVs, [Online] https://insideevs.com/top-6-automakers-200000-federal-tax-credit-limit/

Manthey, N., 2018, FCA: New strategy calls for electric models across all brands, Electrive [Online]https://www.electrive.com/2018/06/02/fca-new-strategy-calls-for-electric-models-across-all-brands/

Matousek, M., April 2018, The 10 most high-tech sedans you can buy F, Business Insider, [online]https://nordic.businessinsider.com/most-high-tech-sedans-you-can-buy-pictures-details-2017-12

Matousek, M., February 2018, Tesla has transformed the car industry — but its biggest strength is becoming its greatest liability, Business Insider, [Online] https://nordic.businessinsider.com/teslas-influence-on-the-auto-industry-2018-2?r=US&IR=T

Matussek, K,. and Behrmann, E., September 2018, VW Can't Escape the Diesel Scandal Fallout, Bloomberg [Online] https://www.bloomberg.com/news/articles/2018-09-12/vw-can-escape-diesel-scandal-fallout

Meyer, D., May 2018, First Dieselgate, Then Dieselban: Germany Invented the Diesel Engine But Is Now Starting to Ban It, Fortune, [online] www.fortune.com/2018/05/31/germany-hamburg-diesel-ban/

Morris, C., May 2017,The Supercar That Inspired Elon Musk To Make Tesla's Model S Ludicrous, EV ANNEX [Online] https://evannex.com/blogs/news/the-supercar-that-inspired-elon-musk-to -make-the-model-s-ludicrous

Musk, Jonathan, november 2016, Tesla Roadster 2009-2012 Buying Guide [online] https://drive-my.com/en/blogs/entry/tesla-roadster-2009-2012-buying-guide.html

Lee, T., 2018, As Uber and Tesla struggle with driverless cars, Waymo moves forward, [Online] https://arstechnica.com/cars/2018/06/as-uber-and-tesla-struggle-with-driverless-cars- waymo-moves-forward/

Paine, C., 2006, Who Killed the Electric Car?, Sony Pictures Classic

Perkowski, J., March 2018, How Foreign Automakers Are Trying To Meet NEV Targets In Response To China's New Electric Vehicle Rules, Forbes, [Online] https://www.forbes.com/sites/jackperkowski/2018/03/16/automakers-ramp-up-nev-targets-in-response-to-chinas-changing-ev-rules/#64e1bbff38ca

Pritchard, C., August 2015, Tesla Motors Inc (TSLA) Model X Pre-Orders Cross 30,000 Units, Business Finance News [Online]http://www.businessfinancenews.com/ 23587-tesla-motors-inc-model-x-preorders-cross-30000-units/

Reuters, 2016, Exclusive: BMW bosses to skip Paris show to thrash out electric car strategy [Online]https://www.reuters.com/article/us-bmw-electric-strategy-exclusive/exclusive-bmw-bosses-to-skip-paris-show-to-thrash-out-electric-car-strategy-idUSKCN11F25Y

Reuters, June 2017, Toyota sells all shares in Tesla as their tie-up ends [Online] https://www.reuters.com/article/us-toyota-tesla/toyota-sells-all-shares-in-tesla-as-their-tie-up-ends-idUSKBN18U05E

Reuters, September 2017, BMW will challenge Tesla and Mercedes by launching 12 electric cars by 2025 [Online] https://www.businessinsider.com/r-bmw-readies-mass-production-of-electric-cars-12-models-by-2025-2017-9?r=US&IR=T&IR=T

Reuters, March 2018, Japan venture aims to build 80 hydrogen fuelling stations by 2022 [Online] https://www.reuters.com/article/us-japan-hydrogen/japan-venture-aims-to-build-80-hydrogen-fuelling-stations-by-2022-idUSKBN1GH072

Reuters, January 2018, Peugeot CEO outlines ambitious plan to re-enter U.S., go electric [online] https://www.reuters.com/article/us-autoshow-detroit-peugeot/peugeot-ceo-outlines-ambitious-plan-to-re-enter-u-s-go-electric-idUSKBN1F706J

Roselund, C., August 2018, 100% clean energy passes California Assembly, PV Magazine, [Online] https://www.pv-magazine.com/2018/08/29/100-clean-energy-passes-california-assembly/

Roy, 2011, 2011 Tesla Roadster Sport 3.0 Review: The World's Best Fourth Car?, The Drive, [online] www.thedrive.com/polizei144/7242/2011-tesla-roadster-sport-3-0-review-the-worlds-best-fourth-car

Stewart, J. B., January 2018, Electric Vehicle Tax Credit Survives, but G.M. and Tesla Aren't Cheering, New York Times [Online] https://www.nytimes.com/2018/01/11/business/electric-vehicles-taxes-tesla-gm.html

Stewart, J. B, August 2018, The Terrible Timing of Tesla's Expiring $7,500 Tax Credit, Wired, [online] https://www.wired.com/story/terrible-timing-teslas-expiring-tax-credit/

The New Yorker, Friend, T., 2009 Plugged In Can Elon Musk lead the way to an electric-car future? [Online] https://www.newyorker.com/magazine/2009/08/24/plugged-in

Valinsky, J. March 2018, Tesla SUV earns a Guinness World Record for towing massive airplane, CNN (online) https://money.cnn.com/2018/05/15/technology/tesla-tows-boeing-dreamliner-video/index.html

Wade, M. June 2018, GM/Cruise Might Be Embracing EV1 History With ‘AV1’ Trademark, Inside EV, (Online) https://insideevs.com/general-motors-trademarks-av1-reminds-us-of-ev1/

Wang, B., 2017, Electric bikes could grow from 200 million today to 2 billion in 2050, [online] https://www.nextbigfuture.com/2017/04/electric-bikes-could-grow-from-200-million-today-to-2-billion-in-2050.html

Yingling, B., March 2018, "Utilities ask Congress to keep electric vehicle tax incentive, Daily Energy Insider [Online] https://dailyenergyinsider.com/news/11363-utilities-ask-congress-keep-electric-vehicle-tax-incentive/

Company PR

Apple, CarPlay, [online] https://www.apple.com/ios/carplay/available-models/

Daimler Media, 2017, Plans for more than ten different all-electric vehicles by 2022: All systems are go, [online] https://media.daimler.com/marsMediaSite/en/instance/ko/Plans-for-more-than-ten-different-all-electric-vehicles-by-2022-All-systems-are-go.xhtml?oid=29779739

Ford Media, February 2017, "Ford | Argo AI: Drive for Autonomous Vehicle Leadership" https://www.youtube.com/watch?v=bVv6Nzj9gF0

Ford Media, January 2018, Ford Details Plans To Improve Fitness, Refocus Model Lineup And Accelerate Introduction Of Smart Vehicles And Services, [Online]https://media.ford.com/content/fordmedia/fna/us/en/news/2018/01/16/ford-details-plans-to-improve-fitness--refocus-model-lineup-and-.html

Ovonic Battery Co, 1998, Nickel-Metal Hydride: Ready to Serve, IEEE Spectrum

GM Newsroom, 2017, GM Outlines All-Electric Path to Zero Emissions [Online] https://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2017/oct/1002-electric.html

Groupe Renault, October 2017, Drive The Future 2017-2022: New strategic plan builds on record results, targets sustainable, profitable growth [Online] https://media.group.renault.com/global/en-gb/groupe-renault/media/pressreleases/21197704/drive-the-future-2017-2022-le-nouveau-plan-strategique-sappuie-sur-des-resultats-records-et-vise-une

Honda, August 2018, Corporate Update 2018 Spring [online] https://global.honda/investors/

Hyundai Media, May 2018, Investor Presentation [online] https://www.hyundai.com/content/hyundai/ww/data/ir/calendar/2018/0000000203/files/hmc-ir-pt-may-2018.pdf

Suzuki Motor Corporation, 2017, Winter 2017-2018, www.globalsuzuki.com/ir/library/data/pdf/meeting_fy2017_winter.pdf

Tesla, March 2013, Tesla Model S Sales Exceed Target (Online) https://www.tesla.com/blog/tesla-model-s-sales-exceed-target

Tesla, August 2013, Tesla Model S Achieves Best Safety Rating of Any Car Ever Tested, (Onlinw) https://www.tesla.com/BLOG/TESLA-MODEL-S-ACHİEVES-BEST-SAFETY-RATİNG-ANY-CAR-EVER-TESTED%20

Tesla Blog, Elon Musk, June 12 2014, #All Our Patent Are Belong To You" [online] https://www.tesla.com/blog/all-our-patent-are-belong-you?redirect=no

Tesla, August 2016, New Tesla Model S Now the Quickest Production Car in the World (Online) https://www.tesla.com/blog/new-tesla-model-s-now-quickest-production-car-world

Toyota Global Newsroom, February 2017, Worldwide Sales of Toyota Hybrids Surpass 10 Million Units [Online] https://newsroom.toyota.co.jp/en/detail/14940871

Toyota Global Newsroom, December 2017, Toyota Aims for Sales of More Than 5.5 Million Electrified Vehicles Including 1 Million Zero-Emission Vehicles per Year by 2030 [online] https://newsroom.toyota.co.jp/en/corporate/20353243.html

VW Mag, September 2017, The Volkswagen Group launches the most comprehensive electrification initiative in the automotive industry with “Roadmap E” [online] https://www.volkswagenag.com/en/news/2017/09/Roadmap_E.html

VW, 2017, Matthias Müller Keynote, https://www.volkswagenag.com/presence/investorrelation/publications/presentations/2017/09-september/Keynote%20Matthias%20Müller%20IAA%202017%20english.pdf