Kenmerken van de Nederlandse markt voor elektrische voertuigen

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Samenvatting

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De opkomst van elektrisch aangedreven voertuigen kan een paradigmaverandering teweegbrengen in de automobielindustrie. De mogelijkheden, maar zeker ook de beperkingen, van elektrische auto's zijn dusdanig dat de auto en het autobezit zoals we dat nu kennen op termijn vervangen zal worden door een waaier aan vervoersopties waarin meerdere typen voertuigen een rol zullen spelen. In dit paper stellen we de vraag of deze ontwikkeling reeds zichtbaar is in a) de elektrische voertuigen die de industrie, bestaande uit gevestigde en nieuwe automakers, heeft ontwikkeld en b) de huidige markt van elektrische voertuigen in Nederland.

Onze analyse laat zien dat er inderdaad elektrische voertuigen ontwikkeld worden voor verschillende marktsegmenten en niches. Zo zijn er relatief veel elektrische sportwagens ontwikkeld en tevens opvallend veel voertuigen (waaronder ook driewielers) met een beperkte snelheid. Wanneer we echter naar de feitelijke markt voor elektrische voertuigen kijken, blijkt dat deze zich toch in de conventionele segmenten bevindt (zoals de Nissan Leaf en de Opel Ampera) en dat de onconventionele modellen nauwelijks verkocht worden.

Als deze trend zich voortzet zal de elektrische auto eenvoudigweg de huidige brandstofauto's vervangen en verandert er verder nauwelijks iets aan het gebruik en het bezit van de auto als zodanig. De markt is echter nog jong en bestaat nu grotendeels uit zakelijke gebruikers en het is denkbaar dat op de particuliere markt een ander beeld zal ontstaan waarin de afwijkende modellen en gebruiksvormen een groter aandeel hebben.

1. Introduction

The automotive industry has been dominated by the internal combustion engine (ICE) for more than a century. Due to factors such as government regulation of emissions, advances in technology, and increases in oil prices, the automobile market has entered into the early stages of what is known as an era of ferment (Sierzchula et al., 2012). Such periods represent times of flux and uncertainty and can lead to industrial transitions where one technology replaces another e.g., when compact discs replaced cassette tapes.

The current automobile market finds the stable dominance of the ICE and a more or less fixed set of incumbent firms being threatened by new technologies and startup companies (Magnusson and Berggren 2011). Vehicle manufacturers have developed several powertrain alternatives to the ICE of which the electric vehicle (EV) is a prominent contender. As technologies have improved, niche markets have opened up where EVs have a competitive advantage over ICE vehicles (Van Bree et al., 2010). Recent market introductions also indicate that large auto makers now view the EV market as a commercial opportunity instead of a regulatory requirement (Magnusson and Berggren, 2011).

These developments imply that the industrial dynamics of the automobile industry are shifting, although the outcome of this situation cannot be known. A combination of electric motors and batteries may be on its way to becoming the dominant design for vehicle powertrain technology. It is also possible that the ICE will yet retain that position. The fundamental question this paper seeks to answer is, *What are the aspects of the market that has emerged from pre-commercial development of electric vehicles?* We will answer that question by analyzing prototype and production models from the global EV industry and then showing how those dynamics have translated to the Dutch EV market. We will then use that analysis to provide a rudimentary forecast for the future of electric mobility.

2. Theory

The industrial life cycle is robust and well-defined in the literature with technological development in the form of dominant designs and radical innovations demarcating eras of ferment and eras of incremental improvement (Utterback and Abernathy, 1975; Tushman and Anderson, 1986). The emergence of a radical innovation creates new market opportunities that require new areas of expertise (Anderson and Tushman, 1990). This situation, known as an era of ferment, disrupts incumbent control of the market and results in a flurry of activity as a host of new and existing firms seek to develop the innovation that will be most successful in the marketplace. As such, eras of ferment are characterized by increases in firm entry rate, industrial performance, technological variety, and high levels of uncertainty (Foster, 1986; Clark, 1985). These periods end when a dominant design emerges from the competing innovations to capture a majority of the market share (Abernathy, 1978). Eras of incremental change are characterized by low levels of uncertainty, a small number of principal incumbents, and competence enhancing improvements to the dominant design (Klepper, 1996; Tushman and Anderson, 1986).

It is important to note that although many technological changes have involved the industrial life cycle progression (radical innovation → era of ferment → dominant design → era of incremental improvement → radical innovation), this cycle is not universally applicable. An era of ferment does not always lead to the rise of a new dominant design. For example, in the 1990s, EVs were developed by automobile manufacturers and introduced to the market, but they eventually faded away and the internal combustion engine (ICE) remained the dominant design. Additionally, an era of ferment may lead to several technologies being successful in different market niches (Windrum and Birchenhall, 1998). This situation arises due to high levels of demand heterogeneity in different markets. Although not all elements of the industrial life cycle are found in every radical change in technology, it still offers a useful perspective for viewing industrial dynamics and thus will be an important theoretical principle in our research.

3. Methods

We chose for a prototype and production model analysis of the pre-commercial period of EV development because it provides insights into industries in situations where there are low sales and a large variety of technological alternatives; such as that found in emerging innovations (Suarez, 2004; Bakker et al., 2012). The number of prototype and production models developed by auto manufacturers indicates their level of interest regarding particular types of electric vehicles. This allows for an industrial analysis including firm type and market segment and is appropriate for examining pre-commercial EV development.

Our analysis of electric vehicles[1] included pure battery models e.g., the Nissan LEAF as well as extended range electric vehicles or plug-in hybrid electric vehicles e.g., the Opel Ampera. Multiple sources were used to gather data with government reports, professional websites, and auto shows providing a majority of the vehicle information. The characteristics of specific EV models were confirmed through mainstream newspaper articles, company press releases, and personal contact with manufacturers. This method was specifically chosen because it provided up-do-date information about a rapidly changing technological landscape.

EV models were classified according the European vehicle classification system: Segment A, Segment B, Segment C, Segment D/E, Segment F, Segment G/H, Segment J/K, Segment L/M, Segment N, Heavy Commercial Vehicles (HCV), and buses. Distinguishing criteria and examples of these vehicle classes are provided in Tables 1 and 2. In addition, the categories of low speed vehicles (LSV) and 3-wheelers were also included because of their prevalence among EV models.

[1] An electric vehicle is any vehicle that uses an electric motor for propulsion. Therefore, there is a broad range of electric vehicles ranging from mild hybrids that use the electric motor at low speeds up to pure battery automobiles.

	Engine Size	Vehicle Length	ICE example	EV example
Segment A	~ 1.0 L	< 3050 mm	Smart ForTwo	Tezzari Zero
Segment B	~ 1.0 – 1.4 L	< 3745 mm	VW Polo	BMW Mini E
Segment C	~ 1.3 - 2.0 L	< 4230 mm	VW Golf	Nissan LEAF
Segment D/E	~ 1.6 - 2.8 L	< 4470 mm	VW Passat	Opel Ampera
Segment F	~ 2.0 - 3.5 L	< 4800 mm	Daimler CL600	BYD Auto e6

Table 1: Vehicle classification scheme (SMMT, 2009)

	Distinguishing criteria	ICE Example	EV Example
LSV	Low top speed	Bellier XLD	GEM eL
3 wheeler	Vehicle with 3 wheels	GM Lean Machine	Aptera 2e
Segment G/H	High performance vehicle	Porsche Boxter	Venturi Fetish
Segment J/K	Seats up to 8 persons	Citroën Picasso	Ford Transit
Segment L/M	4X4 off road	Mercedes M-Class	Toyota Rav4 EV
Segment N	< = 3.5 ton	Peugeot Berlingo	E-wolf Omega 1.4
HCV	> 3.5 ton	Volvo FM9	Balqon Nautilus E20
Bus	Can carry > 10 persons	Champion Defender	Tecnobus Gulliver

Table 2: Vehicle Classification Scheme (ACEA, 2009; SMMT, 2009; SMMT, 2011)

For each EV model, companies were divided into one of four categories – large incumbent, small incumbent, startup, or diversifying firm. Large incumbents were defined as having sold automobiles before 1991 and being one of the 30 largest vehicle manufacturers in the world based on the 2009 International Organization of Motor Vehicle Manufacturers production figures (OICA, 2010). Small incumbents were defined as having sold automobiles before 1991 and not being one of the 30 largest manufacturers in 2009. Startup companies were defined as not having sold automobiles before 1991. Diversifying companies existed before 1991, but were not involved in the sale of vehicles, representing such industries as energy storage and engineering.

Our study analyzed production and prototype models to identify what type of firm developed EVs, and which automobile segments they targeted. This gave an indication of how different types of firms approached EV development and how they expected the EV market to unfold. These pre-commercial efforts and were compared to the early Dutch EV market to in order to find out which approach was commercially successful.

4. Results

The results section begins with a broad EV industry analysis in section 4.1 and narrows its focus to the Dutch EV market in section 4.2.

4.1. The EV industry

4.1.1. Introduction of new EV firms

During an era of ferment there are low barriers to entry leading to an increased number of competing firms. Figure 1 shows the number of individual companies that have produced EV models in any given year from 1991 to 2011. For example, if Volkswagen produced two models in 2007, that would count as only one company in Figure 1. The number of companies that developed an EV fluctuated between two and 14 until the middle of the 2000s. Up to that point, EV models were principally produced by large incumbent manufacturers. The number of companies that manufactured an EV model increased from one in 2003 to 73 in 2011 with startup firms composing a majority of the growth during that time period. This increase in manufacturers was larger than during the last attempt at broad commercialization of EVs during the 1990s, which indicates that the industrial dynamics are different in the current situation. Small incumbents and diversifying firms were largely absent from EV production until 2006 but produced at least 10 models per year since then. The presence of a large number of competing startup firms distinguishes EVs from other powertrain alternatives (flex-fuel, compressed natural gas, hydrogen fuel cell, or hybrid-electric vehicles), which are manufactured almost without exception by large incumbent corporations or publicly funded research institutions. Figure 1 shows that large incumbents have been investing in electric vehicle technology and actively developing new models. This suggests that incumbents recognize the transformative potential of EVs and do not want to miss out on a potential paradigm shift in the automobile industry.

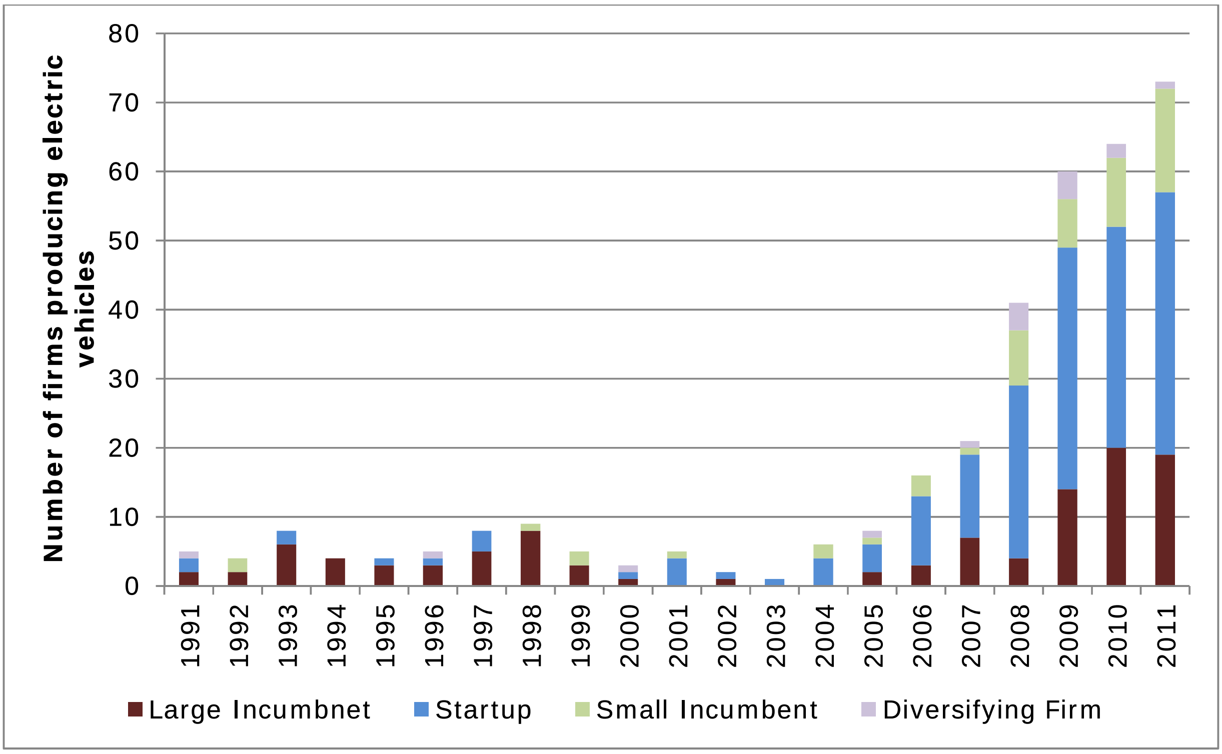

Figure 1: Number of companies producing electric vehicles

4.1.2. EV models by segment

Figure 2 breaks down the EV models produced by manufacturers between 2004 and 2011 into vehicle classes. The most commonly produced models were Segment B (56), LSV (51), Segment G/H (49), and Segment A (44). Manufacturers had also developed more than 25 models in the following vehicle classes: 3-wheeler, Segment C, and Segment N.

Manufacturers developed few models in large vehicle classes of Segment D/E, Segment F, HCV and bus.

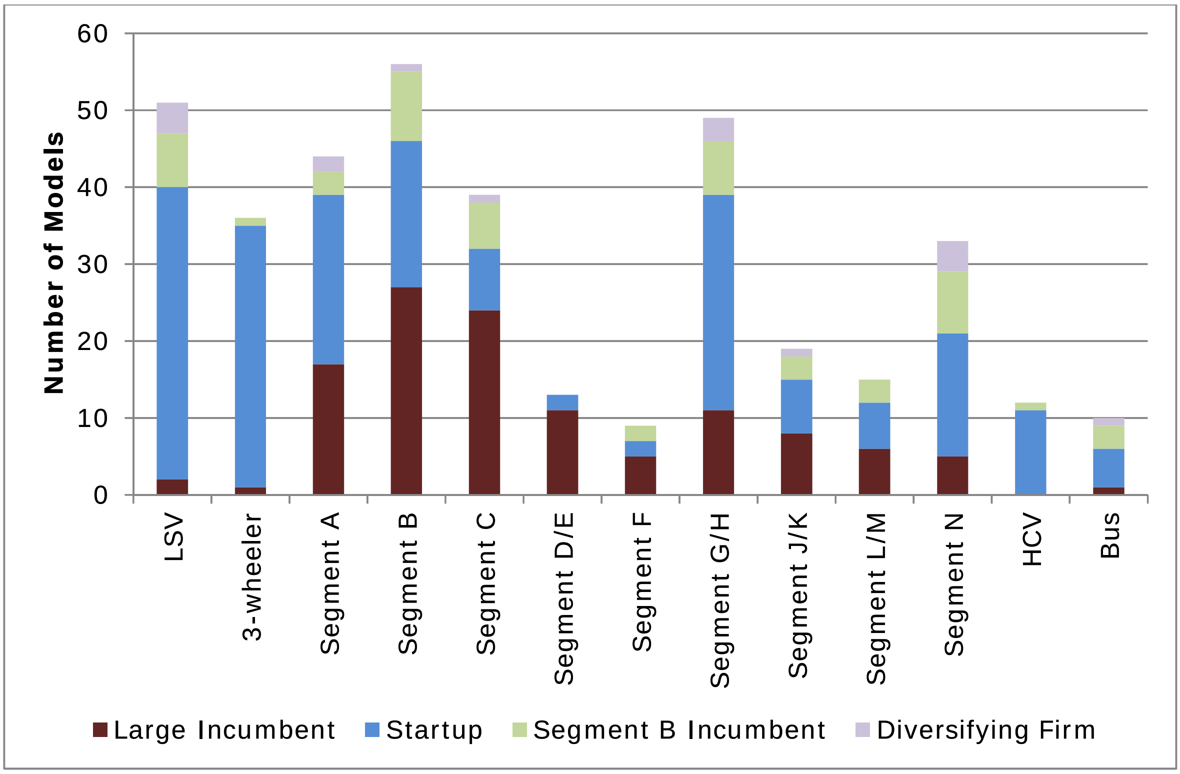

Figure 2: Electric vehicle classification by manufacturer type

In Figure 2, large incumbents and startups had different approaches toward EV production. Large incumbents developed a number of models in Segment A, Segment B, and Segment C. They avoided unconventional vehicles such as 3-wheelers and LSV and large commercial vehicles (buses and HCV). Perhaps large incumbents avoided producing unconventional vehicles like LSV or 3-wheelers because they differ markedly from current customer automobile demand. It is common for incumbents to be more concerned with fulfilling the needs of their current customers than identifying the customer needs of an emerging technology. Startups developed EVs in all vehicle classes while specifically focusing on models at the top and bottom of the market with 3-wheelers, LSV, and sports cars (Segment G/H). Larger passenger vehicles such those found in Segment C, Segment D/E, Segment F, Segment J/K and Segment L/M accounted for a relatively small proportion of the models produced by startups.

Segment G/H, which represents sports cars is reasonable market for EVs due to the expectation of higher price and performance features. EVs can achieve maximum torque as soon as the accelerator is depressed as opposed to ICE vehicles which gradually achieve maximum torque. Sports cars allow manufacturers to focus on the performance capabilities of EVs while decreasing the importance of high vehicle cost. Segment A also makes for a predictable EV market because it is more likely to consist of light-weight city cars that do not need to have a high top speed or long driving range. The high number of LSV and 3-

wheelers fits into a common niche market approach as firms explore potential markets for emerging innovations. There were very few EVs made in Segment D/E, even though it is a popular vehicle segment. This could be because large passenger vehicles highlight performance weaknesses of EVs e.g., low driving range.

4.2. The Dutch EV market

As of July, 2012, there were 4,038 EVs in the Netherlands with 2,830 having been sold since 2010. From 2010-2012[2], EVs comprised approximately .22% of all passenger vehicle sales. Compared to other European countries, the Netherlands has one of the largest EV market shares. Other European countries with high EV market shares are Norway, Denmark, and Switzerland. The Netherlands has used broadly available EV infrastructure and financial incentives to stimulate EV adoption. In July 2012, there were 3,266 charging stations widely dispersed around the Netherlands (Agentschap.nl, 2012). Dutch financial incentives made EV consumers exempt from both registration and annual circulation taxes providing potential savings of thousands of Euros.

Company cars have, to this point, played an important role in Dutch EV sales. Traditionally, company cars comprise 43% of all new vehicle sales (Gutiérrez-Puigarnau and van Ommeren, 2011), but they have accounted for roughly 93% of EV sales in the Netherlands. This indicates a very strong Dutch market for EVs as lease autos, fleet vehicles, and rentals, but weak demand among households. Even though company cars account for a large proportion of new vehicle sales, they comprise only 12% of the total vehicle stock in the Netherlands. This indicates the unlikelihood of achieving a high EV market share when a majority of the EV sales consist of company cars.

Compared to other countries, the Netherlands had relatively high levels of EV market share, charging stations per capita, and financial incentives. To this point, the Netherlands has been a quick adopter of EVs, although Dutch market share has primarily depended on company car sales. Further expansion of the EV market in the Netherlands will depend on either continued demand for EVs as company cars or an increase in sales to households.

4.2.1. The Dutch EV market by automobile segments

The above analysis shows that EV sales have been increasing and that company cars play an important role in their adoption. However, it does not give an indication of what types of EVs have been purchased in the Netherlands. Table 3 compares Dutch automobile sales from 2010 with 2012 1st half EV sales according to vehicle segment. This indicates how Dutch consumer EV preferences relate to their general automobile preferences.

[2] These statistics run through June in 2012.

	2010 Figures		2012 H1 EV	
	Sales	% Market	Sales	% Market
Segment A	112,146	23%	0	0%
Segment B	116,844	24%	152	8%
Segment C	96,063	20%	130	78%
Segment D/E	62,884	13%	1,582	13%
Segment F	726	0%	0	0%
Segment G/H	3,595	1%	17	1%
Segment J/K	44,975	9%	0	0%
Segment L/M	27,661	6%	0	0%
Segment N	7,644	2%	0	0%
Bus	684	0%	0	0%
HCV	9,487	2%	0	0%

Table 3: Netherlands 2010 auto and 2012 1st half EV sales (RAI, 2011; RAI, 2012)

Table 3 shows that Segment C dominated the 2012 Dutch EV market. EV sales from Segment D/E were almost entirely composed of Opel Amperas/Chevy Volts (1380 units). A comparison of general automobile sales to EV sales shows that the most popular vehicle segments in 2010 did not correspond to the most popular EV segments in 2012. Segments A and B represented almost half of all automobile sales in 2010, but they accounted for only 8% of EV sales in 2012. EV consumers almost exclusively preferred the larger passenger vehicles of Segment D. The limited demand in several vehicle segments indicates that the EV market is not nearly as heterogeneous as the general automobile market.

It is also worth noting that almost all of the EVs sold in Table 3 came from large incumbent auto manufacturers such as Nissan, GM, and PSA. EVs sold by startup manufacturers including Fisker, Tesla, Mia, and Think accounted for only 7% the 2012 1st half sales.

5. Conclusions

Our research set out to analyze how the broader dynamics of the global EV industry have translated to the Dutch EV market. The global EV industry has shown many of the traditional characteristics of an era of ferment including an increase in firm entry, a diversification in technological variety (battery chemistries), and exploration of niche markets. An era of ferment can, but does not necessarily, indicate an industrial transition similar to that found when horses were replaced by automobiles with internal combustion engines.

Our research has identified that on the global scale, many different firm types e.g., incumbents, startups, and diversifying firms have been developing a wide variety of EVs e.g., 3-wheelers, low speed vehicles, and automobiles in Segments A-N. This indicates several different paths that EVs could take if a transition in automobile technology did in fact occur. To answer the research question raised in the introduction, Dutch EV market does not represent a significant departure from the current automobile market paradigm.

Table 3 showed that within the Dutch market EV consumers have generally preferred Segment D/E automobiles made by large incumbents.

The future of electric mobility could include vehicles such as the low speed vehicles Tazzari Zero and Renault Twizzy and could feature EVs made by startup firms. However, the EV market would need to make a considerable shift away from its present trajectory. If trends hold, the future EV market will be roughly similar to the current automobile market with electric powertrains replacing internal combustion engines. Consumers would be buying the same size vehicles from the same group of automobile manufacturers.

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