Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles

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Abstract

Sustainable technologies challenge prevailing business practices, especially in industries that depend heavily on the use of fossil fuels. Firms are therefore in need of business models that transform the specific characteristics of sustainable technologies into new ways to create economic value and overcome the barriers that stand in the way of their market penetration. A key issue is the respective impact of incumbent and entrepreneurial firms' path-dependent behaviour on the development of such new business models. Embedded in the literature on business models, this paper explores how incumbent and entrepreneurial firms' path dependencies have affected the evolution of business models for electric vehicles. Based on a qualitative analysis of electric vehicle projects of key industry players over a five-year period (2006-2010), the paper identifies four business model archetypes and traces their evolution over time. Findings suggest that incumbent and entrepreneurial firms approach business model innovation in distinctive ways. Business model evolution shows a series of incremental changes that introduce service-based components, which were initially developed by entrepreneurial firms, to the product. Over time there seems to be some convergence in the business models of incumbents and entrepreneurs in the direction of delivering economy multi-purpose vehicles.

Keywords: sustainable technology, business models, evolution, path dependencies, electric vehicles

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INTRODUCTION

Sustainable technologies hold the promise to reduce harmful emissions and use resources more efficiently (Hockerts and Wüstenhagen, 2010; Johnson and Suskewicz, 2009). Despite being desirable for society, however, these technologies still face difficulties in penetrating mainstream markets (REN21, 2013). One barrier to market penetration is that sustainable technologies challenge prevailing business practices that depend heavily on the use of fossil fuels, especially in the oil and gas, electricity and automotive sectors (Jacobsson and Bergek, 2004; Johnson and Suskewicz, 2009). Since incumbents in these sectors have vested interests in profiting from unsustainable business practices (Cohen and Winn, 2007), they do not seem likely candidates to drive a change to more sustainable technologies. This role is expected from entrepreneurial new entrants instead (Hockerts and Wüstenhagen, 2010). However, new entrants not only face the problem that they have to challenge powerful incumbents (Ansari and Krop, 2012), but also deal with another barrier that is relevant to new entrants and incumbents alike: sustainable technologies lack market attractiveness (Johnson and Suskewicz, 2009). Sustainable technologies often do not fit existing production methods, managerial expertise and customer preferences (Johnson and Suskewicz, 2009) and the potential benefit of resolving environmental degradation in itself does not seem a sufficient condition to generate widespread customer acceptance (Kley et al., 2011; Siegel, 2009).

It has been argued, therefore, that firms need different business models to transform the specific characteristics of sustainable technologies into new ways to create economic value

(Chesbrough and Rosenbloom, 2002) and overcome the barriers that hinder market penetration (Johnson and Suskewicz, 2009; Kley et al., 2011). As Budde Christensen et al. (2012: 499) put it, "it might be that innovative technologies that have the potential to meet key sustainability targets are not easily introduced by existing business models within a sector, and that only by changes to the business model would such technologies become commercially viable." This would involve a fundamental reconsideration of the value proposition (product/services and segments targeted), the value network (product development, production and [after]sales), and the revenue/cost model (payment and financing) (Chesbrough and Rosenbloom, 2002; Demil and Lecocq, 2010; Johnson et al., 2008; Morris et al., 2005; Osterwalder et al., 2005). Moreover, through business model innovation, sustainable technologies would create new sources of value for customers in addition to their positive impact for the environment.

Electric vehicles (EVs) , the sustainable technology[1] on which we focus in this study, also face the challenge of how to create additional customer benefits, in particular to compensate for the higher initial investment compared to conventional cars (Kley et al., 2011). EVs could create such benefits through enabling more comprehensive mobility solutions (Kley et al., 2011), thus moving from product-based to service-based business models (Ceschin and Vezzoli, 2010); serving as energy storage in so-called 'smart energy' systems (Kley et al., 2011); generating new revenue streams from leasing the battery (Budde Christensen et al., 2012) or reusing it for second-use applications (Neubauer and Pesaran, 2011). However, the emerging EV 'industry' is still in search of a viable business model (Budde Christensen et al., 2012; Kley et al., 2011), which is not surprising as "[t]he right business model is rarely apparent early on in emerging

[1] It must be noted that electric vehicles are not sustainable per se. The potential to improve energy efficiency and reduce environmental degradation depends on the electricity source used to power the car. Acknowledging this caveat, we use the term sustainable technology to refer to electric vehicles because, if used correctly, they have a potential to contribute to sustainability, also in view of lower emissions.

industries" (Teece, 2010: 187). Both across and within firms various different business models are being pursued simultaneously through a process of learning, experimentation and adaptation (Demil and Lecocq, 2010; Sosna et al., 2010; Teece, 2010).

A key issue in this context is the respective impact of incumbents and entrepreneurial firms on this process (Chesbrough, 2010; Sosna et al., 2010); in particular because path-dependent behaviour shapes the business model that might eventually become the industry standard (Chesbrough and Rosenbloom, 2002). Path-dependent behaviour might cognitively constrain incumbents in finding new ways for value creation, as they prefer to stay close to what they are familiar with and to rely on a continuation of past successes. Nevertheless, these firms do have "a stable source of income from old business models that can cross-subsidize new business models" (Sosna et al., 2010: 403). Conversely, entrepreneurial firms are less constrained by path dependencies which makes them more flexible in designing more radical business models from scratch, but lack the resources to sustain a process of experimentation for a longer period of time (Sosna et al., 2010). It is therefore not clear upfront how the extent to which incumbent and entrepreneurial firms are driven by path-dependent behaviour will affect business model evolution in an emerging industry.

Despite a growing literature on the evolution of business models (Demil and Lecocq, 2010; Sosna et al., 2010; Teece, 2010), there is still limited understanding of how incumbent and entrepreneurial firms contribute to business model innovation and evolution in unique ways (cf. Hockerts and Wüstenhagen, 2010). We address this gap by exploring the following question: What is the impact of incumbent and entrepreneurial firms' path dependencies on the evolution of business models for the electric vehicle in the automotive industry? Based on a qualitative analysis of EV projects of key industry players over a five-year period (2006-2010), we aim to

identify the main competing business models in the EV industry and trace their evolution over time. By contrasting the historical background, the role of complementary assets, and the impact of critical events, we seek to uncover how incumbent and entrepreneurial firms have influenced the evolution of business models, and thereby also shed light on processes that shape the development of a (future) dominant business model. Before moving to the empirical analysis, first the main tenets of the theoretical debate about sustainable technologies, business models and path dependencies will be discussed.

SUSTAINABLE TECHNOLOGIES, BUSINESS MODELS AND VALUE CREATION

While sustainable technologies have the specific attribute to reduce environmental degradation (Rennings, 2000), firms face the challenge of how to develop a business model that transforms this attribute into sources of economic value creation (Chesbrough and Rosenbloom, 2002). An appropriate business model can increase the market attractiveness of a technology, improve the full value capture of an innovation and lead to a competitive advantage (Björkdahl, 2009). It is unclear, however, what an appropriate or 'right' business model is (Chesbrough, 2010). In case of emerging technologies the right business model is not yet apparent (Teece, 2010) and requires a process of experimentation based on several alterations (Chesbrough, 2010). That is, "one needs to distil fundamental truths about customer desires, customer assessments, the nature and likely future behavior of costs, and the capabilities of competitors when designing a commercially viable business model" (Teece, 2010: 187). A business model therefore evolves over time (Morris et al., 2005; Sosna et al., 2010; Teece, 2010) through "progressive refinements to create internal consistency and/or to adapt to its environment" (Demil and Lecocq, 2010: 228).

While the need for business model innovation has received widespread attention

(Chesbrough, 2010; Demil and Lecocq, 2010), it remains difficult to identify what a business model exactly entails (Teece, 2010). Business models tend to be rather complex (Casadesus-Masanell and Ricart, 2010; Zott and Amit, 2010), and many different conceptualizations have been suggested (Zott et al., 2011). On the one hand, scholars conceive of a business model in a broad sense, as a 'scale model' that describes a business as such as well as the general way in which firms create and capture value (Baden-Fuller and Morgan, 2010; Chesbrough, 2007; Demil and Lecocq, 2010; Teece, 2010). This generic conception enables a comparison of business models of different firms/industries and an identification of business model archetypes (Morris et al., 2005; Zott et al., 2011). Examples of such archetypes are the razor-and-blade business model that used to dominate the printing business (Chesbrough and Rosenbloom, 2002) and instant photography (Tripsas and Gavetti, 2000), or the double-sided market business model in which a firm creates an exchange platform for other producers and customers, popularized by online stores such as Amazon (Rysman, 2009). In an emerging industry, firms are still in search of a generic business model that may become the standard (Morris et al., 2005). Interest in converging to a dominant business model stems from the need to create legitimacy and customer acceptance for the emerging technology that all actors involved in the technology could benefit from (Aldrich and Fiol, 1994). Due to this convergence, "successful business models very often become, to some degree, 'shared' by multiple competitors" (Teece, 2010: 179).

On the other hand, scholars use a firm-specific conception of a business model to describe and design specific components and the interaction between them (Demil and Lecocq, 2010). The literature contains many depictions of components to describe and design a business model (Zott et al., 2011). Exemplary frameworks include Chesbrough and Rosenbloom (2002), Johnson et al. (2008), Morris et al. (2005), and Osterwalder et al. (2005), with key recurring

elements being the value proposition, the value network and the revenue/cost model. The main implication of a firm-specific conception is that within one archetypical business model, firms still have the choice to make unique choices to gain competitive advantage, implying a strategic perspective (Morris et al., 2005; Teece, 2010). While a business model is not the same as a business strategy (Teece, 2010), business model innovation provides firms with opportunities to gain competitive advantage (Morris et al., 2005). The uniqueness of the business model concept is its focus on value creation instead of value appropriation (Chesbrough and Rosenbloom, 2002; Zott et al., 2011). Business model thinking promotes developing unique ways to create value for customers as a way to prevent imitation by competitors (Zott et al., 2011). Just as one firm can have several business strategies, it can also employ various business models to create value for specific market segments (Teece, 2010). The strategic potential of business model innovation thus lies in identifying new sources of value creation (Zott et al., 2011), based on innovations of the different components of a business model and/or the interactions between these components (Demil and Lecocq, 2010; Morris et al., 2005).

How the components inherent to business model innovation could lead to value creation has received attention as well. Two main dimensions of value creation from business model innovation stand out in this regard: efficiency and novelty (Zott and Amit, 2008). They refer to two ways of handling transactions in economic exchanges, corresponding to a cost leadership and product differentiation strategy, respectively. While the focus of efficiency is on cost reductions of existing transactions, novelty highlights new ways to conduct transactions (Zott and Amit, 2008). Firms can employ business model innovation to create value based on one of these sources, but they could also use a combination of different sources (Amit and Zott, 2001). While business model innovation enables a firm to define a new strategic direction, a firm's

existing business model can also constrain what is strategically possible as firms will have an interest in maintaining core components of their business model (Chesbrough and Rosenbloom, 2002). The next section will explore how such path dependencies work out for specific firms, especially comparing incumbent and entrepreneurial firms.

PATH-DEPENDENT BEHAVIOUR IN BUSINESS MODEL EVOLUTION

Not all firms have the same ability to tap into different sources of value creation; it is markedly different for incumbents and entrepreneurial firms (Chesbrough, 2010; Sosna et al., 2010), related to the extent to which firms are cognitively constrained by path-dependent behaviour (Chesbrough and Rosenbloom, 2002). While path dependency alludes to the idea that past events guide future action and history matters, it also implies a persistence in decision-making patterns over time (Sydow et al., 2009). Through a combination of historical background and resource endowment, contingent events and self-reinforcing mechanisms, firms tend to get stuck in a specific path (Garud et al., 2010; Sydow et al., 2009; Vergne and Durand, 2010). In the process of business model evolution, we expect path dependency to have a considerable impact, but to play out differently in case of incumbent and entrepreneurial firms.

Path-dependent behaviour would lead incumbent firms to fit new technologies into their existing business models, because they have the tendency to stay closer to the status quo (Chesbrough and Rosenbloom, 2002; Sosna et al., 2010). As Chesbrough and Rosenbloom (2002: 550) argue, incumbents' "'sense-making' task will be constrained by its dominant logic, which is derived from its extant business model. Hence, that filtering process within a successful established firm is likely to preclude identification of models that differ substantially from the firm's current business model." Accordingly, we expect incumbents to focus on efficiency as

main source of value creation and evolve their business model to optimize cost efficiencies through economies of scale and scope. Besides, incumbents will have an interest to create internal complementarities, bundling new technologies with existing products and services, and serve existing customers with the support of known partners (Amit and Zott, 2001). Incumbents' main objective of business model innovation will thus be to leverage existing complementary assets (cf. Teece, 1986) to create cost efficiencies and reinforce their competitive position. A combination of several self-reinforcing mechanisms – i.e. sticking to established decision-making rules, using internal complementary assets, and meeting the expectations of existing customers (Sydow et al., 2009) – will drive incumbents to not diverge too much from existing business models (Chesbrough and Rosenbloom, 2002). The regulatory system in which firms are embedded will further reinforce the incumbent business model, particularly in industries that have historically seen a large government involvement due to their economic importance or health/safety concerns (Geels, 2002).

Path dependencies do not only constrain incumbents, but also enable an evolution of new business models over time (Sosna et al., 2010). Large firms have vast resources (Helfat and Lieberman, 2002) that provide a wide variety of starting points for business model innovation and allow experimentation with multiple business models simultaneously (Doz and Kosonen, 2010), including cross-subsidization of new business models (Pinkse et al., 2013; Sosna et al., 2010). This improves their chance of adopting a business model that will become the standard eventually (cf. Bayus and Agarwal, 2007). Business model evolution can therefore take much longer as there is no need to make a definite choice straightaway, leading to a greater diversity in business models over a prolonged period. Finally, we expect incumbents to be relatively unaffected by contingent events; not only will the cognitive constraints of the dominant logic

resist adaptations to the business model (Chesbrough and Rosenbloom, 2002; Prahalad and Bettis, 1986), but cross-subsidization will also create a financial buffer against disruptive events (Sosna et al., 2010).

Entrepreneurial firms are less hindered by path dependencies, because they do not face the cognitive constraint to fit new technologies into existing business models and can therefore develop completely new business models (Chesbrough and Rosenbloom, 2002). Entrepreneurial firms are "less constrained in the evaluation of alternative models" (Chesbrough and Rosenbloom, 2002: 550) and more flexible in pursuing radical business models (Sosna et al., 2010). Consequently, we expect these firms to emphasize novelty as main source of value creation (Amit and Zott, 2001) with a radical departure from the established business model in an industry, based on bundling new products and services in unique ways, engaging non-traditional partners, and targeting novel customers (Amit and Zott, 2001). The main objective of business model innovation will thus be to tap into complementary assets of new partners to create a unique value proposition. The novelty aspect of the business model acts as a dominant logic in itself, however (Prahalad and Bettis, 1986). While entrepreneurial firms' pre-entry experience creates the opportunity to leverage relevant knowledge from adjacent industries (Carroll et al., 1996; Helfat and Lieberman, 2002; Klepper and Simons, 2000), it will almost be a requirement to rely on new sources of value creation to pull customers away from incumbents and challenge their dominant market presence (Ansari and Krop, 2012; Hockerts and Wüstenhagen, 2010). The self-reinforcing mechanism is therefore that customers expect entrepreneurial firms to stick to a novelty-based business model to stand out from incumbents (cf. Sydow et al., 2009). The reliance on novelty also implies that entrepreneurial firms will face a greater challenge in creating legitimacy and customer acceptance for their business model (Aldrich and Fiol, 1994).

What constrains entrepreneurial firms in particular are limited resources (Baker and Nelson, 2005). As a result, these firms can only pursue one single business model at one point in time and cannot sustain experimentation for a very long period (Sosna et al., 2010). When they do not choose the business model that will eventually become the standard, they will most likely not survive. In contrast, incumbents still have the option to switch to the standard once it is known (Bayus and Agarwal, 2007), or when their political importance is large enough, they will be supported by the government even if their business model fails. Moreover, entrepreneurial firms are more susceptible to contingent events in finding a viable business model, which can either be beneficial or harmful. On the upside, entrepreneurial firms can exploit contingent events, such as critical incidents or regulatory changes, with greater ease, because they are more flexible in adjusting their business model to a changing context (Demil and Lecocq, 2010). On the downside, small firms lack a buffer to cope with contingent events that are disruptive to their initial business model. Thus, while entrepreneurial firms' business models might use novelty as main source of value creation, these firms are limited in their discovery process as they can only develop one business model and are more susceptible to contingent events.

In conclusion, we expect a distinctive impact of path dependencies on incumbent and entrepreneurial firms' business model evolution. This stems from a complex interplay of several factors, in which the (cognitive) constraints of the dominant logic, the role of complementary assets and contingent events stand out; all related to path-dependent behaviour of firms. Table 1 summarizes our main expectations which we will further investigate in the next sections.

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Insert Table 1

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METHODOLOGY, SAMPLE AND DATA ANALYSIS

The emergence of EVs as an alternative to conventional cars with an internal combustion engine (ICE) is a useful context to analyse business model evolution, because this industry is still in the process of discovering a business model that attracts large numbers of customers (Budde Christensen et al., 2012; Kley et al., 2011). This allows us to trace how and why different firms have been making adjustments to their business model and whether there is a convergence towards one or more business model archetypes (cf. Morris et al., 2005). We adopt a firm perspective on EV business models, which revolves around the vehicle with added service components, while the supporting recharging infrastructure and energy system are largely seen as external (Kley et al., 2011).

EVs diverge from conventional cars on several key dimensions (e.g. higher initial investments and limited driving range) that form a barrier to market penetration (Budde Christensen et al., 2012; Kley et al., 2011). The main technological difference is the propulsion technology (an electric motor versus an ICE) which has a considerable impact on the functioning and driving experience of the car (Chan, 2007). The electric drivetrain alters driving characteristics such as torque, sound and feel of the car, and the immediate availability of power improves acceleration. The relatively low energy density of batteries reduces EVs' driving range, however, which is further aggravated if they use the heavy all-steel body of conventional cars (Orsato and Wells, 2007). Finally, there is the infrastructure issue: EVs depend on a wide coverage of recharging stations. The challenge is to translate these technological differences between EVs and conventional cars into new sources of value creation through a viable business model (Budde Christensen et al., 2012; Chesbrough and Rosenbloom, 2002; Kley et al., 2011).

To investigate business model evolution, we identified all EV projects of key industry players in the period 2006-2010, covering electric vehicles – cars that drive on battery power alone – as well as plug-in hybrids such as the Chevrolet Volt, as they can drive on battery power for an extended range (>20 km). We conducted a content analysis of two industry trade magazines – Automotive News and Ward's AutoWorld – and a car magazine – Autoweek – which provide insight into industry and firm perceptions and offer rich descriptions of technologies and associated business models. We also analysed the Financial Times because of its focus on business strategies and its attention for sustainability as well as the broader political and economic contexts. A keyword search was performed for the period from 2006 until 2010 using search terms referring to plug-in and EV technologies which resulted in a set of 4,796 articles. We started our analysis from 2006 when EVs increasingly (re)appeared on the agenda (Bakker et al., 2012). After an initial period of interest in EVs in the 1990s, 2006 forms a landmark because various firms took first steps towards (re)launching EVs: Tesla launched the Roadster, Mitsubishi the Colt EV concept, and GM, Toyota and Daimler started developing a plug-in hybrid.[2] Table 2 provides an overview of firms engaging in EV projects, based on 1,235 excerpts that we used for the analysis.

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Insert Table 2

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To content-analyse the articles we used the qualitative data analysis software Atlas.ti 6.2.

[2] Limitations of our choice of data sources and specific time window are that some EV developments were omitted (e.g. the EV that the Indian firm REVA Electric Car Company launched in several countries since 2001 did not come back in our data) and that business models were still emerging. However, we aimed to actually capture a period in which car producers for the first time developed and commercialized EVs on an international scale, while keeping the analysis manageable. Still, to not gloss over key developments, we sometimes refer to developments prior to 2006 and after 2010 where relevant. We particularly thank one of the reviewers for many specific suggestions regarding this broader and longer-term picture.

We used a two-stage approach for the data analysis. First, all EV projects for the period 2006-2010 were distilled from the dataset, only keeping those that intended to commercialise EVs and thus excluding projects that did not reach beyond concept car development.[3] We made sense of these projects' business models by compiling and analysing the main business model components per firm over time. We labelled information as referring to business models when it had a connection to general characteristics of value creation and value capture (cf. Chesbrough, 2007; Teece, 2010) and structured it by distinguishing between three main components – i.e. value proposition, value network, and revenue/cost model (see Figure 1 included in the next section) – derived from existing frameworks (Chesbrough and Rosenbloom, 2002; Demil and Lecocq, 2010; Johnson et al., 2008; Morris et al., 2005; Osterwalder et al., 2005). We limited ourselves to three main components to maintain a certain simplicity, needed to trace the changes in each component and the interaction between them over time (Demil and Lecocq, 2010). This first stage had the objective to derive *business model archetypes for electric vehicles* (see Table 3 included in the next section) and trace how these archetypes had changed over time.

In the second stage, the firms with EV projects were examined according to their historical background and complementary assets. Because this paper is part of a wider study on the automotive industry, we used our larger database that includes developments on low-emission vehicles going back as far as 1997. The effects of firms' complementary assets and past experiences were summarized in a table and analysed. Subsequently, we examined the influence of contingent events on business model evolution on a firm and industry level for the 2006-2010 period. Regarding the value proposition, we looked for changes in the target segment, whether it

[3] A concept car that we omitted for this reason for example was GM's AUTOnomy. While this concept car featured an innovative platform which could have led to a radical change in the business model (due to a skateboard-like design), it was never commercialised.

was a luxury or economy vehicle, a specific- or multi-purpose vehicle (Orsato and Wells, 2007), and if there were adjustments to the product/service ratio (Kley et al., 2011). For the value network, we tracked changes in the make/buy decisions in development and production; whether the EV was purpose-built or refitted; and how sales and after-sales process were structured. For the revenue/cost model, we focused on changes in the way EVs were brought to the market; how firms used government incentives; and whether they found new sources of revenue. We summarised all these changes in a matrix and illustrated them visually on a timeline. Based on the visual timeline, narrative descriptions were constructed for the evolution over time (Bourgeois and Eisenhardt, 1988), which was further simplified to emphasize the decisive points to increase the explanatory power while keeping as much richness as possible. Tables 4 and Figure 2, included below, contain the key elements, as will be explained in the next sections.

FINDINGS

This section presents the main findings of our analysis of the impact of incumbent and entrepreneurial firms' path dependencies on business model evolution in the EV industry. First, the emergence of business models on a generic level will be explored. In this first subsection, four EV business model archetypes will be explained, including their main components. The second subsection discusses the process through which individual firms have tried to make adjustments to their business model to position strategically vis-à-vis rivals. This entails the role of path-dependent behaviour in the evolution of the business model on a firm level and then at a more aggregate approach to explore whether there has been a convergence at an industry level. The major findings are subsequently used to discuss the main differences in business model evolution between incumbent and entrepreneurial firms as initially presented in Table 1.

Electric vehicle business model archetypes

As mentioned above, this study uses a framework for business models that distinguishes three components: the value proposition, the value network, and the revenue/cost model (see Figure 1). The value proposition consists of the content in terms of the product/service ratio and the targeted customer segments. The value network reflects how the car itself is developed and produced as well as the sales and after-sales process. The revenue/cost model indicates which payment model firms use to charge customers and how they finance their venture, including government support. When using this framework to broadly sketch the dominant business model for (conventional ICE) cars, one can argue that carmakers target mainstream customers on a global scale with cars they produce themselves. These firms focus on multi-purpose vehicles in high-output production facilities, developed and produced collaboratively with suppliers and competitors, and sold or leased as-a-whole to customers. These choices have resulted in an affordable ICE-based mobility system that is firmly rooted in a widespread petrol-station network (Orsato and Wells, 2007).

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Insert Figure 1

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With regard to EVs, carmakers need to reconsider the business model and develop one that enables sustained EV mobility, addresses infrastructure issues and triggers customers' willingness to buy. Firms face questions about the correct value proposition, i.e. whether to focus on products or services and how to target the desired customer. They encounter choices regarding the value network, i.e. whether to make or buy EVs, how to sell them, maintain sold

vehicles, and how to establish linkages with suppliers and other producers. And there are choices referring to the revenue/cost model. Due to technological challenges and cost issues, firms feel obliged to provide additional services, such as leasing batteries that continue after the purchase of the vehicle has taken place (Kley et al., 2011).

Our analysis yielded four EV business model archetypes that firms in our sample have adopted so far. We derived these archetypes by distinguishing two dimensions of the value proposition. On the one hand, the value propositions differed with regard to the target customer, i.e. some firms targeted the luxury segment, others the economy segment. This dimension not only captures the target customer of the business model, but also tends to reflect the corporate identity, being either a luxury or a mainstream carmaker. On the other hand, the value propositions varied in terms of the main purpose of the car, i.e. a specific-purpose or a multi-purpose vehicle. While the purpose reflects a traditional division between car firms (e.g. between sports cars and family cars), in the case of EVs this dimension also shows how firms cope with EVs' limited range. Combining these two dimensions led to four EV business model archetypes: luxury specific-purpose; luxury multi-purpose; economy specific-purpose, and economy multi-purpose. The subsections that follow will discuss them consecutively with overviews of key aspects included in Tables 3 and 4.

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Insert Tables 3 & 4

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Luxury specific-purpose business model

The first EV business model archetype, luxury specific-purpose, offers affluent customers expensive EVs made for specific purposes only, such as leisure or urban commuting. Tesla

Motors (Roadster) is an example using this business model and the one that gained most visibility. Chrysler (Dodge EV), BMW (Mini E) and Audi (eTron) also announced to pursue this business model, but have made less progress; in fact, Chrysler cancelled its EV commercialisation project. In this business model, the car's driving experience and image are paramount, while range is not so important. BMW started a pilot in the US, as part of its Megacity project, using the electric Mini E for urban purposes. In the pilot, BMW learnt that range was no major issue for this segment: "Ninety-five percent of our Mini E customers realized very quickly that with a 100-mile range, on a daily basis, really there is no issue" (Guilford, 2010b). Tesla offered the Roadster, a luxury sports car, which accelerates within four seconds from 0 to 100 km/h. While these cars are expensive, attributes such as a fast acceleration are seen as benefits that compensate for the initial investment costs. Moreover, the typical customer for high-performance EVs is assumed not to be very price-sensitive and use them for leisure purposes. These customers also do not have a large need for an additional service component for recharging because they tend to have at least one other car for daily purposes and a garage in which the EV can be recharged.

The luxury specific-purpose value proposition is also tied into a specific layout of the value network. The luxury aspect is reflected in the sales and after-sales services. For example, Tesla decided to sell the Roadster in flagship stores designed by the creator of the Apple stores. "We're going to be in places like where I went with Apple – mainstream, where people are shopping day to day," stated George Blankenship, Tesla Motors' vice president for design and store development (Guilford, 2010a). While Tesla lacks a network of dealers, this approach ensures a high quality and allows educating customers about the advantages of electric driving. The service and maintenance of the car is provided via so-called rangers, sent to the customers as

a replacement of on-site maintenance. With regard to development and production, these luxury vehicles are usually produced in small quantities. Considering the high costs of developing a car from scratch and the difficulties to fit EVs into the existing production system, firms using this business model initially decided to refit existing sports cars with EV technology. Refitting refers to using parts of an existing model, replacing the ICE with an electric motor, and adapting the overall system to the new propulsion technology. Tesla refitted the Elise of the British sports carmaker Lotus, Chrysler intended to refit the Lotus Europe and Audi planned to use its R8 platform. Sports cars such as the Lotus were suitable because its aluminium/plastic body makes it lightweight, reducing the requirements for the battery's power capacity. However, also in refitted cars the new propulsion technology – which includes the battery, electric motor and battery management system – is key to competitive advantage. Tesla decided to use the design and assembly facilities of Lotus, but developed the battery, the motor and the control system itself. It used more than 6,000 thousand small standard laptop batteries and a proprietary management system to cool, charge and discharge them.

Luxury multi-purpose business model

The next EV business model archetype, luxury multi-purpose, also targets the high-performance market and shares many features with the luxury specific-purpose business model, such as customers' low price sensitivity and limited need for a recharging service component. However, this type differs in development and production. These EVs are multi-purpose because they can seat more than two passengers and transport several items (Orsato and Wells, 2007), and tend to be sedans. The multi-purpose aspect has implications for the car's performance, as it adds weight which requires more power for an adequate performance level. As a result, these cars have larger

batteries to propel the vehicle or have an additional power source on board – e.g. a back-up motor – which adds complexity to the vehicle and has consequences for the value network and the revenue/cost model. Building luxury multi-purpose EVs requires more tangible and intangible resources from a wide network of suppliers and partners, all of which considerably increase production costs.

A case in point is Fisker, a new entrant from California that pursued the luxury multi-purpose business model by building the Karma, a sedan with plug-in hybrid technology. In contrast to Tesla, Fisker designed the car itself but purchased the technology from outside partners. It bought the batteries from A123 which were supposed to be safer and easier to pack into a car than Tesla's approach of using laptop batteries, but also more expensive. From General Motors, Fisker purchased the plug-in technology which meant that the Karma had two propulsion technologies on board, making it less agile and less spacious. Valmet Automotive, a contract manufacturer with a focus on specialty low-volume cars, assembled the car. Due to Fisker's specific choices, the Karma became relatively heavy, more costly, whereas its driving capabilities were dependent on outside partners' expertise and development.

Economy specific-purpose business model

EVs were also commercialised with business models that target price-sensitive customers. The firms adopting an economy specific-purpose business model largely applied it to target urban commuters and commercial customers. For urban commuters EVs' positive sustainability impact seems most important, if only for the sake of reduced costs from improved fuel efficiency. Yet, this target group is often not able or not willing to bear with the additional initial investment costs, limited range, and lengthy recharging time. Due to these disadvantages carmakers were

required to focus on those components that could bring down the costs for the customer. Specific-purpose EVs also tend to be suitable for commercial customers such as fleet operators, postal services or utilities. Such customers can better cope with the limited range as they have the skills to predict the use of the car, plan routes and manage recharging cycles. Besides, they do not depend on a public recharging infrastructure which they install on their own premises instead. The main obstacle for commercial customers was the uncertainty about possible cost decreases; these are the result of often unpredictable or unknown (future) price differences between gasoline and electricity and the residual value of EVs which depends on the battery.

The main features of the economy specific-purpose business model are a focused value proposition, combining product and service aspects with adjustments to the revenue/cost model to reduce the initial investment. Firms using this business model started to add a service component to their product by renting or leasing the battery separately from the car. Battery leasing makes EVs more affordable and shifts uncertainty about the battery's reliability from the customer to the firm, while also increasing the car's residual value. Think, a small Norwegian EV producer, sold the car separate from the battery to be able to offer a price below that of other cars with green credentials. "We want to be under the price of a Prius," and "[take] away [customer] concern about battery management" (Automotive News, 2008).[4]

The economy specific-purpose business model has also taken the form of a more radical departure from the traditional business model for conventional cars. Firms have tried to overcome the problem of high initial costs with car-sharing programmes, increasing the service component beyond battery leasing. Car sharing is based on a belief that Generation Y is more interested in mobility as such than in car ownership, which opens up partial ownership as viable value proposition. A Toyota representative stated: "Maybe it's not an owned car; it's a shared car

[4] Think announced bankruptcy in 2011.

or a Zipcar. It means working with a different type of customer, which automakers don't like. I challenge Toyota with the question: Who owns the EV customer? Is it Toyota? Is it Zipcar? Is it the utility company?" (Guilford, 2010d). In 2009, Daimler started with the car-sharing initiative, car2go, with 200 Smart cars in the cities Ulm and Austin. At the time, these cars were still equipped with an ICE, but Daimler eventually integrated EV technology into the Smarts. [5]

Economy multi-purpose business model

The last of the four archetypes is the economy multi-purpose business model. Incumbents that already focused on the economy segment with conventional cars used this business model to launch all-round electric sedans. These firms have faced the largest challenges in attracting customers' interest. Due to the multi-purpose focus and the need for a large-sized car, the tension between high initial investment costs and range anxiety, on the one hand, and limited financial means of the customers, on the other, is more pronounced compared to the other three archetypes. Firms using this business model made a wide range of incremental adjustments to business models used for conventional cars. To deal with high investment costs, they changed the revenue/cost model by leasing the car, selling the car separate from the battery, or integrating government incentives to lower the retail price. These firms also found additional sources of revenue, for instance by selling used batteries or credits earned in regulation programmes, and licensing their technology to other firms.

Unlike many luxury EVs that were refits of existing cars, the economy multi-purpose option led carmakers to develop purpose-built cars produced in-house. This was seen by firms as the only way to achieve the necessary performance and cost targets. Refitted cars often suffer

[5] In 2011 another electric car-sharing scheme, Autolib, was established in Paris. Autolib provides EVs through a subscription service and recharging infrastructure and uses the Bolloré Bluecar which was first deployed within this car-sharing scheme.

from a sub-optimal fit between the existing technology and features of the new technology, such as the chassis design not being optimized for EVs. Heavy batteries need to be fitted in the chassis floor for optimized weight and stiffness attributes, which requires changes to the chassis that add weight and costs. While two main players with this business model – Nissan and General Motors – developed purpose-built cars produced in-house, they first outsourced battery development as they had little experience with this activity. To deal with customer concerns about battery lifetime, fuelled by negative experiences with deteriorating batteries for mobile phones, these firms provided an extended warranty on batteries.

To deal with the issue of range anxiety, some firms opted for a technological solution by adding a petrol-based back-up motor as a range extender, e.g. in the case of GM's Chevrolet Volt. Other firms adjusted the value proposition by offering additional services such as fast-charging, battery-swapping or the option to get a conventional car from the dealer for longer trips. Nissan offered a mobility service package for a monthly fee, granting a 50% discount on rental cars for longer trips. While most firms within the economy multi-purpose business model were incumbents such as General Motors, Nissan and Mitsubishi, the fast-charging and battery-swapping options were pioneered by Better Place, a Silicon Valley start-up from former SAP executive Shai Agassi. Better Place's business model was entirely service-based and aimed to offer cars like mobile phone schemes; i.e. pay an initial price for the car and then pay per kilometre driven. Renault and Nissan partnered with Better Place to offer these solutions in pilots in Israel and Denmark where a fast-charging and battery swapping infrastructure was partially installed.[6]

Overall, our findings show that different archetypes require different product-service system configurations (Ceschin and Vezzoli, 2010; Kley et al., 2011). For business models

[6] Better Place filed for bankruptcy in 2013 due to low acceptance and too high costs.

targeting the economy segment the importance of compensating the customer for the high initial investment costs, limited driving range and uncertainty about battery lifetime were particularly significant. Business models for the luxury segments were not only less concerned with these higher costs, but also depended less on a service component related to the need for regular recharging. Nevertheless, both business models targeting the economy and luxury segments underwent considerable changes over the period under study. This process of business model evolution will be examined next.

Path dependencies and contingencies in the evolution of EV business models

In the period under study several different business model archetypes developed. Firms often took their existing business model for conventional cars as a starting point to incrementally adjust it to compensate for the downsides of EVs for customers, suggesting path-dependent behaviour. In this section, we will examine in more detail how path-dependent behaviour influenced business model evolution, contrasting luxury and economy segments, and within that discussing incumbent and entrepreneurial firms.

Business model evolution in the luxury-vehicle segment

The incumbents BMW and Audi and the new entrants Tesla and Fisker pursued the luxury archetypes. Their reasons to target this segment differed considerably, however. For BMW and Audi, it was a logical step, as they have production capabilities and facilities, and well-known brands in the luxury segment, as well as the reputation of being trusted firms; capabilities they could leverage in the EV market. Moreover, BMW already had experience with EV technology through its hydrogen car development programme, and an understanding of serving urban

affluent customers through its Mini Cooper brand.

Tesla and Fisker lacked the complementary assets, such as production facilities, an existing customer base, and the legitimacy of an established, trusted firm; an issue of particular importance because cars are a high-involvement purchase. Nevertheless, these entrepreneurial firms brought specialized knowledge to the EV industry that the founders had built up in previous ventures (cf. Helfat and Lieberman, 2002), which influenced their business models. Tesla had developed an intelligent high-performance battery management system, enabling extremely fast acceleration. The founders Elon Musk who also founded PayPal, and Martin Eberhard, an electrical engineer, initially licensed technology from AC Propulsion, a firm specialized in high-performance electric drivetrains. Tesla further improved the battery management technology through innovation in-house. Fisker was founded by the designer Henrik Fisker, who had 20 years of work experience at BMW and Ford, and had been responsible for the designs of the sports cars BMW Z8 and Aston Martin DB9. Consequently, Fisker had superior design capabilities that influenced its choice for a luxury multi-purpose car.

The evolution of the value proposition seemed similar for incumbents and new entrants; first gain resources and knowledge by serving the luxury market with refitted EVs and then build purpose-built models. Initially the firms in the two luxury archetypes decided to use parts of existing cars. Tesla used the chassis of the Lotus Elise, Fisker the propulsion technology developed by General Motors, BMW refitted its Mini, and Audi intended to retool the R8 super sports car. Later on Tesla, Fisker and BMW started to design and produce EVs from scratch. Elon Musk even argued: “I don't think any manufacturer, Tesla included, has really designed a car to optimize the electric powertrain […] It's a bit like the early days of automobiles where you had horseless carriages […] It works, of course. You can take a carriage and put an engine on it

and you can drive around, but it's not the best way to use an internal combustion engine" (Guilford, 2010e).

In the later years of the period under study, the firms in the luxury archetypes showed signs of extending their business model in new directions. The new entrants seemed to make their business model less radical, while BMW chose to leave the beaten track with plans to build an EV completely from scratch, with an "i" subbrand for which it initiated a new project that functioned outside the firm's existing structures. It commented that project i was a "wild think tank where people were absolutely free to question everything" (Guilford, 2010c). Accordingly, BMW invested $100 million in a carbon-fibre plant to bring down vehicle weight.[7] Tesla and Fisker tried to mainstream their ventures instead and scale up production. While Tesla's first model, the Roadster, was assembled by Lotus in the UK, its follow-up, the multi-purpose Model S aimed at in-house production, for which an abandoned production facility was bought from Toyota: "There's never been a better time to buy automotive equipment in the industry […] We're getting first-rate equipment for pennies on the dollar" (Reed, 2010). Fisker also intended to scale up and develop an economy multi-purpose vehicle - the Fisker Nina - largely following the same route as Tesla by buying an abandoned production facility from General Motors.[8]

The value proposition of incumbents and entrepreneurial firms in the luxury segment was largely similar, but there were notable differences in the value network and revenue/cost model. While the incumbents could rely on their existing network and revenue streams, the entrepreneurs were following a more distinctive path in their sales process and revenue/cost model. Due to a lack of existing dealers, the new entrants were forced to find alternative

[7] In 2013, BMW began mass production of the EV i3. Although the i3 is marketed with a focus on urban mobility, its price (comparable to a Nissan Leaf at €35,000), the possibility to seat four people and the optional range extender seem to make it more suitable for the economy multi-purpose category. However, other models that will come out of Project i such as the i8 will be targeted to the luxury segment.

[8] The Fisker Nina never entered the market as Fisker had to stop production in 2012 and faced bankruptcy in 2013. The Tesla Model S was launched in 2013.

marketing channels. Their initial plan was to sell their cars via the internet or through Apple-like flagship stores in major cities. The Chinese new entrant, BYD argued for example that flagship stores would have the added benefit of educating customers: "It's not a just a dealership […] You're not just buying cars - you're buying elements of the green solution. We already make all of these things. The only way we can educate customers on the components within this ecosystem is through these Apple-like stores that are not just selling electric vehicles" (Automotive News, 2010b).

For the new entrants, it was a real challenge to fund their activities, because they did not have a revenue stream from existing business (Sosna et al., 2010). Consequently, the entrepreneurial firms had to find creative ways to finance their operations. Besides (government) loans and venture capital investments, the new entrants also traded credits from government programmes. California mandated the seven largest incumbents to sell 7,500 zero-emission vehicles (ZEV) and 60,000 low-emission vehicles by 2012. Every carmaker could earn credits per ZEV sold. Small firms like Tesla, while exempted from the requirement, were allowed to earn credits estimated to be worth $5,000. One Tesla Roadster earned four credits, i.e. $20,000 per car, if traded on the market. Honda bought credits from Tesla for an equivalent of 368 cars and ordered additional credits for another 287 cars. Other incumbents also bought credits from Tesla, but details were not disclosed. Small EV producers, such as Aptera, also applied this strategy, but in smaller numbers. New entrants also generated additional income through licensing their technology for powertrains and battery management software. Tesla stated: "We're very interested in supplying electric powertrains. We'll supply them as long as people want them from us" (Guilford, 2010e).

Most players in the luxury archetype started with a value proposition of refitted luxury

models to build resources and knowledge, to then also move to broader segments by scaling up production. BMW's Project i is remarkable as it aims for the upper end of the economy segment, while also planning to stay true to its luxury brand identity as the firm intends to launch luxury sports EVs in the coming years. The main difference between incumbents and new entrants in this segment could be found in the value network and revenue/cost model; new entrants could not rely on existing networks and funding and tested alternative marketing channels and sought additional revenues to finance their operations.

Business model evolution in the economy-vehicle segment

With the exception of Think, only incumbents served the economy segment by staying close to their business model for conventional cars. The incumbents had the experience and the international scope to develop, produce and commercialise multi-purpose EVs based on large-scale production in various countries. To achieve scale with EVs, both General Motors and Nissan developed purpose-built EVs. The smaller incumbent Mitsubishi instead refitted its "i" car with an electric motor, while Think developed a purpose-built urban commuter based on a modular design. Nevertheless, the incumbents initially lacked the resources to develop and produce EV technology, and either outsourced battery development (General Motors) or started joint ventures with battery producers (Nissan and Mitsubishi). With increasing commitments in EV technology, however, the incumbents adjusted their value network, investing in battery technology to develop and produce these core components in-house to gain control over their value proposition.

In line with their international scope, the incumbents intended to commercialise EVs on a worldwide scale. When the Volt concept was unveiled, General Motors announced: "We see it

being sold round the world" (Simon, 2007). These international aspirations also had implications for the platform. As General Motors decided to add a back-up motor, the Volt was designed so that it could use different fuel types. "If it's in Europe, it could be biodiesel; if it's in Brazil, it could be E100 (100% ethanol) […] GM is committed to making this a volume play globally" (Winter, 2007). By targeting mainstream markets, incumbents also had to provide certainty about product reliability. General Motors argued, "if you go after a mass audience, you have to give them that peace of mind to know that they won't be stranded […] People are looking for a real car, not just an electric car. That's a significant difference between us and our competitors" (Simon, 2010). And Nissan stated that "We weren't aiming for something totally different […] We want it to be mainstream" (Greimel, 2010). To gain legitimacy in the customers' eyes, General Motors gave warranties of up to 8 years or 100,000 miles, a practice later followed by its rivals.

To compete in the economy multi-purpose segment, General Motors and Nissan recognized early on that they had to provide a product that would be competitive with comparable cars in this segment. General Motors argued that an EV "needs to be affordable to the buyer of a normal mid-sized car" (Simon, 2007), an aspect Nissan emphasised as well: "It was important for us for the Leaf to be perceived as a real car, and affordability is a part of that" (Automotive News, 2010a). While General Motors had the range anxiety solved, Nissan still faced the challenge that customers would fear being stranded. Nissan therefore envisaged offering battery swaps; initially to take place at Nissan dealers. "As a customer, you are not concerned about 'Is this battery reliable? Will it run out?' […] We take care of that" (Guilford, 2008). Later Nissan partnered with Better Place to offer battery-swapping services. In addition, Nissan offered a programme for free recharging and inspections at Nissan dealers and a discount

on rental cars when longer range was needed. Nevertheless, a remaining barrier to the mainstreaming of EVs was the limited possibility to offer a wide range of variants per model. While conventional cars are available in different configurations (e.g. chassis type, transmission, engine), EVs tended to be available in one configuration only with limited options for customisation.

While the business models in the economy segment witnessed an evolution towards additional services, the changes were fairly incremental in the period of our study. One of the reasons why incumbents did not make large adjustments seemed the lengthy approval process. The duration of EV projects was fairly long and once top management had approved a project only minor changes were possible. Especially the value proposition was set in stone; those modifications that we could observe related to a reconfiguration of the value network – e.g. internalizing battery development – and the revenue/cost model, which was one of the most volatile components of the business model. In the early years, most incumbents offered EVs like conventional cars, but when demand did not pick up, firms leased the battery separate from the car to lower the purchasing price and reduce uncertainty about future technological advances in battery technology. As Nissan put it: "Our thinking is that it might give customers some protection from technological advances […] Battery technology could advance rapidly over the next three or four years. This way, they wouldn't be stuck owning an out-of-date battery" (Chappell, 2009). Leasing the battery separately also created a secondary market for used batteries, which could be used as energy storage in commercial power generation or households. In 2009, Nissan started a joint venture with Sumitomo Corp., which specialized in trading used batteries. Another change in the revenue/cost model had to do with creating a better fit with the lease market that is particularly important in the US; a change that was further accelerated by

government incentives that applied to the lease market. As Nissan stated: "We could arrange it so that they apply the tax credit to the cost of the lease, which would bring down the total ownership cost" (Chappell, 2009).

To summarise, the firms in the economy segment stayed quite close to their value proposition for conventional cars. The changes they made – such as internalising battery development, adjusting the pricing strategy, and leasing the battery – were fairly incremental, but a logical consequence of the increasing strategic importance of EVs and the need to be more cost competitive and to control core components. The presence of entrepreneurial firms was negligible in this segment, except maybe for the role of Better Place in providing complementary services to the EVs of Renault and Nissan. The only development that seemed more radical was Daimler's move to stimulate its car2go car-sharing services with the Smart brand. As such, car-sharing was something that Nissan also envisioned: "It is an entirely different way of owning and using a car […] With such a high initial fixed cost it makes sense for individuals to pay an annual fee for use of an electric vehicle in a car-sharing scheme" (Harding, 2009). However, there were no strong indications of other incumbents moving in the same direction.

Converging EV business models? The role of contingent events

Our findings showed that the EV industry still pursues different business models that rival each other. We found no clear evidence that the industry is moving towards one unified EV business model, but some convergence seemed to be taking place towards the economy segment. Taking a more aggregate perspective, several contingent events occurred within and outside the industry that influenced the evolution of business models; these included regulation, customer preferences, competitive moves of rivals, technological developments, and the emergence of best

practices. Bandwagon effects could be observed for some business model archetypes, both in general and at the firm level.

The global financial crisis was one of the main external events that affected business model evolution in the EV industry. To prevent massive job losses, many governments adopted bail-out and incentive plans for struggling car firms. These incentives stimulated EV development, because they were often pegged to sustainability requirements. The US government launched the Advanced Technology Vehicles Manufacturing loan programme, containing $25 billion for green technologies, for which carmakers could also apply. In the UK, the Automotive Assistance Programme provided £2.3 billion of loans and guarantees for R&D and production of green vehicles. In response to the incentives, an increasing number of established car firms, including Ford, Hyundai and Volvo, started developing EVs using the economy multi-purpose business model. The incentives were high enough to compensate for the battery costs and made economy multi-purpose EVs price competitive with conventional cars. The incentives were less significant for the luxury segment, because they only accounted for a marginal share of the purchasing price.

While the incentives could also have stimulated entrepreneurial firms to engage in EVs, it proved much easier for incumbents with relevant complementary assets to make this move. Generally, it takes much longer for new entrants to develop an EV. Therefore, from the moment the incentives were announced, incumbents were considerably faster in bringing EVs to the market; new entrants struggled with the short timeframe. As a consequence, only existing entrepreneurial firms and incumbents were stimulated; the majority of which already focused on the economy multi-purpose model, thus inducing some convergence. Business model evolution in the direction of economic multi-purpose EVs was also influenced by existing customer

preferences and expectations, because retail customers tend to be conservative with a bias towards conventional cars. Economy multi-purpose EVs enable a gradual switch to EV mobility. This contingency especially benefited plug-in hybrids, not least because they could also use the existing infrastructure.

Several contingent events also came from within the industry. One of the main events for EV development was the relative success of the Tesla Roadster. The Californian firm succeeded in making EV technology attractive by promoting its high-performance features. While Tesla's success created a halo effect for the EV industry as a whole, it did not lead to direct followers that also pursued the luxury specific-purpose business model. Best practices and competitive moves by direct rivals particularly affected firms operating within the economy multi-purpose model. Trailing General Motors, many firms adopted a longer warranty period. Moreover, practices such as leasing the battery separately from the car itself and offering a conventional vehicle for longer trips quickly diffused throughout the industry. The development of battery technology was another contingency with an impact on business model evolution. The battery still forms the main bottleneck for further market penetration of EVs. Business models that stand to gain most from increased driving ranges are those in the multi-purpose segments, because these cars tend to be fairly heavy. While the lack of battery technology as a complementary asset was pushing carmakers to continue outsourcing of this activity to specialized battery firms, this is gradually changing as battery technology is seen as key to future competitiveness in the EV industry. Interestingly, many innovative aspects of the business models that we studied actually came from limitations of the batteries currently in use. The fact that firms did not control batteries' technological progress was one of the main drivers behind novelties such as substitute vehicles for longer trips, battery swapping options or car-sharing schemes. Firms had to work

their way around the technical problem over which they had no control through ingenious adjustments to their business models.

DISCUSSION AND CONCLUSIONS

With the general challenges faced by firms with regard to a transition to more sustainable technologies as background, this study set out to understand the role of path dependencies in the evolution of business models used to commercialise such technologies. While the extant literature has particularly focused on the technological and system attributes (Jacobsson and Bergek, 2004), we paid attention to the need for business model innovation to bring emerging sustainable technologies to the market (cf. Chesbrough, 2007). We addressed key decisions of firms in developing a business model to effectively overcome the disadvantages currently hindering further market penetration of sustainable technologies (Budde Christensen et al., 2012; Johnson and Suskewicz, 2009; Kley et al., 2011). As it has been argued that path-dependent behaviour affects incumbent and entrepreneurial firms differently (Chesbrough and Rosenbloom, 2002; Sosna et al., 2010), our study explored how this difference influenced the move to a business model standard for EVs, focusing on the impact of the dominant business model logic of a firm, the complementary assets, and contingent events that firms faced along the way (see Table 1).

Discussion of findings

Our findings revealed that incumbents and entrepreneurial firms in the car industry approach business model innovation differently. While differences broadly reflected the notion that incumbents are more cognitively constrained than new entrants by path dependencies that create

the need to stay close to the existing business logic (Chesbrough and Rosenbloom, 2002), these differences were not always unequivocal. Most incumbents indeed stayed rather close to their existing business model used for conventional cars, targeting the same customer group with a comparable product-focused content, but Daimler's car2go initiative and BMW's plans for project i were notable exceptions. The findings are in line with our expectation that incumbents would focus on efficiency as a main source of value creation (Amit and Zott, 2001), as these firms envisaged EV mass production from the outset and adjustments were mainly driven by cost reduction requirements, e.g. lowering the purchasing price by changing the revenue/cost model. Yet, they made a few adjustments to several business model components. For example, they offered additional services, such as leasing the battery separately, providing a longer warranty or the option to rent a conventional car for longer distances, and outsourced the supply of core components related to the battery of the EV. Nevertheless, most of these practices were not entirely new to incumbents or the car industry, as they usually had been applied before to other ICE vehicles. For example, Daimler had used its Smart brand to experiment with business model innovation in the form of a novel design, new retailing channels and an alternative production strategy, while the South Korean carmakers Kia and Hyundai pioneered extended warranties to compensate for their low brand image.

Still in the EV industry, entrepreneurial firms were the main source of key novelties in business models that later diffused throughout the industry as they found creative ways to circumvent the drawbacks of EVs (e.g. cost, range, charging time) and initially started their business models with different types of novelties to create value for the customer (Amit and Zott, 2001). Tesla and Fisker developed business models that emphasized the superior advantages of EVs in the shape of high-performance luxury EVs (cf. Kley et al., 2011), and found customers

willing to pay a premium for an electric sports car with exceptional acceleration, whereas Better Place introduced a mobile phone payment method to solve the range and recharging challenges. However, over time and due to contingent events, these entrepreneurial firms moved into less expensive EVs and on a large scale. In the case of Tesla in particular, the halo effect of the Tesla Roadster seems to have gained the firm legitimacy, but no substantive imitation by other firms (Aldrich and Fiol, 1994). However, the only firm that could sustain its activities in a proper way after our study period was Tesla, which underlines the susceptibility of entrepreneurial firms indicated in the theoretical section.

Incumbents' complementary assets not only led them to stay close to their existing business models, but also allowed them to respond to contingent events such as government programmes more rapidly than entrepreneurial firms. With the exception of the battery, incumbents could depend on their existing value network. In the luxury segment, refitting was a common practice to quickly move into the EV industry. In the economy segment, the rising popularity of EVs created an opportunity for firms with hybrids to leverage these models by creating plug-in versions, thus trying to ride the wave of electric mobility with fairly minor technological adjustments. Nevertheless, Nissan and General Motors also developed purpose-built EVs which reduced the leverage potential of production assets, although the Leaf and the Volt still used existing platforms. Another complementary asset that incumbents could leverage was their dealer network; in fact, there were many signs that this network might even become more important as it could play a central role in delivering the new service-based components of the value proposition. Moreover, most incumbents could depend on internal revenue streams to finance their EV projects; although it must be noted that part of these projects were financed from government funds. Yet, in the period of study, the incumbents tended to focus on one

business model only, which was adjusted over time. This might be due to the fact that we only considered the initial stages of business model evolution in this industry, when firms launched their first models on a limited scale. There were indications that firms would eventually try more business models simultaneously, while staying within the same business model archetype. Nissan was already pursuing slightly different models by selling the Leaf not only with an integrated battery, but also with a battery-swapping service (in collaboration with Better Place, as envisaged at the time).

Entrepreneurial firms could not depend on complementary assets such as existing production facilities and a dealer network, and had to work their way around this. In refitting existing cars, they had to build ties with other firms in the automotive industry. Entrepreneurial firms also built complementarities by combining products and services in unique ways to attract new customers. We expected entrepreneurs to focus on one business model at a time and use knowledge gained in adjacent industries, which they indeed did, but as noted above, incumbents did the same. The use of prior knowledge was more obvious in some cases than in others. Fisker's founder brought unique capabilities in car design. For Tesla and Better Place, the influence of the founders' experience was less evident, although they could leverage skills in attracting funding and handling novel technologies.

Finally, our findings suggest that incumbents' business models (and the firms themselves) were more resilient in the occurrence of contingent events. Once incumbents had made a choice for a specific configuration of the different components of their business model, changes were fairly marginal. General Motors and Chrysler even continued their EV ventures after they went bankrupt. Yet, this continuation was also a necessity because the government bailout required a prolonged engagement in sustainable technologies. However, in the case of

Chrysler, the takeover by Fiat resulted in a cancellation of the EV project. While not too apparent in the findings, there were indications that EV projects suffered from internal cost-cutting measures when firms were in dire straits. Incumbents turned out to be more agile in anticipating government incentives and their complementary assets enabled them to use these incentives to enter the EV industry. Nevertheless, entrepreneurial firms that had already entered the industry at an earlier stage were also able to gain from these incentives. In fact, government support was an important enabler for firms such as Tesla and Fisker to broaden their business models. The entrepreneurial firms were financially vulnerable to contingent events as well. Their main sources of funding – government programmes and venture capital – were showing erratic behaviour that made the continuation of their operations highly uncertain.

In summary, all three factors that tend to drive path-dependent behaviour – i.e. the dominant business model logic, complementary assets, and contingent events (see Table 1) – seemed to work in close alignment, creating a self-reinforcing mechanism (Garud et al., 2010; Sydow et al., 2009; Vergne and Durand, 2010). In the short period that we studied this stimulated most firms in the direction of the economy multi-purpose business model (see Figure 2). However, due to the short time range of the study, no firm conclusions can be drawn, as many EVs were still in the concept phase and there is much dynamism. The economy multi-purpose business model suffers most from the drawbacks of the battery and thus seems less promising than the economy and luxury specific-purpose segments. There were indications that the efforts of BMW and Daimler could break with the economy multi-purpose trend with their focus on urban commuters, electric sports cars and car-sharing schemes. Overall, the least promising business model appeared to be the luxury multi-purpose segment due to technical impediments; that is, the promise of high-performance acceleration is compromised by the added weight that

comes with the multi-purpose aspect.

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Insert Figure 2

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Contributions, limitations and future research

With this study, we aimed to contribute to the emergent literature on business models (Zott et al., 2011) through an empirical exploration of the influence of path dependencies on business model evolution in the case of EVs. This builds on recent suggestions that business model research would be more fruitful from a dynamic perspective (cf. Chesbrough, 2010; Demil and Lecocq, 2010; Sosna et al., 2010). Our findings showed that even in the 'conservative' automotive industry, business models tend to be fairly fluid. However, the different business model components were quite distinct in this respect; while the firms in our study did not make radical changes to the value proposition, most adjustments occurred in the value network and the revenue/cost model. Since these adjustments are particularly pronounced in the early stages of a new industry, the fact that we focused on the initial years of the renaissance of the electric vehicle might have caused us to see more changes than would be typical though. We would expect business models to become less fluid over time when the industry reaches a more established state.

Our study also sought to contribute to the literature on sustainable technology (Hockerts and Wüstenhagen, 2010; Jacobsson and Bergek, 2004). It helped shedding light on the way in which technology and system attributes – e.g. limited driving range due to inadequate battery technology, high initial investment costs, and lack of recharging infrastructure – translate into

specific components of a business model: its value proposition, value network, and revenue/cost model (cf. Chesbrough and Rosenbloom, 2002). This literature also argues that incumbents might not be involved in the first stages of the development of sustainable technologies (Hockerts and Wüstenhagen, 2010). Our findings suggest that entrepreneurial firms were indeed the first to develop the main novelties in EV business models, but many incumbents were active in developing EV business models around the same time, and could thus not really be labelled as 'followers'.

The study has several limitations. Firstly, although we were able to collect and analyse vast amounts of data, the industry trade and car magazines that were used as main sources are all based in the US. Despite their global orientation, it might be that these magazines missed some developments in Europe and/or the Asia-Pacific region. For Europe in particular, the inclusion of the Financial Times was a counterbalance, but contains fewer details on the car industry. There were also limitations in identifying all the components of a business model from the information provided by the magazines and newspaper, as this is not their main aim. To address this problem as good as possible, we decided to focus on three main elements of the business model – value proposition, value network and revenue/cost model – which were easier to track.

Secondly, we decided to take a firm perspective and a fairly narrow focus on EVs over a relatively short time period. While this helped us to focus our analysis, we acknowledge that EVs need to be seen in the overall development of low-emission vehicles (LEVs) over a much longer period. Since the early 1990s, three LEV technologies have competed as 'sustainable' alternative to the ICE: fuel cell, hybrid, and electric vehicles (Bakker et al., 2012; Pinkse et al., 2013). The evolution of the four EV business model archetypes will also be affected by developments in hybrid and fuel cell vehicles, which could be seen as additional contingencies. And while our

study was longitudinal in nature, the short period of time considered implies that, as mentioned above, our findings on convergence on a specific business model archetype are highly tentative. Our firm perspective might also have led us to disregard business models that were coming from outside the automotive industry. Although Better Place was not successful in the end, it is an illustration of how the dominant business model in the car industry, which is still focused on the production and sales of cars, might be subsumed under a new business model that is completely service-driven (Budde Christensen et al., 2012; Kley et al., 2011). Tracking further developments in EV business models is worth follow-up investigation, especially because the number of firms moving into this industry has only increased since the period covered in this study.

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Tables and Figures

Table 1 The expected impact of path dependencies on business model evolution

Path dependencies	**Possible impact on incumbent firms' business model innovation & evolution**	**Possible impact on entrepreneurial firms' business model innovation & evolution**
Dominant business model logic	• Incumbent firms are cognitively constrained by the existing business model and will make new technologies fit into existing business models	• Entrepreneurial firms are <u>not</u> cognitively constrained by the existing business model and will design novel business models for new technologies
	• Incumbent firms will focus on efficiency as main source of value creation of the business model	• Entrepreneurial firms will focus on novelty as main source of value creation of the business model
Complementary assets	• Incumbent firms will create complementarities by bundling old and new products and services and use the business model to serve existing customers	• Entrepreneurial firms will create complementarities by bundling new products and services in unique ways and use the business model to attract new customers
	• Incumbent firms will experiment with different business models simultaneously and cross-subsidize with revenues from existing business models	• Entrepreneurial firms will focus on a single business model at one point in time and leverage pre-entry knowledge from adjacent industries
Contingent events	• Incumbent firms will not be susceptible to contingent events and tend to stick to a business model once it is in place	• Entrepreneurial firms will be susceptible to contingent events and make continuous changes to their business model
	• Incumbent firms will not be vulnerable to disruptive contingent events as they have a financial buffer from existing business activities	• Entrepreneurial firms will be vulnerable to disruptive contingent events as they lack a financial buffer to cope with the disruption

Table 2 Excerpt counts per firm for electric and plug-in vehicle technology (in absolute numbers and as percentage of all articles on electric vehicles in total)

Firm	2006	2007	2008	2009	2010	Total	Share
Incumbent firms							
GM	18	70	52	71	56	267	22%
Nissan	0	9	32	75	69	185	15%
Toyota	5	18	22	29	25	99	8%
Mitsubishi	5	9	18	22	28	82	7%
Daimler	3	3	10	31	18	65	5%
Chrysler	0	6	29	16	4	55	5%
Ford	2	11	8	16	10	47	4%
BMW	0	0	11	9	24	44	4%
Renault	0	1	9	14	10	34	3%
Peugeot	0	0	4	14	5	23	2%
Audi	0	1	1	5	6	13	1%
Honda	1	1	4	2	5	13	1%
Hyundai	0	0	2	8	1	11	1%
VW	0	0	3	6	2	11	1%
Subaru	0	0	2	2	0	4	0%
Entrepreneurial firms							
Tesla	2	12	14	23	23	74	6%
Fisker	0	2	9	17	11	39	3%
BYD	0	4	5	6	5	20	2%
Think	0	5	6	6	2	19	2%
Better Place	0	1	3	6	5	15	1%
Reva	0	0	0	3	0	3	0%
Chery	0	0	0	1	1	2	0%
*Others**	14	26	21	35	14	110	9%
Total	50	179	265	417	324	1,235	

* Others include firms such as Tanfield, Smith Electric Vehicle, Aptera, Coda, V-Vehicle, etc.

Table 3 Electric vehicle business model archetypes

Archetype	*Value proposition*		*Value network*		*Revenue & cost model*	*Examples*
	Product content	*Service content*	*Production and development*	*Sales*		
Luxury specific-purpose	- High-performance two-seater car - Delivers fast acceleration	n/a	- Refitted conventional car - Production is outsourced	- Flagship stores - Dealers	- Sales and leasing	- Tesla Roadster - Audi eTron, - Chrysler Dodge EV
Luxury multi-purpose	- High performance sedan - Additional, more complex power supply (plug-in or stronger battery) - Delivers fast acceleration, experience and is also usable as a family car	n/a	- Refitted conventional car - Production outsourced	- Flagship stores - Dealers	- Sales and leasing	- Fisker Karma
Economy specific-purpose	- Urban commuter two-seater - Promises to be sustainable and innovative	- Provides charging infrastructure - Possible car sharing option	Refitted and purpose/built, Production mostly in-house	- Internet sales / subscription	- Pay per mile - Rent battery separate from car	- car2go - Think - Mini E
Economy multi-purpose	- All-round sedan - Promises to be sustainable and innovative	- Provides battery swapping option - Offers optional conventional car for longer trips	Purpose-built, production mostly in-house	- Dealers	- Sales and leasing - Rent battery separate from car	- Nissan Leaf - GM Volt - Mitsubishi iMiev - Tesla Model S - Fisker Nina

Table 4 Selected EV business models, path dependencies and evolution

Firm/ Cars	**Value Proposition (Content & Segment)**	**Value Network (Production & Sales Process)**	**Revenue & Cost Model**	**Path Dependency**	**Evolution**
Incumbent firms					
General Motors Volt	Product/Service Content - Chevrolet Volt is an EV with a range extender (runs on petrol and can partially use ethanol E-85) - Considered renting the battery - In 2010 apps become an addition to the value proposition, allowing remote access to see charging percentage, next charging spot, etc. Target segment - Economy, multi-purpose car (sedan) under Chevrolet brand	Development & Production - Initially outsourced development and production of batteries - Later built own battery plant - Sought to keep costs low by reducing parts (Volt has 10% of the moving parts of an ICE) - Assembled Volt at existing Hamtramck plant in Detroit Sales process & After-sales service - Sales at GM Dealer - Service at GM Dealer; dealers need to meet certain requirements, need to purchase Volt tools, install two charging stations and have a demonstrator car at the dealership; special training is provided through web-based courses	Pricing - Initially considered to rent the battery - Plan to sell the car globally - Later offered selling or leasing of car including battery - Lease in the U.S. for $350 after $2,500 down payment (36 month) - Gives 8 year / 100,000 mile warranty on battery to increase residual value Government support - Loan from the US government through bailout plan - Integrated $7,500 tax credits in offering	Dominant business logic - World's largest car producer for most of its history - Globally active - Focus on economic cars Complementary assets - Has production facilities - Has EV1, patents, battery management knowledge - Also developed hybrid technology Contingent events - Was in financial distress - Had EV1 experience which was sold in limited numbers - Learned through EV1 experience about range anxiety amongst customers - Previously engaged in fuel cell technology, developed	Value proposition - Initially designed the Volt to accommodate different low-emission vehicle technologies - Later only designed for plug-in hybrid Value network - Initially outsourced development and production - Consecutively added production facilities for EV core components Revenue & cost model - Initially considered to rent battery separately, but then decided to integrate the costs in the lease - After Nissan gave $350 lease for Leaf, GM also offered a $350 lease

				Autonomy and Hi-wire concept, which combined a skateboard platform and chassis - US government loan for green technology	
Nissan Leaf	<u>Product/Service Content</u> - Nissan Leaf is a full EV - In 2010 apps were added to the value proposition, allowing remote access to see charging percentage, next charging spot, etc. - Initial design was like conventional cars - Next version was planned to be more futuristic - In 2008 Nissan announced to ease complex recharging infrastructure, including charging at home, at work, while shopping and also including battery swapping <u>Target segment</u> - Economy, multi-purpose car under Nissan brand	<u>Development & Production</u> - In 2007 Nissan formed joint venture with NEC = AESC to develop batteries - Was initially produced in Japan and shipped to foreign markets - Later it was intended to be produced also in the US and the UK - Nissan built production plant in the US using a US government loan - Built battery production plant in Portugal <u>Sales process & After-sales service</u> - Sold at dealers and over the internet - Extensive assistance offered for customers, e.g. for recharging installation - Dealers and technicians were trained through internet training programme plus four-day training	<u>Pricing</u> - In 2009, planned to sell the car separate from the battery to protect customers from technological advances and to integrate tax credits - Intended to charge same price as Honda and Toyota hybrids - Later intended to sell the car and lease the battery separately in Japan - In the US customers preferred leasing which combined battery and car - Lease plan in the US offered for $349 after $2,000 down payment (36 month) - Gave 8 year/ 100,000 mile warranty on battery to increase residual value <u>Government support</u> - Made sure that customers knew about tax incentives and supported them to include these	<u>Dominant business logic</u> - Sold economic cars as one of the most profitable car producers in the industry - Globally active <u>Complementary assets</u> - Had Europe's most productive plant in Sunderland where it also planned to produce the Leaf - In 2009 started joint venture with Sumitomo Corp., a trading firm that would sell and lease second-hand batteries <u>Contingent events</u> - Previously engaged in small EV projects, e.g. Nissan Prairie Joy EV	<u>Value proposition</u> - Initially planned to rent the battery separately from the car and later added optional battery swapping service in selected areas <u>Value network</u> - First produced in Japan only and subsequently extended production to the UK and the US <u>Revenue & cost model</u> - After GM gave high warranty on battery, Nissan also increased warranty

		sessions - Nissan offered optional support package (in Japan), e.g. to be towed for free to the next dealer, to get conventional car for longer distances, etc.	- Received US government loan for production plant <u>Additional income</u> - Intended to sell used batteries to solar-power generators and other secondary customers		
Mitsubishi iMiev	<u>Product/Service Content</u> - iMiev is a full EV - Initially planned with in-wheel EV motors - Later with central EV engine - Planned to look futuristic <u>Target segment</u> - Economic multi-purpose - In 2009 targeted fleet customers in Japan - Intended to target urban delivery services - In 2010 was offered to the wider public	<u>Development & Production</u> - Refitted car based on Mitsubishi "i" car - Produced batteries in joint venture with GS Yuasa - Assembled in Mizushima plant, Japan <u>Sales process & After-sales service</u> - Via Mitsubishi dealers	<u>Pricing</u> - In 2008 cost $ 45,000 before incentives of $ 25,000 in Japan - Price was reduced when Nissan announced its price ($40,700) for the Leaf from $48,800 to $42,130 ($30,700 after subsidies) in Japan - Offered for $30,000 in the U.S. <u>Government support</u> - Integrated government incentives in sales price in Japan <u>Additional income</u> - Production of rebadged iMievs for Peugeot to spread development costs with slightly different design, styling and suspension - Delivery contract over 100,000 EVs	<u>Dominant business logic</u> - Economy car producer <u>Complementary assets</u> - Relatively small car producer - Production plant and commercialization network in place - Comparatively little previous knowledge of low-emission vehicles <u>Contingent events</u> - Was in financial distress - Used EVs to compensate/ leapfrog lack of hybrid technology - Pre-stage to develop plug-in hybrid	<u>Value proposition</u> - First targeted fleet market and subsequently the wider public <u>Value network</u> - n/a <u>Revenue & cost model</u> - Talks of cross-shareholding with Peugeot led to supply contract

			in four years		
BMW Mini E	<u>Product/Service Content</u> - In 2009, limited commercialization of 450 full EV two seaters based on Mini - Installed charger in garage of lessee - In 2010, adding connectivity for recharging - Active E lease announced for 2011 - Planned to commercialize EVs under new brand "i" <u>Target segment</u> - Luxury specific purpose - Planned luxury sports car and urban economy vehicle under new brand i	<u>Development & Production</u> - Refitted Mini EV - In 2010, refitted 1 series EV - Partnership with SGL to develop lightweight material for planned urban commuter vehicle 'Megacity' which was purpose-built - Built $100 million carbon fiber plant <u>Sales process & After-sales service</u> - Only limited number of cars were leased - Announced via the internet - Because of the low number of vehicles only 8 dealers in 3 states were able to service the cars	<u>Pricing</u> - Lease for $850 per month including servicing, maintenance, at-home charging station - In 2010, planned a leasing option to make the technology affordable, with the possibility of including a mandatory take back option <u>Additional income</u> - n/a	<u>Dominant business logic</u> - Luxury car producer <u>Complementary assets</u> - Production facilities and commercialization channels in place <u>Contingent events</u> - Experimented with fuel cells before	<u>Value proposition</u> - Learned in the extended pilot that 100 miles are sufficient for urban drivers and subsequently designed following cars for that range <u>Value network</u> - Initially refitted Mini with EV motor, then considered refitting 1 series for test - Later decided to build purpose-built car <u>Revenue & cost model</u> - n/a
<u>Entrepreneurial firms</u>					
Better Place	<u>Product/Service Content</u> - In 2007 suggested to build recharging network and battery swapping stations in various selected regions	<u>Development & Production</u> - Collaboration with Renault/Nissan - Renault agreed to supply 100,000 Fluence EV cars with battery swapping technology - Memorandum of	<u>Pricing</u> - Battery was supposed to be owned by firm itself - Mobile phone payment system - Pre-paid plans - Considered offering cars for free	<u>Dominant business logic</u> - Founder Shai Agassi previously worked for SAP - Agassi had a track record of driving innovation; combining innovative technologies with new	<u>Value proposition</u> - n/a <u>Value network</u> - Added additional partner with Chery Automobile <u>Revenue & cost</u>

	Target segment - Economic multi-purpose - Focus on cities and 'islands' nations, e.g. Israel	Understanding with Chery Automobile (China) to develop EV prototypes for switchable batteries Sales process & After-sales service - Internet - Only had a few demonstration facilities	Government support - Sought to enter countries with government incentives first (e.g. China or France) Additional income - n/a	business models - Venture capital partners Complementary assets - Collected $200 million funding - In 2010 raised another $350 million from investors Contingent events - New generation is familiar with mobile payment plans	model - n/a
Think City	Product/Service Content - Full EV Target segment - Economic specific purpose - Planned to add a multi-purpose model - First targeted Europe, later targeted US market	Development & Production - Initially produced in Norway, later outsourced to Valmet Automotive, Finland and subsequently in the US in a plant financed with US government loans - Announced in 2010 small scale production (modular micro production) Sales process & After-sales service - Planned to sell almost entirely via the internet	Pricing - Lease battery separate from car - Battery would be included in 'mobility pack' price (between $100 und $200 per month) - Targeted to stay under $20,000 per car sales price Government support - Received US government loan for production plant Additional income - n/a	Dominant business logic - Was started in the 1990s - Already used battery leasing plan in Europe Complementary assets - Had production plant in Norway Contingent events - Previously owned by Ford (until 2003) - In 2006 until 2009 backed up by venture capital with IT background - In 2009 backed by new investors	Value proposition - First targeted Europe and after availability of incentives and loans in the US targeted North America as well Value network - Was initially produced in Norway, then after investments from new investors, production was outsourced to Valmet, Finland. Later a production plant was built in the US Revenue & cost model - n/a
Tesla Roadster	Product/Service Content - Full EV	Development & Production - Refitted	Pricing - Selling and leasing	Dominant business logic - Founder Elon	Value proposition - Initially started refitting Lotus

	Target segment - Initially luxury sports car - Later planned to enter economic multi-purpose segment	roadster based on Lotus Elise - Mainly bought components - Developed its own battery management system - Bought abandoned Fremont plant to produce EV Sales process & After-sales service - Intended internet sales & flagship store approach to control marketing expenses and quality, was not allowed in all states - Stores were designed by Apple store designer - After-sales service at customer through 'Ranger' - Expected less income from after-sales	- Started selling for $109,000 Government support - Received US government loan for development and production of the new Tesla Model S Additional income - Refitted Daimler's Smart EVs with their innovative battery management system - Was trading EV credits earned in the California ZEV programme to other car producers - Provided Toyota with powertrain	Musk was Silicon Valley entrepreneur, co-founded and sold PayPal Complementary assets - In 2009 received funding (estimated $50 million) from Daimler for a 10% stake - In 2010 Toyota invested $50 million in Tesla - Tesla bought Fremont plant from Toyota to produce new model S for $42 million Contingent events - In 2009 received loan $465 million from the US government to develop and produce Model S - Collected $226 million from IPO in 2010	Elise sports cars. Planned from the beginning to add a mid-sized car (which became the Model S) and an economic car Value network - After buying the Fremont plant and obtaining money from the US Department of Energy, Tesla had the resources to develop and produce the Model S Revenue & cost model - n/a
Fisker Karma	Product/Service Content - EV with range extender Target segment - Initially luxury, multi-purpose - Subsequently intended to build more economic model Nina	Development & Production - Integrated GM engine technology from the Volt - Purchased batteries from supplier A123 - Karma was first assembled in Finland by Valmet Automotive Inc. - Planned own production for economic	Pricing - Sales planned to be around $105,000 Government support - Received loans from the U.S. government for development and production ($528.7 million)	Dominant business logic - Founder Henrik Fisker was an automotive designer for 20 years at BMW and Ford - Designed BMW Z8 and the Aston Martin DB9 Complementary assets - Bought	Value proposition - Was planned to change from Luxury specific purpose to economic multi-purpose Value network - Changed from outsourcing to own production due to several contingent events, particularly

		model <u>Sales process & After-sales service</u> - Intended to establish a dealership network	<u>Additional income</u> - Design consultancy, e.g. for Tesla's Model S	previous GM plant in Wilmington, Delaware for $20 million <u>Contingent events</u> - Received conditional loan of $528 million for development and production of economic model Nina	receiving loans from US Department of Energy for economic model Nina <u>Revenue & cost model</u> - n/a

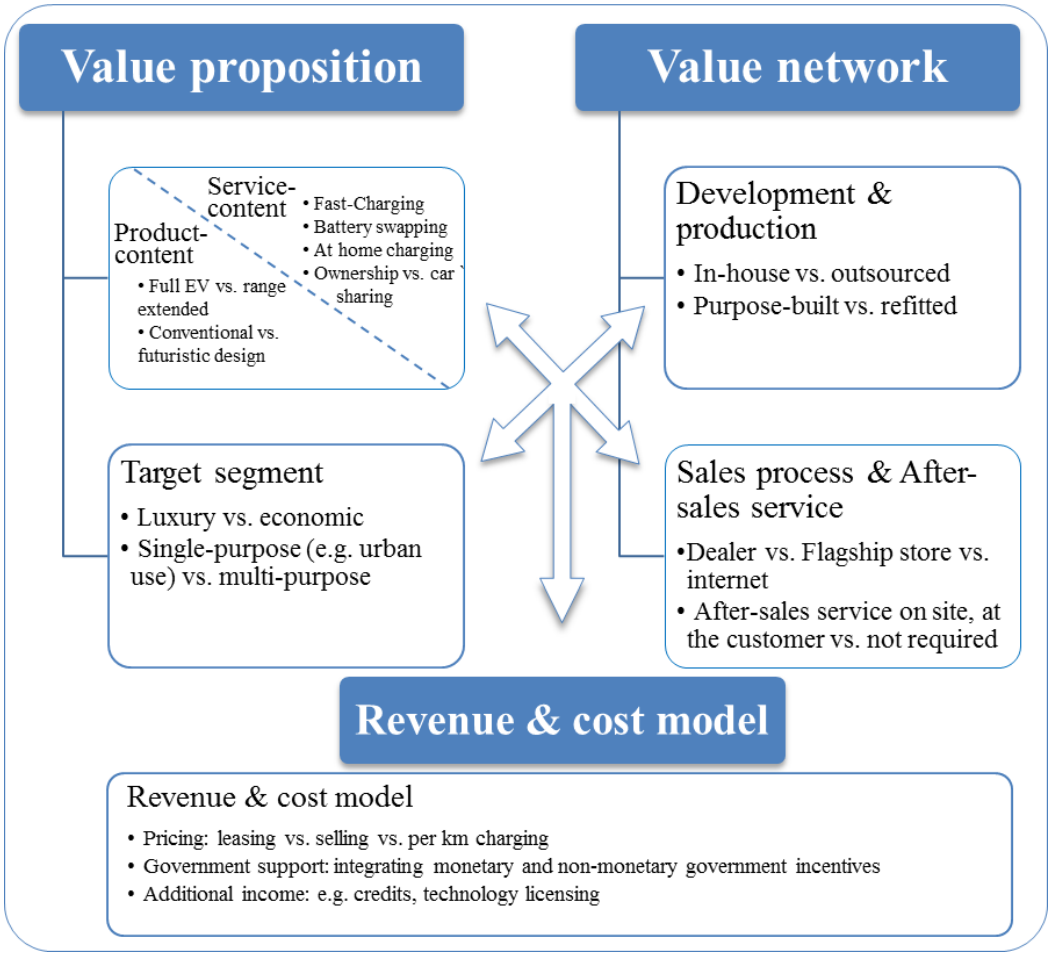

Figure 1 EV mobility business model components

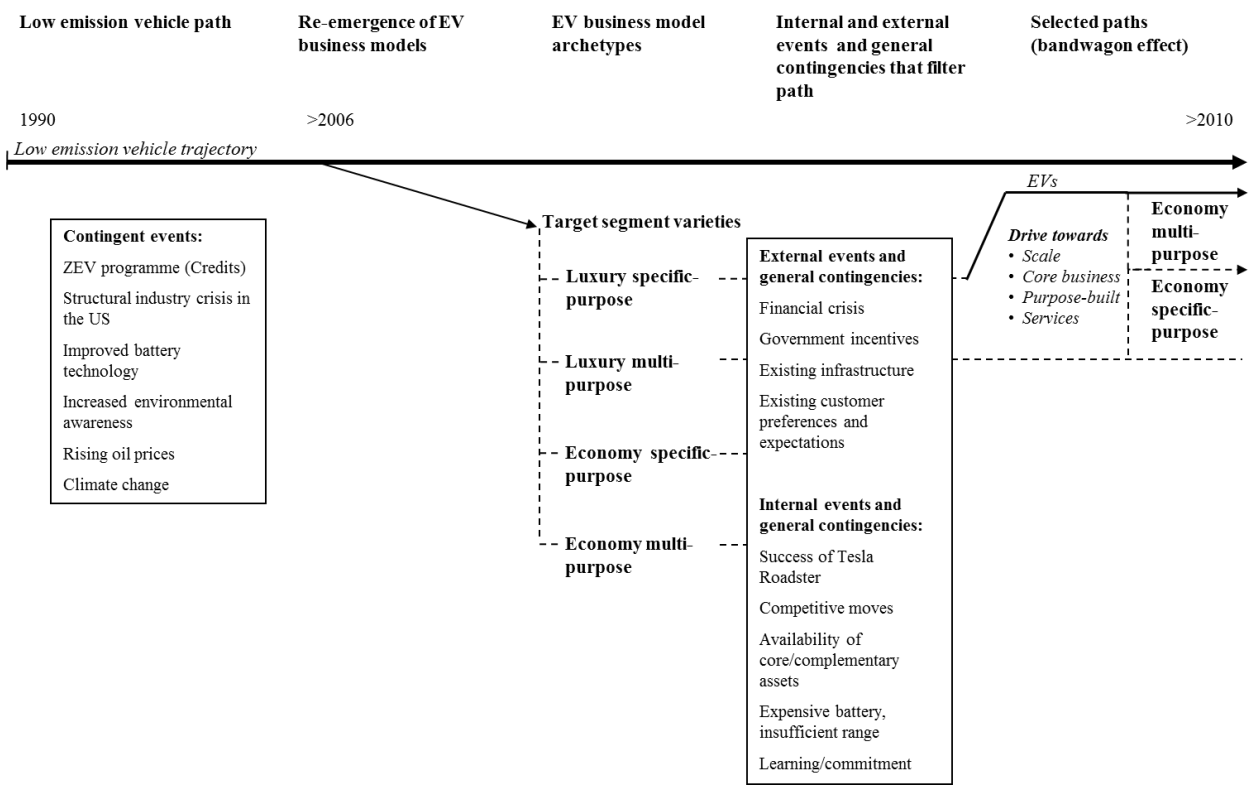

Figure 2: EV mobility industry evolution