Abstract

In many countries, the market for electric vehicles is not scaling up as expected despite huge public subsidies and technological progresses. One potential explanation is the absence of profitable business models that support commercialization and drive wide diffusion of electric vehicles. Business models that served conventional cars may not be appropriate for electric vehicles because of technological limitations such as shorter driving range and long charging cycles as well as higher acquisition cost. Recent years, however, have witnessed a growing body of scientific literature on electric vehicle business models. Nevertheless, the insights from this literature are fragmented and rarely address the business model with all its constituting elements. In this article, we review relevant literature on electric vehicle business models and distill key insights along each business model element. This way, our study provides a comprehensive and condensed overview of state-of-the-art research, while identifying potential directions for future research for scholars.

1. Introduction

> *"Within a year, I hope, we shall begin the manufacture of an electric automobile. I don't like to talk about things which are a year ahead, but I am willing to tell you something of my plans.*
>
> *The fact is that Mr. Edison and I have been working for some years on an electric automobile which would be cheap and practicable. Cars have been built for experimental purposes, and we are satisfied now that the way is clear to success. The problem so far has been to build a storage battery of light weight which would operate for long distances without recharging. Mr. Edison has been experimenting with such a battery for some time."*

Henry Ford, The New York Times 1914, p. 10

More than 100 years ago, Henry Ford and Thomas Edison worked together on a car powered purely by electricity. Although the electric car was prevalent at the beginning of the automobile era, over the long run it could not stand the superiority of the internal combustion engine vehicles (ICEVs).

Over the last years, electric mobility gradually infiltrated many areas such as public transport, logistics, and individual mobility, demonstrating a remarkable comeback. Electric vehicles "are not simply replacements for conventional vehicles; they provide access to revised and wholly new values" (Delucchi et al. 2014, p. 19). However, the great breakthrough is still to be achieved. Many new companies entered the automobile market with innovative products, while some of them such as Better Place and Mia Electric went bankrupt only a few years after their inception. Although many governmental programs were designed and launched to drive the introduction and diffusion of electric cars, the success of these programs has been rather moderate. In Germany, for instance, the government announced its objective of having one million electric vehicles on German roads by 2020 (Federal Republic of Germany 2009). More than twelve years after this announcement, however, the number of battery electric vehicles (BEVs) reached about 309.000, only a small portion of the original target (Statista 2021). Like Germany, countries all over the world have set ambitious goals with respect to e-mobility, among others, to comply with national and international agreements that aim at environmental protection by fostering the use of renewable and sustainable energies in the mobility sector. It should be noted, however, that a country such as Norway has experienced a large diffusion of electric cars. For example, in 2020, 52.2% of new passenger cars registered in Norway are battery-powered electric vehicles and another 20.4% are plug-in hybrid electric vehicles. This is because of many incentives and policies such as exemption from taxes, no road tolls or public parking fees, reduced ferry fares, privileges such as traveling in bus lanes and free recharging in public parking lots in addition to cheap electricity (Fevang et al. 2021). Norway remains, however, an exception. Whereas the market development of electric vehicles is hampered by the chicken and egg problem, as electric vehicles require a well-developed charging infrastructure and the charging infrastructure needs a critical number of vehicles to become profitable, from a technological viewpoint the battery and powertrain technologies could achieve important advances during the recent years.

Electric mobility is multi-dimensional. It is a systemic innovation (Abdelkafi and Hansen 2018), as it calls for the involvement of many stakeholders whose contributions are important to make the whole system work. Scholars from different fields have been researching electric mobility from a technological, societal and market perspectives in the attempt to understand the reasons behind the slow penetration rate of electric vehicles.

The discovery of innovative business models is crucial in order for companies to achieve a successful commercialization of new technologies. Technological advances in e-mobility have been remarkable in the recent years. What explains the difficulties in market growth could be attributed to the absence of business models that make companies benefit from the technology in a profitable manner. Companies are still in search for the model of success by experimenting and learning from failures. Scientific research has been growing to address various fields of electric mobility and successful market development, and thus related directly or indirectly to business models.

This article demonstrates that the business model approach contributes to the identification of possible solutions against barriers in front of the wide market diffusion of electric vehicles. We argue that business models can stimulate the creation of new ideas to cope effectively with the limitations of the technology.

This article does not focus on electric mobility business models in general, but more particularly on business models for electric passenger vehicles. Electric commercial vehicles are not in our focus because we believe that the car industry rather needs business model innovation for passenger vehicles than for commercial vehicles. First, because of the need to intensify and communicate their sustainability efforts, commercial companies may decide to buy e-vehicles, instead of ICEVs. Second, companies have higher financial capability than individual persons and can pay for the higher-priced e-vehicles. Third, as shown by some studies (Breetz and Salon 2018), electric cars can reach the break-even point if drivers achieve a high enough mileage level per year. This mileage level (related to the car utilization per year) can rather be reached by commercial companies, which optimize fleet utilization, than individual persons or households. Furthermore, we only focus on electric passenger vehicles because considering the whole electric vehicle market can be a challenging endeavor, since technologies such as e-busses, e-bikes, and other vehicles used for public transportation have been around for a long period of time. Our study reviews extant literature, not only for the sake of providing a pure survey on the current state of the literature, but more importantly to distill a series of key insights regarding business models for electric passenger vehicles. To get a full picture of existing research, we draw on articles that are fully devoted to business models or only address a part of the business model. Some articles may only cover the economic feasibility of a business model, but not deal with other equally important elements of the business model. In this way, we are able to provide an overview of the current scientific literature.

In section 2, the article provides some theoretical background related to electric mobility and business models. Section 3 describes the methodology we use to identify and analyze extant research before deriving key insights in section 4. Based on this, section 5 proposes some future and potentially relevant research directions followed by the conclusions in the last section.

2. Electric mobility and business models

Electric mobility and business models are terms that still lack of a broadly accepted definition. In the following, we deal with both concepts by drawing on existing literature.

2.1 Electric mobility

The electric vehicle looks back on a long history. At the beginning of the development of the automobile, electric cars based on battery energy storage were thought to be successful. However, within a relative short period of time, electric vehicles were replaced by internal combustion engine vehicles that use fossil fuels. More than 25 years ago, the United Nations Framework Convention on Climate Change was initiated, leading to an increasing introduction of climate treaties and climate protection targets on international and national level, thus affecting many countries worldwide. Nowadays, in several countries, the diffusion of electric vehicles is pushed by governmental incentives. For example, in Europe, the transport sector accounts almost for one quarter of greenhouse gas emissions, and is considered as the main reason for air pollution in cities (European Commission 2018). Therefore, electric vehicles are becoming increasingly relevant for future mobility, mainly because they can – in contrast to ICEVs – rely on renewable energies, thus contributing to a clean environment and sustainable development (Shareef et al. 2016).

There are many types of electric vehicles: battery-powered electric vehicles (BEVs) with at least one electric motor and battery for energy storage, plug-in hybrid electric vehicles (PHEVs), which consist of an electric motor and combustion engine, and fuel cell electric vehicles (FCEVs), in which the electric motor is powered by hydrogen. BEVs and FCEVs do not use fossil fuels, and therefore, do not generate CO_2 locally. Note also that e-mobility is an umbrella term for transportation that uses electric cars and other transportation means powered by electricity such as e-bikes and e-busses.

In electric mobility, the electric vehicle itself is only a part of a whole system. Electric mobility covers not only the technologies that enable a sustainable transportation of people and goods by using electricity (e.g., electric bicycles, electric motorbikes, or electric trucks), but also comprise different actors such as energy providers, car manufacturers and customers. In addition, it involves an appropriate infrastructure that consists of charging stations, software applications, communication interfaces, etc. Madina et al. (2016, p. 284) define e-mobility as "the use of electricity for powering the drive trains of road vehicles", but emphasize the role of information and communication technology for a functioning infrastructure as well as the importance of collaboration among multiple actors. Delft (2013, p. 68) describes electric mobility "as a new traffic system, with new infrastructure, so called 'smart' electric grids, as well as new business models". Abdelkafi et al. (2013, p. 4) define e-mobility as "… a system of interacting actors, technologies, and infrastructures that aims to achieve sustainable transportation by means of electricity". Thus, most researchers address the diversity of actors and the required infrastructure, thus referring to the complexity of the e-mobility system.

2.2 Business models

Business models have been defined differently in the literature. Some scholars use a holistic approach like Sanchez-Miralles et al. (2014, p. 46) who define business models as a "set of involved agents and business relationships among them", while others adopt a multi-perspective approach by regarding business models a kind of superior model to summarize different aspects of the firm. For example, Bohnsack et al. (2014) distinguish among three elements of business models: the value proposition, value network, and revenue/cost model. These elements can be considered separate models, altogether forming the business model concept.

For Amit and Zott (2001, p. 511), a business model depicts "*the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities*" (Italic in the original). Teece (2010, p. 179) discusses the links to business strategy, innovation management and economic theory, while mentioning that a business model "articulates the logic, the data, and other evidence that support a value proposition for the customer, and a viable structure of revenues and costs for the enterprise delivering that value." A well–accepted and widely used business model tool is the canvas by Osterwalder et al. (2005), who understand a business model as "a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams" (Osterwalder et al. 2005, p. 10). Based on previous literature, Abdelkafi et al. (2013, p. 12) conclude that "a business model describes how the company communicates, creates, delivers, and captures value out of a value proposition". Massa et al. (2017) analyzed the different streams of business model definitions. They identified three basic perspectives of how business models have been interpreted so far in the scientific literature: Business models as an attribute of a firm, a cognitive or linguistic schema, and a formal conceptual representation describing the activities of a firm.

3. Methodology

A multi-stage approach has been implemented to select the scientific articles on business models and electric vehicles to be reviewed. By examining the electric mobility literature, different synonyms are identified. These terms are electric vehicle, e-mobility, electric mobility, electrical mobility, electro mobility, electric car, electrical car, electrical vehicle, in singular and plural. The Web of Science was used as search engine by selecting the Web of Science Core Collection, including the citation indexes SCI-EXPANDED and SSCI, thus searching only for articles in English that have been published between 2012 and mid-2021. Additionally, the focus was allocated to scientific articles dealing with BEVs, excluding articles considering only PHEVs and/or FCEVs or other electric vehicles.

Database	**Article parts searched**	**Search terms**	**Time frame**
Web of Science Core Collection	Title	electric vehicle(s) AND business model(s)	2012-mid-2021
		electric vehicle(s) AND value(s)	

	electric car(s) or electrical car(s)
	e mobility or electric(al) mobility or electro mobility
	electrical vehicle(s).

Table 1: Search parameters for literature sources

By using the term “electric vehicle(s)” as a search query in the title of articles, we obtained a large number of articles: more than 8000 results. Because of this, we decided to look for combinations of the term electric vehicle(s) with the key words “business model(s)” and “value(s)”, as illustrated in table 1. The reason why the term “value” is used in our search is that it represents an essential construct in most operationalizations of the business model concept proposed in the literature (e.g. Massa et al. 2017). The combinations of terms: “electric vehicle(s)” and business model(s) or value(s) have returned 52 results in total. The other key search terms shown in table 1 have been used without combination with any other key word, since the number of articles is well manageable. In detail, the term “Electric(al) car(s)” has led to 361 results; “e-mobility”, “electric(al) mobility”, and “electro mobility” resulted in 150 articles, whereas by using “electrical vehicle(s)” we obtained 241 results. Altogether, we identified, at this first stage, a starting sample of 804 research articles.

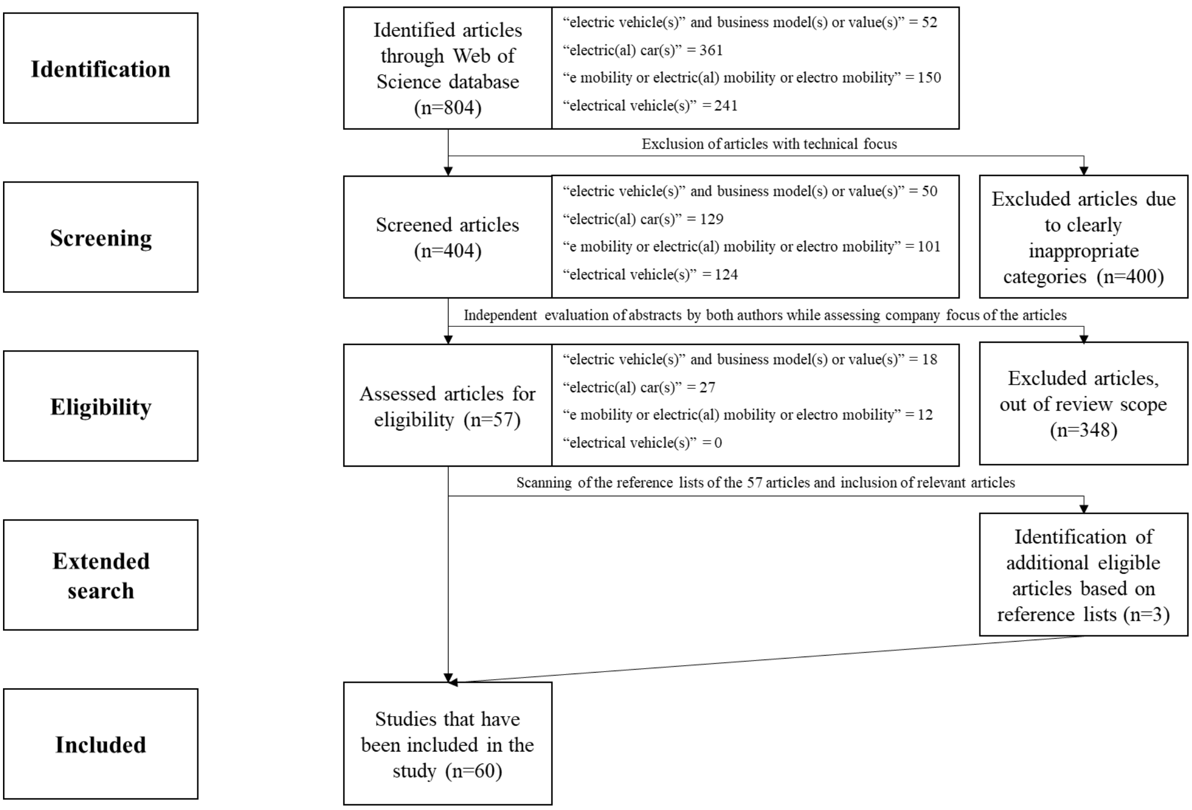

Figure 1: Flow diagram for the selection of literature reviewed in accordance with PRISMA (Moher et al. 2009)

In the second stage, we exclude articles from the sample with technical focus such as those related to medicine, electronics, or mechanical engineering. These articles are clearly not related to business management and economics, or business models. The application of this filter results in 50 articles for the search query based on the combinations “electric vehicle(s) and business model(s)" and "electric vehicle(s) and value(s)". By excluding articles with technical focus, "Electric(al) car(s)" results in 129 out of 361; "e-mobility", "electric(al) mobility", and "electro mobility" led to 101 from the 150 articles originally identified, whereas "electrical vehicle(s)" results only in 124 instead of the 241 articles obtained without applying the filter. Altogether, this second stage has led to 404 articles. This initial search and selection of the literature has been conducted by both authors together, based on the titles of the articles.

In the third stage, both authors read separately the abstracts of the 404 articles to identify, whether they fit or not. An important requirement for including an article to the final sample was a clear connection to companies and/or attractiveness of electric vehicles to customers. In effect, companies, be they for-profit or non-profit, should leverage (new) business models to capitalize on EV technology and commercialize electric vehicles to users. In addition, the acceptance of electric vehicles by users is an important leverage for the success of e-vehicles in the market. Hence, the articles should address an element of the business model and/or report on studies involving many e-vehicle companies or users with clear business model recommendations for companies. Scientific articles that only address technological aspects such as the development of battery components and others that explore macro-economic effects of EVs are excluded from the final sample. Although these articles cover important topics related to the evolution of EVs and electric mobility in general, they go beyond the scope of this review.

After reading the abstracts separately, both authors elaborated a list of the articles that they would include in the final sample. Based on the criteria used to decide about the inclusion or exclusion of an article (clear relationship to the topic of interest and explicit focus on companies and customers instead of e.g., policy making), the agreement level was more than 90%. For the articles about which the authors initially disagreed whether they should belong to the final sample or not, the whole text was inspected thoroughly. Subsequently, discussions between both authors have helped reaching a final decision. This filtering process revealed 10 articles related to "electric vehicle(s) and business model(s)", 8 articles to "electric vehicles(s) and value", 27 articles associated with "electric(al) car(s)", 12 articles connected to "e-mobility", "electric(al) mobility" or "electro mobility" and no articles for electrical vehicle(s). Thus, this third stage resulted in 57 articles.

To be sure that we do not miss any relevant literature, we checked the reference lists of all 57 articles, while looking for articles published in 2012 or after. Our hypothesis is that, if our sample is missing relevant articles, e.g., because of our key terms or filtering process, we might find many additional articles. Both authors scanned independently the reference lists. If we were doubtful whether an article should be included or not, we referred to the abstracts or full text. This phase has led to only three additional articles. Therefore, our final sample contains 60 articles. Due to the small number of articles identified at this stage, we could conclude that the likelihood of missing some relevant literature is rather low. Note, however, that the likelihood of missing newest literature is higher because it may not have been cited or even recognized by most recently published articles.

4. Literature analysis

As mentioned above, many frameworks for the operationalization of the business model concept have been proposed in the literature (Osterwalder and Pigneur 2010; Wirtz and Daiser 2017; Johnson 2018). In this work, we apply the business model framework by Abdelkafi et al. (2013) and assign the articles to five business model elements: value proposition, value creation, value delivery, value capture, and value communication. We use this framework because it explicitly considers value communication, an element that is of high relevance for increasing the acceptance of electric cars among potential users and customers. This is not to say that all other business model frameworks in the literature disregard this element. Some of them include value communication, though as sub-element and not as primary element in business model conceptualization. We believe, however, that especially when companies embark on the development of business model concepts to support a new technology, they should dedicate a special attention to value communication so as to frame and convey the value of the new technology in a way that convinces and creates a need with the potential customer. Table 2 consists of all analyzed research articles and shows the elements of the business model framework addressed in each article. Our analysis of the literature was driven by the following questions:

1) How can the literature on business models in electric mobility be structured?
2) Could we derive a set of key insights that best describe most important research results from the literature?

To avoid the bias that can occur in the literature analysis, it should be noted that the analysis of the articles has been conducted individually; every author has read and coded the relevant literature separately. The analysis process is similar to the coding process that is common in qualitative data analysis. We use two types of coding: the first derives directly from the business model construct, its elements, and sub-elements. The elements (sub-elements) are: (1) value proposition (no sub-elements), (2) value creation (key processes and resources, and key Partners), (3) value delivery (customer segments and relationships as well as distribution channels), (4) value capture (revenue stream and cost structure) and (5) value communication (story for value communication and communication channels). Thus, we applied these categories to code the articles from the literature. Table 2 is the result of this coding process. Thus, the elements and sub-elements are our main theoretical constructs. On the other hand, our analysis of the raw text of the articles enabled us to discover repeating ideas among articles. These repeating ideas have been aggregated in so-called main themes. The main themes represent the main constructs that are used in the "key insights". This procedure for qualitative data analysis is in line with Auerbach and Silverstein (2003).

	Article	Business Model Framework Element				
		Value Proposition	Value Creation	Value Delivery	Value Communication	Value Capture
1	(Madina et al. 2016)	x	x	x		x
2	(Sanchez-Miralles et al. 2014)	x	x	x		
3	(Robinson et al. 2014)	x	x	x		x
4	(Bohnsack et al. 2014)	x	x	x		x
5	(Kong and Bi 2014)	x	x			
6	(Budde Christensen et al. 2012)	x	x			x
7	(Larson et al. 2014)				x	
8	(Moons and Pelsmacker 2015b)				x	
9	(Dijk et al. 2016)		x		x	x
10	(Rudolph 2016)			x	x	
11	(Türnau 2015)			x	x	
12	(Wang et al. 2017)	x	x			
13	(Fontaínhas et al. 2016)			x		
14	(Barbarossa et al. 2015)			x	x	
15	(Cherubini et al. 2015)	x		x	x	
16	(Moons and Pelsmacker 2015a)			x	x	
17	(Graham-Rowe et al. 2012)			x	x	
18	(Conejero et al. 2014)	x	x			
19	(Gebauer et al. 2016)				x	
20	(Schwedes et al. 2013)		x			
21	(Golembiewski et al. 2015)		x			
22	(Späth et al. 2016)		x			
23	(Miao et al. 2015)	x	x			x
24	(Jiang 2016)				x	
25	(Miao et al. 2013)			x	x	
26	(Rothkrantz et al. 2013)	x	x			
27	(Kölbl et al. 2013)			x		
28	(Miao et al. 2014)	x	x	x		
29	(Vom Stein et al. 2015)		x			
30	(Rasouli and Timmermans 2016)				x	
31	(Vervaeke and Calabrese 2015)	x	x			
32	(Nosi et al. 2017)		x	x	x	
33	(Barbarossa et al. 2017)			x	x	
34	(Yan et al. 2019)			x	x	
35	(Tran et al. 2019)			x	x	
36	(Noel et al. 2019)	x		x	x	
37	(Harrison et al. 2018)				x	
38	(Kühl et al. 2019)		x		x	
39	(Sovacool et al. 2017)	x	x			

40	(Liao et al. 2019)	x	x		x	x
41	(Liao et al. 2018)	x		x		x
42	(Nian et al. 2019)	x				x
43	(Dorcec et al. 2019)					x
44	(Han et al. 2017)				x	
45	(Bohnsack and Pinkse 2017)	x	x			
46	(Danielis et al. 2020)	x			x	
47	(Giansoldati et al. 2020a)	x			x	
48	(Bobeth and Kastner 2020)				x	
49	(Giansoldati et al. 2020b)				x	
50	(Jia et al. 2020)					x
51	(Zolfagharian et al. 2021)			x	x	
52	(Zarazua de Rubens et al. 2020)	x	x	x	x	x
53	(Plananska 2020)		x		x	
54	(Huang et al. 2021)	x		x	x	
55	(Stauch 2021)	x	x		x	
56	(Yang et al. 2020)	x	x			
57	(He and Hu 2021)			x	x	
58	(Delft 2013)	x	x			
59	(Moons and Pelsmacker 2014)				x	
60	(Nieuwenhuis 2018)	x	x			

Table 2: List of analyzed articles

Figure 2 shows the topological interactions between the analyzed articles. The illustration, made with the aid of the software tool CitNetExplorer[1], reveals two larger clusters of interrelated articles, whereas several articles show no link to other articles. The first cluster consists of articles tightly related to the work of Budde Christensen et al. (2012). This cluster primarily consists of articles that deal with value proposition and value creation. The second cluster largely focuses on value communication and is based on Graham-Rowe et al. (2012). Note that the most interconnected article is that Bohnsack et al. (2014) whereas the articles by Dijk et al. (2016) and Noel et al. (2019) have connections to both clusters.

[1] www.citnetexplorer.nl

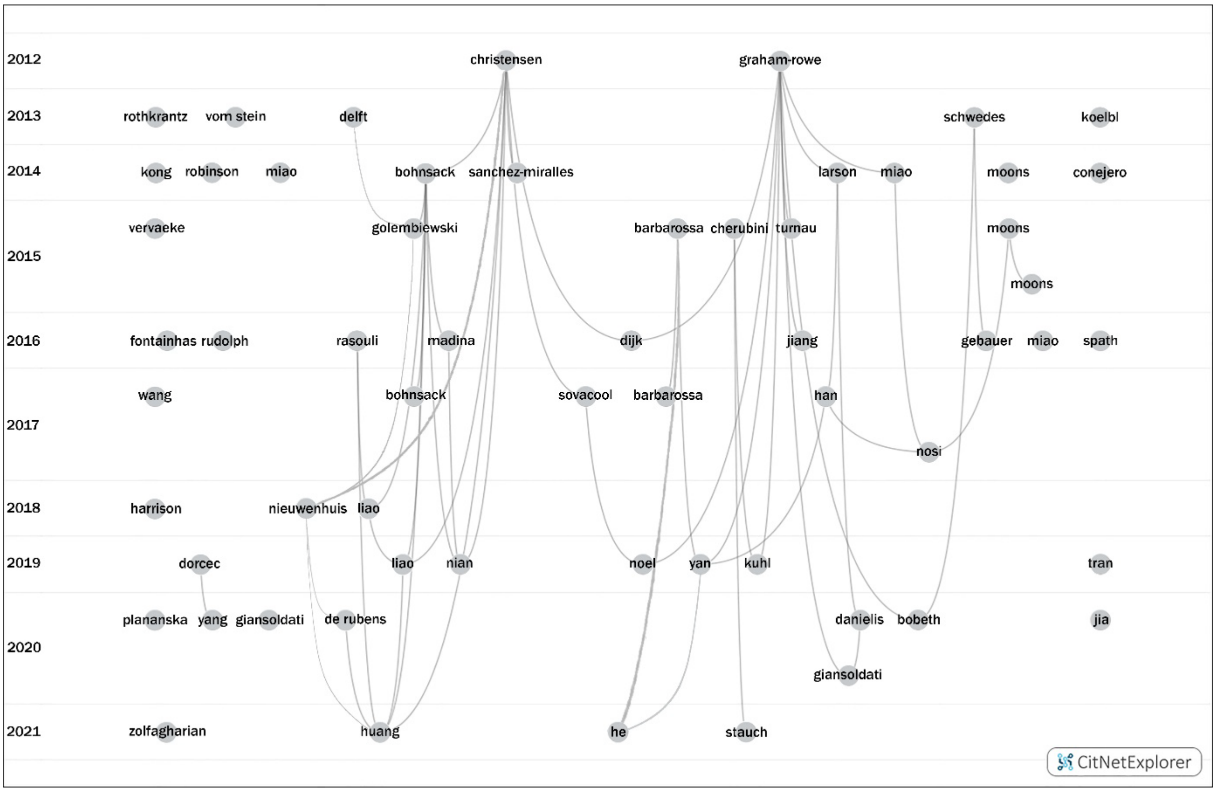

Figure 2: Citation network of the analyzed articles

Figure 3 shows the journals, in which the selected articles have been published and the number of articles published in each journal: Sustainability journal is represented with ten articles; Technological Forecasting and Social Change with five articles; Transportation Research Part A: Policy and Practice, Journal of Cleaner Production and Energy Policy each with four articles. Figure 4 provides the distribution of the articles over the years from 2012 to June 2021, with most articles in the sample are published in 2015 (9 articles).

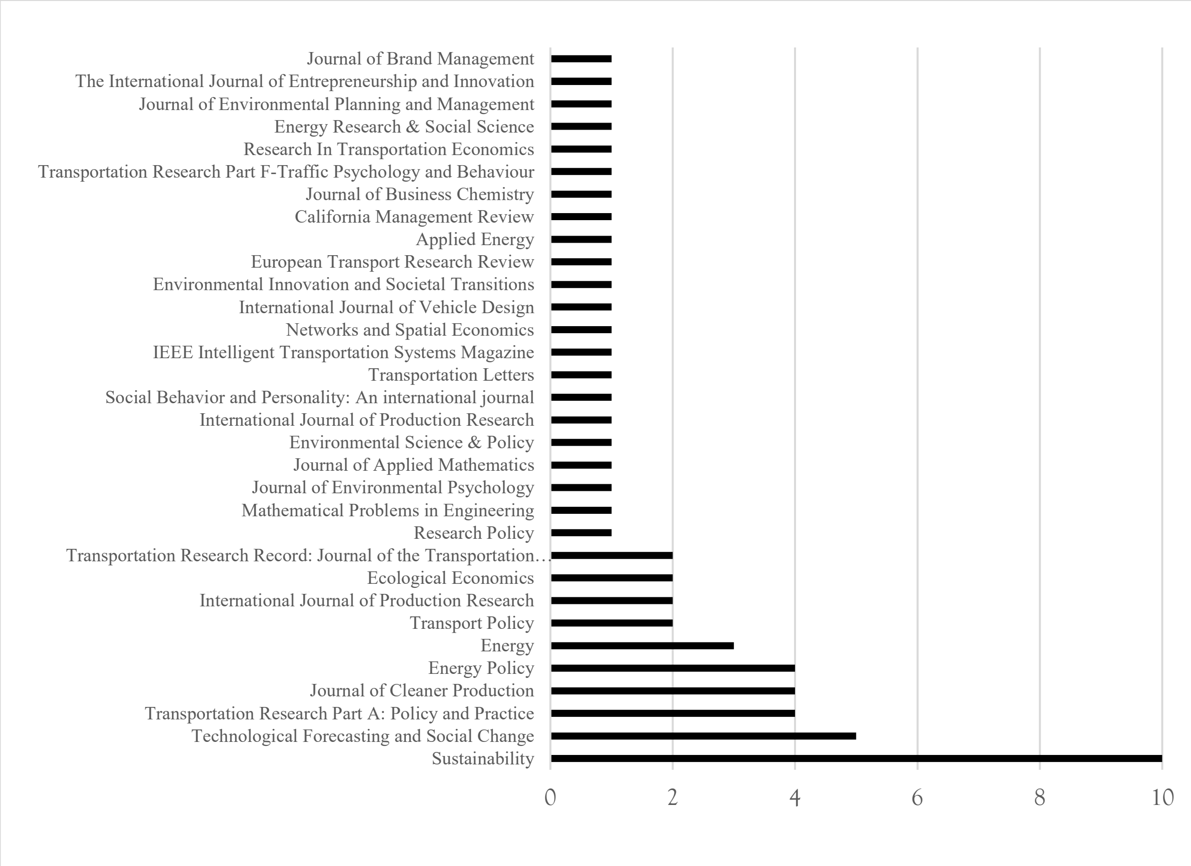

Figure 3: Journals of the set of articles

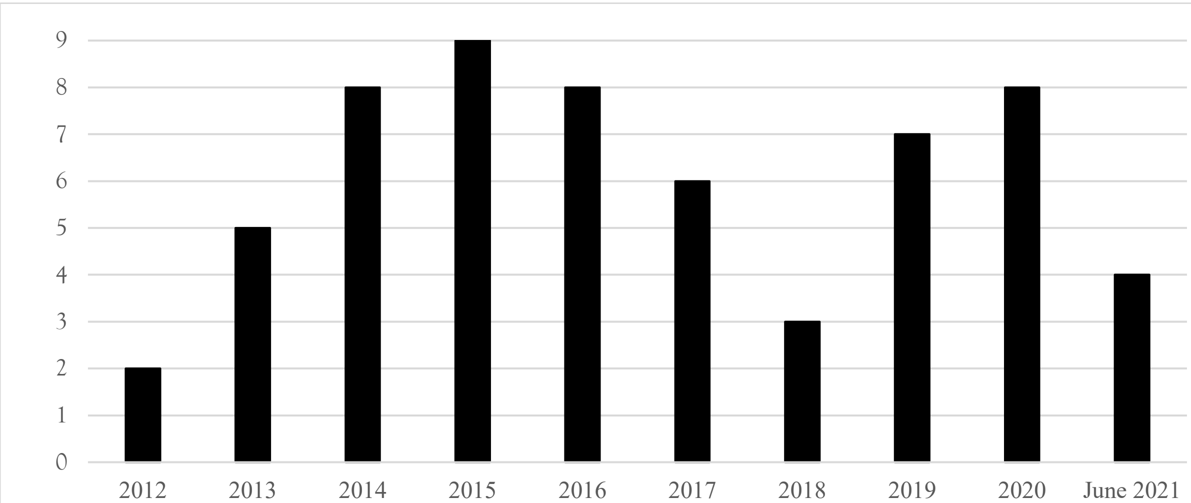

Figure 4: Distribution of the articles over time

The quality of the articles is evaluated by means of the Scimago Journal ranking. The quality of the journals is summarized in the following table. It is obvious that most articles used for this review have been published in Q1 or Q2-journals, which are journals with good scientific standards.

Journal	Scimago Quartile
Sustainability	Q2
Technological Forecasting and Social Change	Q1
Transportation Research Part A: Policy and Practice	Q1
Journal of Cleaner Production	Q1
Energy Policy	Q1
Energy	Q1
Transport Policy	Q1
International Journal of Production Research	Q1
Ecological Economics	Q1
Transportation Research Record: Journal of the Transportation Research Board	Q2
Research Policy	Q1
Mathematical Problems in Engineering	Q3
Journal of Environmental Psychology	Q1
Journal of Applied Mathematics	n.a.
Environmental Science & Policy	Q1
International Journal of Production Research	Q1
Social Behavior and Personality: An international journal	Q3
Transportation Letters	Q2
IEEE Intelligent Transportation Systems Magazine	Q1
Networks and Spatial Economics	Q1
International Journal of Vehicle Design	Q3
Environmental Innovation and Societal Transitions	Q1
European Transport Research Review	Q1
Applied Energy	Q1
California Management Review	Q1
Journal of Business Chemistry	n.a.
Transportation Research Part F-Traffic Psychology and Behaviour	Q1
Research In Transportation Economics	Q1
Energy Research & Social Science	Q1
Journal of Environmental Planning and Management	Q1
The International Journal of Entrepreneurship and Innovation	Q2
Journal of Brand Management	Q2

Table 3: Journal quality of the analyzed articles by using the Scimago Journal & Country Rank[2]

4.1 Business Models in General

This section deals with business models in general and does not address a particular business model element. The key insights are derived from the fact that electric mobility triggers far-reaching changes in the automotive industry so that companies have to capitalize on new sources of value; that appropriate business models for electric vehicles are hardly thinkable without considering the limitations of the charging infrastructure; and that appropriate business models should be profitable without governmental subsidies.

Key insight 1: Electric mobility challenges current business models, while making it necessary for companies to capitalize on new sources of value

Electric mobility, in particular electric vehicles as part of it, induce a complex system of interdependent actors and elements. The production and use of electric vehicles significantly change existing structures within the automobile industry, leading to changes in business

[2] www.scimagojr.com

models from component and module supply over car production and commercialization to energy supply and accompanying services.

Take the example of car rental services (Miao et al. 2014; Rothkrantz et al. 2013; Vervaeke and Calabrese 2015). Rental services leveraging conventional cars is a business model that is well established with many successful players acting in the market. However, the shorter driving ranges and longer charging cycles, as compared to conventional cars, make the management of electric car fleets a complex and challenging task. Consequently, there is a need to develop management approaches and solutions to ensure that car rental business models can function smoothly with electric cars. For example, to deal with this challenge, Conejero et al. (2014) develop a model for the improvement of the management of electric car-rental services by using an iterative algorithm model and mathematical simulations.

The sources of value for business models can also change (Huang et al. 2021). For example, Delucchi et al. (2014) identify three sources of value in electric vehicles: the electric drivetrain, the charging system, and new identity expressions. The electric drivetrain has a higher acceleration and can regenerate electricity during the braking process. The charging system leads to "a sense of independence from oil, the satisfaction of using a relatively clean source of energy, avoiding inconvenient trips to refueling stations, avoiding exposure to toxic gasoline vapours, being assured of always having fuel readily available and (currently) stable electricity prices compared with fluctuating gasoline prices" (Delucchi et al. 2014, p. 18). New identity expressions appear in the form of new activity patterns of users, new assignments of vehicles and new individual and social values. Hence, electric vehicles change the supply and demand sides by creating new sources of value. By understanding how e-mobility may challenge business models and the new sources of value, companies can better plan the transition to EVs, reducing the risk of business model failure.

Key Insight 2: OEMs' electric vehicle business models cannot be developed independently of the charging infrastructure.

Electric vehicles and charging infrastructures go hand in hand. The creation of competitive electric vehicle business models is limited by the chicken and egg problem. A critical mass of electric vehicles is necessary in order for the installation of a broad charging infrastructure to be profitable, and the existence of such an infrastructure is required to increase the demand for electric vehicles. In the words of Yang et al. (2016, p. 738): "The imperfect charging infrastructure constrains the development of electric vehicles, which then affects the construction of the former." Therefore, the number of electric vehicles and available charging stations must be balanced at any given time. An increase in the number of electric vehicles should be accompanied with a growth of the charging infrastructure to encourage the use of electric vehicles, as shown by Zhang et al. (2018). Better Place (Budde Christensen et al. 2012; Sanchez-Miralles et al. 2014; Bohnsack et al. 2014; Naor et al. 2015; Sovacool et al. 2017) is a famous example of a failed (though innovative) business model due to the company's inability to overcome the chicken and egg problem. Despite huge investments, Better Place could not achieve the critical mass of customers because of a too slow market uptake of EVs. There were not enough electric vehicles to compensate for the high investments required in battery swapping infrastructure. Better Place could not go beyond the economic break-even point and missed its profitability objectives (Budde Christensen et al. 2012). Thus, business models are required for electric vehicle commercialization and for successful operation of the charging infrastructure. The infrastructure business models should consider a growing number of electric vehicles over time.

Key insight 3: In the long run, electric vehicle business models should be self-sustaining without governmental subsidies.

Many scholars (Lu et al. 2014; Li et al. 2016; Shen et al. 2016) emphasize the importance of governmental support in boosting technological advances by sharing the research and development risks with the private sector. This technological progress would probably not occur if EVs were not subsidized, e.g., indirectly through funding of innovative research projects conducted by companies involved in the development and production of EVs, or directly through incentives such as tax reliefs and buyer's premium (monetary contribution by the government for buyers who purchase a new EV).

Electric mobility research in China shows that despite the possibility of government-driven formation of new markets (Lu et al. 2014), firms need to be accorded a certain degree of leeway and flexibility (Li et al. 2016; Shen et al. 2016). Especially at the beginning of electric vehicle commercialization, political incentives are important drivers (Li et al. 2016), ideally reducing the overall costs of electric vehicle development (Adepetu et al. 2016; Jiang 2016). Too many constraints in the ecosystem, however, hamper the development and chances for the leverage of successful business models. Firms need a certain level of freedom to act and develop new markets (Li et al. 2016). Wang et al. (2017) emphasize that the strong dependence of the electric vehicle market on subsidies and non-monetary incentives may lead to a collapse as soon as those incentives are removed. Thus, economically profitable business models should be independent of government subsidies in the long run.

4.2 Value Proposition

Because of new sources of value, companies need to develop and offer customers new value propositions. They "face questions about the correct value proposition, i.e. whether to focus on products or services and how to target the desired customer" (Bohnsack et al. 2014, p. 289). The value proposition is a central aspect to enable the transition to a new technology (Cherubini et al. 2015) and to differentiate the business model from existing ones. Literature shows that particularly new entrants will not be competitive against incumbents, unless they develop innovative value propositions, in other words products and services that support their market entry. In addition, evidence from the reviewed literature shows that companies should increasingly rely on value-adding services.

Key insight 4: Companies can use compensating, enhancing, and coupling tactics to create innovative value propositions and to introduce potential customers to the new technology. The introduction of new value propositions can be challenging for incumbents, opening the door for new entrants to take an advantageous position in the market.

A study on customer preferences found that "vehicle attributes such as purchase price, fuel economy, and driving range play a very relevant role" (Danielis et al. 2020, p. 92). With respect to purchase price and driving range, electric vehicles still have to go through a long way before catching up with conventional cars. However, there are different ways to mitigate the current issues of the technology in order to fulfill eventually better the expectations of customers. In this context, Bohnsack and Pinkse (2017) describe three different tactics how companies can reconfigure their value propositions. First, compensating tactics can tackle the disadvantages of the new technology, for example a short driving range is compensated by offering fast charging stations, or a conventional car is provided at no fee during the weekend in order for the driver to travel long distances. Second, enhancing tactics offer value-added services like car-sharing or create new value to the customer. This tactic is dealt with in more detail in the key insight 5. Third, coupling tactics lead to completely new business models by establishing an entirely different product or service to address new markets. It is recommended to move from compensating to enhancing to coupling tactics to increase the potential of finding new sources of value creation (Bohnsack and Pinkse 2017). Enhancing and coupling tactics might be more difficult to realize by incumbents than new entrants, since they can conflict with the existing business model. Note, however, that Liao et al. (2019) could not verify a significant increase of BEV attractiveness by applying compensating tactics.

With these new value propositions, customers are slowly introduced to unfamiliar technologies. The creation of new and different value propositions for electric vehicles can be challenging for incumbent firms, thus opening up the way for new entrants to create innovative and successful business models (Dijk et al. 2016).

Key insight 5: Automotive companies should increasingly rely on the integration of attractive value-adding services into their electric vehicle-based value propositions to increase the accessibility of the electric vehicles by the market.

High-quality value-adding services can motivate car drivers to buy electric vehicles (Yan et al. 2019). A product service system (PSS) enhances manufactured products through service elements. Mont (2002, p. 239) defines a PSS as "a system of products, services, supporting networks, and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models."

Cherubini et al. (2015) use the PSS concept for the analysis of four electric mobility key sub-systems: vehicle, infrastructure, on-board electronics, and energy. With PSS business models, companies can reduce the total costs of ownership and mitigate potential risks to the customers. One of the most prominent services in electric mobility is car sharing. Several automotive manufacturers, companies from the transportation sector, as well as startups have implemented car sharing services. Autolib, a French car sharing startup that leverages a fleet of 3000 electric vehicles in Paris, is an example of a successful PPS-based business model (Vervaeke and Calabrese 2015). Autolib covers a combination of a product and several services like self-service rental terminals, charging stations and a website. It constitutes a "new value system" (Vervaeke and Calabrese 2015, p. 261) for urban mobility. Taking the car to an extreme form of servitization, Nieuwenhuis (2018, p. 43) asserts, that "cars will become ICT platforms for which suppliers develop 'apps'."

In the case of a new technology, customers require support to get accustomed with its use. One of the first most innovative service-based value propositions for EVs was proposed by Better Place, which consists in the separation between vehicle and battery. Better Place went bankrupt just short time after its inception because of many reasons. In a recent article, Yang et al. (2020) reconsider this complex value proposition to the customer with wide reach implications to value creation and profit formula. The authors acknowledge that separating battery and vehicle "reduces the purchase and use costs of vehicles, the residual value of second-hand vehicles is further guaranteed, and there are no worries about vehicle body disposal when vehicles are scrapped" (Yang et al. 2020, p. 17). It reduces range anxiety as well as charging time and supports users in their EV buying decision. However, the complexity induced by this value proposition regarding battery replacement stations on a broad level and the willingness of car manufacturers to hand over the control over the battery to another market player are limiting factors to the suitability of the service-oriented value proposition.

In China, innovative service-based value propositions developed by the Chinese car manufacturers had a major contribution to sales' growth of electric vehicles. The Chinese car market (Kong and Bi 2014; Li et al. 2016; Lu et al. 2014; Shen et al. 2016; Yang et al. 2016; Wang et al. 2017; Miao et al. 2015; Jiang 2016; Miao et al. 2013) is currently one of the fastest growing markets for electric cars in the world. Car-leasing and car sharing business models are found helpful for Chinese electric car manufacturers to overcome certain barriers such as the lack of a charging infrastructure and conservative buying behavior (Wang et al. 2017). Huang et al. (2021) studied consumers preferences for three PSS-oriented value propositions: battery-leasing, EV-leasing and EV-sharing. Consumers are found “to perceive battery-leasing and EV-buying models to be close substitutes, while EV-leasing and EV-sharing models are perceived as independent” (Huang et al. 2021, p. 1). The charging process of the battery-leasing model is similar to the EV-buying model with an additional option of battery swapping, leading to potentially substitutable business models whereas EV-leasing and EV-sharing are conceptually different.

A recent study in Germany conducted by Stauch (2021), in which the author examines the combination of vehicle and energy services, shows that bundles of an electric vehicle and community solar power improves customers’ willingness to pay compared to an EV alone. Thus, the selling of EVs in combination with solar power as PSS, while partnering strategically with community solar suppliers might be beneficial to promote EV adoption and its market accessibility.

4.3 Value Creation

Key insight 6: Incumbent companies in the automotive industry should leverage new ways for enforcing innovation to overcome organizational inertia that is due to established technologies and old business models.

Incumbent manufacturing firms in the automotive, chemical, electronics and battery sectors try “to exploit opportunities offered by the value creation process in the field of electric mobility” (Golembiewski et al. 2015, p. 807). Electric mobility involves firms from different fields and can lead to converging technologies. Delft (2013) examines the convergence process of the automobile (production of electric vehicles) and chemical industry (production of batteries) from 1990 to 2009 and found that incumbents are confronted with the known dilemma of exploitation and exploration. They must concentrate on the exploitation of proved technologies, and at the same time be open to change and actively consider completely new technologies as well as new business models. As such, incumbent firms have to maintain ambidextrous organizations (Delft 2013), or to radically move a part of the company outside the organization, for example by establishing spin-offs (Bohnsack and Pinkse 2017). A study in the Stuttgart region in Germany found that incumbent firms even try to slow down the transition process by fending off radical innovations in order to exploit their current market position based on proven business models and established technologies (Späth et al. 2016). Incumbents perceive a high level of risk because of BEVs and react intuitively by trying to protect the status-quo of the business through defensive strategies (Jiang 2016). Nevertheless, “understanding, working, and experimenting with a firm’s business model will be essential for incumbent firms, especially in times of market convergence” (Delft 2013, p. 81).

While incumbent firms face difficulties to overcome existing mental models and organizational inertia, they possess more resources such as capital, knowledge, and workforce, as compared to new entrants. To survive the threat of an upcoming technology like the electric vehicle, they are required to find solutions to enforce innovativeness and to keep up with smaller, innovative-born companies. It should be noted, however, that organizational inertia and the exploitation-exploration dilemma are hardly electric mobility specific. Literature on innovation and organization has dealt with these issues much longer before electric mobility. Because of this, the contribution of the literature on electric mobility in this regard rather confirms past findings within a new context and is therefore rather marginal than ground-breaking.

Key insight 7: New entrants and incumbents should proactively embark on partnerships.

Key insight 7.1: New entrants require partnerships with stronger and more powerful actors in the automotive ecosystem.

Key insight 7.2: Incumbents need to partner with other firms for the creation of new knowledge that is required for value creation.

Currently, actor networks in electric mobility exhibit a higher level of complexity and closer network relationships (Schwedes et al. 2013). Within these networks, the distribution of power among actors is uneven. New entrants, no matter their innovativeness level, are likely to be less powerful than incumbents. To mitigate the disadvantages of their low-power position, these firms embark on inter-firm partnerships with incumbents (Naor et al. 2015; Wesseling et al. 2014; Schwedes et al. 2013; Golembiewski et al. 2015; Budde Christensen et al. 2012, 2012, 2012; Wesseling et al. 2015). In addition, small companies and new entrants that are pioneers in the field of sustainable development should consider lobbying activities for environmental policy to increase the number of potential customers for electric vehicles (Wesseling et al. 2015). In this regard, larger incumbents can carry out lobbying activities much more effectively. Hence, collaboration with incumbents can improve the success chances of the business models of new entrants.

In spite of higher power position than new entrants, incumbent firms also need cooperation with external partners. By means of a patent analysis in the battery value chain from 2000 to 2011, Golembiewski et al. (2015) found that actors focus on their core competencies and acquire new knowledge and capabilities at technological interfaces through cooperation with partners. One specific challenge, however, is to successfully learn and implement new knowledge that is created through interactions with other companies. In another study that measures technological distances of cross-industry collaborations in electric mobility, companies from the automotive and chemical industries are found to lack the ability to integrate and leverage new knowledge generated within collaborations due to large technological distances between both industries. To overcome this inability of absorbing knowledge efficiently, companies can collaborate with diversified as well as focused firms, or by working with similar large firms with a broad knowledge (Vom Stein et al. 2015). While partnerships and collaboration are extremely important to hedge against the risks of a paradigmatic shift to a technology, the development of in-house knowledge and internal capabilities is crucial for a successful transition of car producers to hybrid and electric vehicles. For example, Pohl (2012) found that Honda and Toyota achieved an intensified in-house knowledge development, while Pohl and Yarime (2012) emphasize the critical relevance of strong product development capabilities maintained by both Japanese manufacturers.

Electric vehicle technology clearly calls for partnerships and coordination of activities among many actors. No matter whether a company is a new entrant or incumbent, it needs partnerships to create value to the customer. However, the motives for partnering with other firms can be different. New entrants seek to establish strong linkages to more powerful partners, whereas incumbents aim to generate new knowledge. Because of organizational inertia, it is not surprising that incumbents find it hard to integrate the knowledge created during partnerships into existing structures. In addition, the establishment of connections to policy makers seem relevant for incumbents and new entrants alike. Whereas big players in the automotive industry have traditionally maintained close relationships with policy makers, the call for lobbying activities by new entrants may appear a difficult task because of their relatively small weight in the industry.

Key insight 8: Actors in the electric vehicle value chain should leverage digitalization to create new ways for value creation to the customer.

Electric vehicles will inevitably benefit from digitalization. This opens up new opportunities for additional value creation to customers. For instance, additional value can be created by using charging stations for offering digital services of third parties, e.g., for advertising purposes (Madina et al. 2016; Robinson et al. 2014). Or an advanced navigation system can steer a car driver to the closest charging station, while taking the shortest route (Vervaeke and Calabrese 2015). In this regard, Rothkrantz et al. (2013) introduce an electric vehicle parking and routing system that uses an ant-based control algorithm. The optimized navigation system can improve the efficiency of rental systems of electric cars by decreasing the average travel times, leading to a lower energy consumption and a more effective use of the battery capacity.

Valuable input for product and business model improvements can be captured through automated social media analysis, as shown by Kühl et al. (2019). Such input may not only serve the improvement of the vehicle itself, but also the full product service system (Kühl et al. 2019).

4.4 Value Communication

For decades, people have been used to a certain level of mobility services, making them unlikely to accept other forms of mobility with lower performance, e.g., regarding driving range, total cost of ownership, and refueling. This can lead to a (partly) rejection of EVs. Based on web-based customer survey of a rental car company for electric cars (BEVs and PHEVs) in Bavaria, Germany, Türnau (2015) found that the perceived attractiveness to EVs is lower than to conventional cars. In the same context, based on a survey study that examines consumer's intention to purchase electric vehicles in the wide area of China, Jiang (2016) reported a low willingness level to purchase EVs because of an overall low perception level of the EV value. This is because consumers still face certain risks regarding EVs. Consumers still exhibit a "wait-and-see attitude". These risks are due to the perception that EVs are more cost intensive than ICEVs, that batteries are potential sources of safety problems, and that the broad use of EVs will lead to an increased electricity price. Some consumers may still perceive EVs as underdeveloped and an immature technology (Graham-Rowe et al. 2012). Türnau (2015, p. 16) concludes that "when one talks about electric mobility, the assessment of (potential) users' perspectives and acceptance of this new technology is a major scientific challenge as well."

Key insight 9: OEMs need to educate their customers about electric vehicles to increase their openness toward this technology.

Education can enhance customers' perceived attractiveness and acceptance of electric vehicles (Zarazua de Rubens et al. 2020). Increased knowledge about EVs might be beneficial for EV diffusion (Giansoldati et al. 2020b). To overcome the barriers of adoption, consumers have to be informed properly on EVs (Larson et al. 2014; Franke et al. 2016; Liao et al. 2019; Tran et al. 2019). Thus, marketing is crucial for the success of BEV (Harrison et al. 2018). The promotion of environmental benefits and positive aspects of electric vehicles improves consumers' perceived value (He and Hu 2021). As demonstrated by Tran et al. (2019), this can lead to a higher acceptance of electric carsharing. The communication of suitable information can even decrease the level of price sensitivity towards EVs (Hahnel et al. 2014). In the same context, Larson et al. (2014) note that improved consumer education on electric vehicles is feasible and can be more effective than the risk-reducing alternative to monetary incentives.

Key insight 10: To reduce perceived risks, companies and government should enable customers to co-create and get active experience with electric vehicles and related infrastructure.

Manufacturers and government should better promote EVs (Jiang 2016; Miao et al. 2014; Liao et al. 2019; Han et al. 2017) by triggering positive associations (Nosi et al. 2017). A good example of how to evoke positive associations and to reduce perceived risks is to demonstrate the performance of a fast-charging process in contrast to a slower charging process. Letting people actively participate in the charging process impacts positively their attitudes towards EVs, independently of the type of charging. This can improve people's opinion about EVs significantly (Gebauer et al. 2016).

In addition, giving consumers the possibility of being part of the value creation process—also known as value co-creation—can have a positive effect on the buying intention of potential customers. For example, in a study involving Chinese students in Shanghai, Miao et al. (2014) found that service-oriented companies such as EV rental firms should focus on customer participation and service quality. Intensive communication and collaboration, e.g., by engaging customers in an open discussion with rental companies and car manufacturers to develop new service programs and new car models can improve customer satisfaction. This leads to an improved customer post-purchase intention, which is expressed in a higher probability of repurchasing products or services and recommendation of the consumer experience to other potential customers (Miao et al. 2014). Nevertheless, a study focusing on Italian millennials shows that co-creation initiatives that aim to capture suggestions and recommendations for product improvements should be applied carefully by electric vehicle manufacturers because they might rather discourage than encourage young and inexperienced customers (Nosi et al. 2017).

Key insight 11: Companies need to understand the real motives why their potential customers would buy an electric vehicle, in order to better capitalize on the sources of value in their value propositions.

Cost, comfort and safety are essential factors for the market success of eco-friendly vehicles (Tarigan 2019). Nevertheless, there are other factors that influence the attractiveness of vehicles. Barbarossa et al. (2015) investigate the effects of green self-identity on ethical motives, attitudes and behavioral intentions towards electric car adoption by using an online survey involving participants from Denmark, Belgium and Italy. They show significant differences in the motivational process across countries, thus recommending different marketing approaches, depending on the cultural background of customers. In a second study, Barbarossa et al. (2017) found that addressing green self-identity represents a major success factor in marketing campaigns by promoting eco-friendly behavior.

The attractiveness of cars depends on the difference between brand personality and consumers' desired self-personality (Moons and Pelsmacker 2015b). Within a study by Moons and Pelsmacker (2015b), four car brands, different in their brands personality, had to be evaluated by participants before and after launching an electric car. By adding the electric car as an eco-friendly product, car manufacturers are found to be able to improve the attractiveness of their brand with a desirable personality dimension: responsibility. In general, consumers tend to choose certain car brands for self-enhancement. Thus, marketing campaigns should emphasize consumers' desire to self-enhancement by connecting EVs to the category of environmentally friendly products.

An online survey involving 1023 respondents from Belgium, indicates that for most customer segments, electric car usage intention depends primarily on emotions, followed by the attitude towards EVs (Moons and Pelsmacker 2015a). In addition, the experiences anticipated by customers drive their behavior (Moons and Pelsmacker 2014). Consequently, it is important to fine-tune the promotion of EVs regarding emotions and anticipated experiences that they might evoke in potential car drivers.

He and Hu (2021, p. 15) propose that companies could highlight the negative consequences of using gasoline cars and positive aspects of using an electric vehicle. "Once consumers are proud of adopting EVs or feel guilty about using gasoline cars, they may be more likely to adopt EVs. It is noteworthy that the messaging should pay more attention to the transmission of positive emotions rather than negative ones, because negative emotions are found to be less effective than positive emotions" (He and Hu 2021, p. 15). Pride is a key trigger for men regarding EV adoption, while for women guilt primarily triggers their decision to buy and use an electric vehicle. Therefore, more information about the green image might be beneficial for targeting men, while highlighting environmental concerns might increase women's willingness to adopt EVs. Customers who are environmentally versed and interested in adventure, hedonism and benevolence should be particularly interested in EVs at the beginning of market introduction (Moons and Pelsmacker 2015a). Bobeth and Kastner (2020) also mention that directly addressing social and moral motives as well as the impact on a sustainable future in the early diffusion stages, for example by means of mass media campaigns, can improve the market diffusion of EVs.

Key insight 12: Car manufacturers <u>may</u> leverage social networks to communicate the value of electric vehicles and boost their acceptance among potential customers.

To improve value communication and support the acceptance of EVs, automotive manufacturers can facilitate social processes such as direct interactions between potential buyers and EV owners (Bobeth and Kastner 2020). This can occur by leveraging different media such as social networks (Yan et al. 2019). Rasouli and Timmermans (2016) examined the influence of social networks on the latent choice of electric cars by conducting a stated choice experiment among representatives of the Dutch population. The authors conclude that the relative costs of electric vehicles and their attributes have the highest impact on the acceptance of electric cars, whereas social influence plays a subordinate role. What's more, the proportion of people owning electric cars in different member groups of social networks, classified into family, friends, colleagues and peers, can have an impact on the stimulation of purchase intention. Therefore, because electric vehicles are at a very early stage of market diffusion, we believe that the leverage of social networks can make a difference and support the successful introduction of EVs.

4.5 Value Delivery

Value delivery consists of two elements: channels for value delivery and customer segments. With respect to the channels for value delivery, it does not seem that there will be a big change as compared to the conventional car. In effect, by means of an on online survey among car owners in Switzerland, Plananska (2020) found that car dealers play a significant role in the vehicle purchase process but hinder the sale of EVs because they rarely offer EVs to customers. In this regard, car dealer training with the objective of increasing their knowledge about EV might be beneficial for the promotion of the technology.

"Car drivers do not change their mobility behavior to fit their cars but drive the cars that fit their mobility behaviors and needs" (Kölbl et al. 2013, p. 50). Therefore, comprehensive knowledge about customers lead to a better segmentation of the market, and to the selection of appropriate channels for value delivery.

Key insight 13: To segment the market appropriately, companies in the automotive industry need to consider customers' preferences along the attributes of the electric vehicle as well as their behavioral patterns regarding the use of the charging infrastructure.

Several studies dealt with drivers' behavior and expectations. For example, survey data captured between 1995 and 2010 in the Stuttgart region, Germany, reveals that BEVs with a driving range of 160 km are sufficient to drive approximately 87% of all daily car trips (Kölbl et al. 2013). Because of high upfront investments and low running costs, electric vehicles will pay off, only if car owners drive a high mileage per year. Most car owners, however, drive annual distances that are below the mileage threshold required for electric vehicles to achieve a better Total Cost of Ownership (TCO) than conventional cars. Since potential customers are aware of this disadvantage, OEMs may rather target so-called innovators or early adopters with special affinity to sustainability (Rogers 2003), who are willing to pay more for a new, rather expensive technology. Another option is to add an extra value to the electric vehicles that conventional cars cannot accommodate easily, or only at higher cost, so that car manufacturers can address a big portion of the market (Abdelkafi et al. 2013).

The driving distance seems a key attribute for market segmentation, but in the electric vehicle market there are other product attributes along which customers' preferences may differ substantially. An interview study with 162 respondents from different districts of Shanghai city, China, found that customers between 20 and 35 years with high education level give higher priority to enjoyment (fashionable design, color or exterior elements) over environmental benefits, whereas people between 35 and 45, who own an ICEV, allocate higher importance to the purchasing price, operating costs and safety (Miao et al. 2013). In the context of market segmentation, Barbarossa et al. (2017) also underline the importance of adopting value-based segmentation approaches. Cherubini et al. (2015) emphasize that the value proposition must fit to certain variables of market segmentation like different types of end-users, e.g., private, corporate, and public bodies, and behavioral variables such as urban and extra urban driving as well as lifestyle. For private end users, companies can distinguish two target groups: high-spending consumers, who define the car as a status symbol (Noel et al. 2019), and consumers with high environmental awareness and relatively high sensitivity to operating costs. Hence, firms may "make themselves attractive to identified target customers by using unusual segmentation characteristics which typify trendsetters" (Cherubini et al. 2015, p. 46). Another study in the Netherlands found that, in the early stages of e-mobility, the main potential purchasers are young and middle-aged people with higher incomes in low-density cities, and therefore, companies should focus their marketing activities on this market segment instead of the whole market (Zolfagharian et al. 2021). Zarazua de Rubens et al. (2020) propose that car manufacturers target public authorities to sell their vehicles. Municipalities, for example, often receive financial support from the government to fulfill environmental goals and thus, to increase the number of electric vehicles. Consequently, municipalities can represent an appropriate customer segment. Another recommendation concerning market segmentation is mentioned by Abdelkafi and Hansen (2018) who propose focusing on companies instead of individual buyers. For example, in Germany, commercial companies do about 60% of new car purchasing in order to extend or replace their car fleets.

Other ways for EV market segmentation have been identified in a study conducted in China. Huang et al. (2021) found that highly educated women would prefer innovative value propositions such as EV sharing, leasing, or even battery-leasing over EV purchase. In addition, young people born in the 1990s would select EV-leasing as best option.

The segmentation of the electric vehicle market can include charging infrastructure considerations. Morrissey et al. (2016) differentiate between urban and rural user segments and analyze data from 37 fast charging points distributed over Ireland. In urban areas, clients were found to use fast charging technology close to their homes for convenience reasons, not because they intend to drive long distances. Rural drivers, however, charge farther away from their homes and use fast charging stations when they go for a long trip. The identification of such behavioral patterns related to the use of charging infrastructure is especially important for pricing, adjusting extra-offerings to the customers, and even adapting the advertisements to be perceived by customers at the charging station.

It becomes obvious that except for sporadic results, the scientific literature does not provide actionable solutions or concepts for customer segmentation in the electric vehicle market. While several studies have been conducted in this regard, it is still not clear what customer segments OEMs should target along the stages of the product lifecycle to scale up effectively the market.

Key insight 14: New entrants should leverage electric vehicle niche markets before moving into mass markets.

Instead of addressing a large mass market, companies can start with the introduction of EVs in niche markets (Daziano and Chiew 2012; Kong and Bi 2014). In a smaller market, customers' heterogeneity is low. Consequently, companies can reduce business model complexity and allocate resources more efficiently. Because of their restricted resources, especially new entrants should focus on niche markets, at least at the beginning. An analysis of the industrial dynamics of electric vehicles with focus on electric vehicle prototypes and models from 1991 to 2011 shows that startup companies rather target niche markets such as sports cars or city cars with low speed and compact design. Large incumbents, however, tend to develop EVs for their current mass market vehicles (Sierzchula et al. 2012). This is in line with observations in other industries, where innovations are first launched in niche markets (Christensen 2008). Nevertheless, by drawing on Better Place as an example, Sovacool et al. (2017) argue that the identification of new niches can have certain limits. Though innovative, Better Place exceeded the limits of users' demand and manufacturers' possibilities (Sovacool et al. 2017). From this, it follows that while new entrants should start with serving market niches, the target niche should rather be defined carefully and not arbitrarily.

4.6. Value Capture

Value capture has not been investigated intensively, in contrast to other business model elements. In addition, the research related to value capture is rather unspecific and descriptive. For instance, Robinson et al. (2014) examined financing—as one among other elements—of the business model for solar-powered charging stations. Cherubini et al. (2015, p. 46) advise firms to develop "pricing strategies that meet specific needs", whereas Madina et al. (2016) conclude that the manner by which the energy bill is structured after the use of charging stations is crucial for the development of sustainable business models.

Key insight 15: Companies should reduce the fixed cost level of electric vehicles by making part of these costs variable to reduce the level of upfront-investment required for the initial acquisition of electric vehicles. Charging costs can be integrated in the fees paid by customers when they use leasing and carsharing models. Price setting for charging can depend on a reference price (e.g., charging costs at home) and on the battery charge level at a specific point in time (dynamic price setting).

Many scholars mention the purchase price as a crucial barrier in electric vehicle adoption (Vilchez et al. 2019; Nian et al. 2019; Han et al. 2017). Nian et al. (2019) propose that a shift of a part of the purchase price to the running costs of an EV might support a successful market introduction due to much lower electricity costs compared to fuel costs for ICEV. By this measure, purchase price and variable costs of an EV become more similar to the purchase price and variable costs of an ICEV, thus reducing consumers' perceived cost disadvantage. Liao et al. (2019) show that for EVs, leasing is preferred by consumers, whereas for PHEV and ICEV, car purchasing is still most popular. Car leasing can even be regarded an option to allocate costs of charging infrastructure via subscription services (Zarazua de Rubens et al. 2020). Liao et al. (2018) show that leasing only the batteries even improves BEV attractiveness. By using methods from value engineering, and taking a Chinese firm as a case study, Miao et al. (2015) draw conclusions on when to sell or lease a low, middle and high price EVs. Assuming a life cycle of 10 years for all vehicles, it is found that low price EVs should be leased at the beginning and middle of the EVs' lifecycle, while shifting to sale in the last 30% of lifecycle. For middle price EVs, leasing should be adopted for the whole life cycle, whereas for high price EVs sale is the appropriate mechanism for value capture in the first 45% of lifecycle before converting into leasing.

Carsharing, based on pay-per-use value capture model, also constitutes a possibility for improving accessibility of EVs to the market, while reducing upfront investments by customers. In a study that compares two carsharing companies based on lifecycle costs and monetary revenues, Jia et al. (2020) derive, by means of a sensitivity analysis, different factors influencing the break-even point. The most influential factor is found to be the EV purchase price, followed by the unit rental price, governmental subsidies, and operational cost.

As far as value capture through charging services is concerned, Dorcec et al. (2019) found that for the use of charging stations in parking lots, the reference price such as the cost of charging at home is crucial. If this reference price is high, they are also willing to pay a high price to charge their vehicles at the parking lot, and vice versa. Consumers are also willing to pay less if the current level of charge in the battery is high, and vice versa. Charging speed and the time of the day, however, may not have a significant impact on the willingness to pay of customers.

Key insight 16: Companies need to examine the effects of incentives on their business models to completely understand their impact on customers' purchase decision, whereas financial incentives can be more effective for lower car market segments and non-financial incentives for high car market segments.

To improve their value capture, companies need to understand what customer incentives are appropriate. The probability of purchasing an EV even increases more through financial incentives than through technological improvements (Danielis et al. 2020). In Italy, for example, the introduction of cheaper EVs in the small and medium-sized vehicles, which account for more than half of the Italian car market, is advisable to boost EV sales (Giansoldati et al. 2020a). Incentives can be offered by the government or by the company itself and can improve the chances of companies to implement profitable business models. Companies may consider, at an early stage, incentives as a tool to support the business model.

Rudolph (2016) investigates the impact of different incentives (direct purchasing grant, free parking, a separate CO_2 tax, increased fuel costs through tax elevation and a higher availability of the charging infrastructure) on the purchase decision for different types of vehicles (BEV, PHEV, FCEV and ICEVs). It is found that these incentives increase the attractiveness of electric vehicles over conventional cars, especially for those people that aim to achieve low CO_2-emission rates such as cyclists and public transport users. It is noteworthy, however, that this can have adverse effects. As the target group includes non-car users, such incentives increase the total number of cars, the total distance driven, and the space requirements for parking facilities and roads, resulting in the substitution of public transportation and bicycles by electric vehicles.

Since the impact of incentives can be dependent of customer groups, Fontaínhas et al. (2016) explore the impact of monetary and non-monetary incentives on two different customer segments: users of lower/middle car market (VW e-Golf and VW Golf), and users of higher end car market (Tesla S and Audi A7). Since the purchasing price is considered the main barrier for EV market uptake, especially in the small and medium market segment, the authors conclude that “financial benefits should be directed to lower market car segments and non-financial benefits should be more effective for high market car segments” (Fontaínhas et al. 2016, p. 1475).

5. Potential Directions for Future Research

This contribution provides an overview of the literature on electric vehicle business models. It leads to recommendations that can be considered in future research work. To our view, future research should have a holistic view on business models, since the consideration of isolated elements can lead to local optimization, while ignoring relevant tradeoffs such as value capture vs. value creation or value proposition vs. value capture. In addition, the business model framework we used for the literature analysis includes value communication, an element that has not been considered in many previous business model conceptualizations. Most business models definitions rather include value proposition, creation, delivery, and capture. This review, however, provides evidence that value communication is an important aspect that has been addressed by a fair body of research and that success or failure of the EV business models depends on how this element harmonizes with the other business model elements.

A relevant question should be asked, however: What role does scientific research play in the development and improvement of business models in electric mobility? (1) Is it ex post research, meaning that business models are analyzed after implementation, in other words, identification of the patterns of successful business models? (2) Or is it ex ante research, in the sense that it provides sound and scientifically supported methodologies for the development of appropriate business models for electric vehicles. In the second case, research can be more effective in framing and impacting electric vehicle business models that are rolled out in practice. We believe that business model research will benefit from both approaches. The first approach investigates the contingency factors such as customer segments and preferences, product attributes, and pricing decisions, under which certain EV business models are more successful than others. The second approach is more focused on the development of methods and tools that support companies in creating new innovative business models. Whereas the first approach is more common in management and business administration literature, the second is more popular in engineering and design fields. Both are complementary and support the development of EV business models. EV business model research can be supported by elaborating an extensive cross-country database of EV business models that can be extended and analyzed over time. Comparative studies between different countries can be helpful in identifying what business models are more likely to thrive in one country or another. For example, Norway has an initial situation that is completely different from most countries in Europe because of the wide diffusion of electric cars. In addition, subtle differences between countries such as the percentage of households that have a garage available can have an important impact on business models for charging infrastructure. Obviously, the availability of a garage reduces the need for charging stations in parking facilities.

Arend (2013, p. 399) asserts that "one has to move from the business model idea's focus on the practical realities to an alternative focus on what is possible in the future (although there remains some catching up to do to what is already existing)." This is particularly true for electric mobility in conjunction with digitalization. Digitalization significantly expands our possibilities for the creation of new business models. Accordingly, a wide variety of conceivable services can be created and launched to support the transition to electric vehicles. Therefore, more conceptual research is required to expand our view on how to leverage digitalization capabilities for the generation of new digital value propositions and new ways of digital value creation. Information technology and information systems' researchers that do business model research can study and uncover the potential of digitalization in creating new electric vehicle business models.

Whereas most articles focus on the technology or actors involved in electric vehicles, only a small portion (12 percent) concentrates on charging infrastructure. Because the charging infrastructure is a crucial element for a functioning electric mobility system, certain questions still have to be answered. For example, who should take the responsibility for charging infrastructure in public space, public and private institutions? And most critical, how can companies justify the investments for charging infrastructure? How can the value proposition of actors in the charging value chain be expanded to embrace new services and offerings that add value to the customers and generate profits? Here, research can contribute through future studies and Delphi-method-based research to capture latent knowledge of practitioners and technologists and then aggregate this knowledge into innovative business model options. In addition, capturing use cases that work well in different countries can expand the knowledge database and facilitate cross-regional knowledge transfer.

Regarding the business model elements, there is a lack of research on value capture of business models for electric vehicles, more specifically, in the electricity, automotive, and charging value chains. The major question is how to make a business model economically viable, while offering a competitive product to the consumer. The convergence of these value chains might trigger new perspectives, leading to new ways for capturing value. Business model simulations, can provide valuable support in this regard by revealing the effects of the business model changes on company's value chain performance (Täuscher and Abdelkafi 2018). Furthermore, innovative financing models can make electric vehicles more attractive to customers and the expansion of charging infrastructure more appealing to interested entrepreneurs.

In the future, business models related to fuel cell electric vehicles (FCEV) should receive more attention in research. In our sample, only some contributions mentioned this technology as part of a holistic view of electric mobility (Bohnsack et al. 2014; Harrison et al. 2018; Rudolph 2016). While few car manufacturers push the market diffusion of FCEV, research considers FCEV business models only incidentally. The discussion of FCEV is, indeed, very controverse (Ball and Weeda 2015; Cano et al. 2018). It is not easy to predict the future role of the fuel cell in the automotive industry. Recently, Volkswagen has claimed that FCEVs are not interesting for passenger vehicles. Some Asian (and also German) manufacturers are, however, making progress in this technology. Some observers even predict that FCEV will be the next widely diffused technology in the car industry. Toyota, for example, is allocating a lot of R&D efforts in FCEVs (Ball and Weeda 2015). Very important, however, is that technology and business models go hand in hand. Some technologies—as shown by many examples in the past—are not successful, until entrepreneurs discover new business models that support the diffusion of the technology. Conceptual research as well as exploratory future-oriented studies that analyze various evolutionary paths of the different mobility technologies with the business model as a unit of analysis, could provide significant insights into future mobility as well as strategic moves of automotive manufacturers and supply chains in competition.

6. Conclusions

The goal of this article is twofold: first, to review the business model literature on electric mobility with focus on electric vehicles while using the five elements of the business model as a framework and second, to integrate the main findings from the literature into key insights.

The analysis, which is based on articles published between 2012 and June 2021, shows that the articles do not necessarily deal with all business model aspects. Therefore, our review integrates the findings from the literature into coherent key insights with respect to: (1) the business model in general and (2) business model elements.

Regarding general business model aspects, literature emphasizes the systemic, and complex nature of electric vehicle technology. Successful business models cannot be obtained through an actor-focused, local consideration, but should span various actors. Obviously, the business models that perform well with the conventional technology cannot be transferred to the new context without adaptations and coordination activities among actors inside the system. In particular, the new business models by automotive manufacturers should go hand in hand with the charging infrastructure; the chicken-egg problem still represents a significant barrier against the diffusion of electric vehicles. In the attempt of mitigating the chicken-egg problem and to share risks with companies, governments develop public policies for the support of electric vehicles. Though subsidies are mainly spent to develop technologies for innovative value propositions, in the long run, whole business models should be profitable, even without governmental support. In other words, companies should be able to demonstrate the financial sustainability of their business models, even beyond the phase of funding.

Regarding value propositions, literature recommends combining electric vehicles and value-adding services such as car sharing or leasing into complex PSS systems. This result seems valid among different countries and regions, as studies conducted in Europe and China converge. This insight is, however, hardly new or specific to electric vehicles, as incumbents in the automotive industry have leveraged PPS systems for many years, in combination with the conventional technology. Whereas incumbents can still rely on these old business models—also called servitization—new entrants should develop innovative value propositions to compete successfully. In this regard, they can draw on a repertoire of three tactics that aim to augment existing value propositions or even generate new ones: compensating, enhancing, and coupling tactics.

As for value creation, incumbent firms in the automotive industry should overcome organizational inertia due to established procedures and processes that often result in rigid mental models, favoring old ways of doing business. Thus, maintaining ambidextrous organizations that support exploitation and exploration can facilitate innovation and the shift toward electric vehicles. Companies also need to innovate their value creation. To do so, they should capitalize on enabling digitalization technologies, which are finding rapidly their way to the (electric) car. To innovate their value creation, companies should understand their customers' real requirements, while avoiding that their value creation is endowed with a complexity that the customers do not want to pay for. In addition, a fundamental aspect in value creation is partnerships. New entrants and incumbents have different motives regarding the selection of the actors to partner with. Whereas new entrants look for partners with financial strength and power, incumbents select their partners for the sake of co-creating knowledge. Since the biggest asset of new market entrants is generally knowledge, the relationship new entrant-incumbent may be rather complementary than competitive, although special attention should be allocated to the adequate handling of intellectual property rights.

Value communication seems an essential cornerstone in electric vehicle business models, although value communication, as such, has not been explicitly considered in many business model conceptualizations. We identified several approaches how companies can address value communication effectively. Effective value communication goes beyond the design of communication messages or the choice of a particular communication channel such as social media. It additionally embraces additional aspects, in particular customer education and reduction of perceived risks through co-creation opportunities with the customer. Certainly, however, good communication starts with understanding why customers buy electric vehicles. This not only enables companies to better shape and design their value propositions, but also to define the actions and appealing message that addresses the emotions of potential customers. Companies should make customers anticipate positive experiences, since the anticipated experience drives behavior.

Value delivery has two components: distribution channels and customer segments. Our sample of articles barely contains research dealing with electric vehicle distribution channels. The reason is that electric vehicles seem to be marketed through the same channels used to distribute conventional cars. However, a good body of research is available in the field of customer segmentation. Literature recommends market segmentation along product attributes such as driving distance. In addition, there is clear advice for new entrants, who should rather focus on serving niche than mass markets.

Value capture is potentially the business model element that is least understood. The key insights from the reviewed literature are twofold. First, companies should reduce the level of electric vehicle fixed costs by making part of them variable. Second, to boost their sales. companies need to better understand the impact of potential purchasing incentives on the customer's buying behavior. Value capture needs much more attention from research to identify ways that improve the profitability of electric vehicle business models.

This work also proposes some directions for future research. These research directions can support researchers in defining new areas of investigation in electric vehicle business models. Given the increasing sustainability orientation of companies and markets, the opportunities that electric vehicles provide to reduce dependency on fossil energy as well as the ever-increasing CO_2 emission level pressures on automotive manufacturers, research on electric vehicles should be intensified to enable the shift toward a more sustainable mobility in the future.

Despite the insights that this work provides into current research on EV business models, some limitations are worth mentioning. In effect, the search results are based on the Web of Science research tool and predefined search terms. Had we used other search tools and/or additional key terms, we could have identified additional research articles, which potentially could add more insights.

Coming back to Henry Ford's citation at the beginning of this article. In contrast to the year 1914, when electric vehicle could not make a progress because of the upcoming ICEVs, nowadays, the electric vehicle might be on the road for a better future. This is not only because of its rapid technological improvements, but also due to the possibilities that derive from the design of innovative business models.

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