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Prescriptions for the Successful Diffusion of Carsharing with Electric Vehicles

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ABSTRACT: The current mobility paradigm is challenged and carsharing as well as electric vehicles are promising solutions leading to a possible new mobility paradigm. Carsharing can be a trigger for the diffusion of electric vehicles and vice versa and mobility providers around the world prepare for this innovation-package of technology- and service-innovation. This research aims to understand which factors influence the adoption of carsharing with electric vehicles in order to be able to plan for an effective introduction of this innovation. For this, 34 interviews with multiple stakeholders were conducted, revealing a comprehensive set of factors comprising environmental factors, adopter characteristics, and innovation attributes. This determination of success factors for the adoption of "E-carsharing" leads to prescriptions for the successful diffusion of it. Following these prescriptions as well as decreasing costs of technology and scale-effects should enable E-carsharing to diffuse into the mass market and become economically successful. This, as well as appropriate regulatory framework conditions are prerequisites that the innovation can unfold its multifarious economical, ecological and social benefits for our societies.

Keywords: electric vehicles, carsharing, E-carsharing, diffusion of innovation, success factors

1 INTRODUCTION

A variety of factors, such as rising oil prices and global warming, challenge the current mobility paradigm which is based on gasoline-fuelled cars in private ownership. These challenges are reinforced through regulatory measures (e.g. congestion charges) and conclude in social changes. These social changes together with technological changes (such as battery innovations) are likely to lead to a new mobility paradigm - one based on new offerings and new business models. Energy-efficient, low-carbon mobility services may emerge and electromobility and carsharing are possible future scenarios [1, 2].

Battery electric vehicles (BEVs) enable energy-efficient and emission-free mobility as long as renewable energy is used. Therefore, the wide adoption of BEVs could provide substantial ecological and economic advantages and governments incentivise electromobility. Their diffusion is currently hindered by high acquisition costs leading to unattractive lifetime costs. Further, there is only a little variety of offers and the range is limited to about 100-300km with charging times of up to 8h [1].

"Carsharing" means that a car is shared by a community. This work focuses on modern carsharing which is professionally organised by mobility providers, offering different vehicles at different places to their customers. There are two versions of carsharing, station-based and free-floating carsharing. Station-based concepts (e.g. Zipcar, http://www.zipcar.com/) offer vehicles available at fixed stations, e.g. rented parking-lots, and cars are booked before usage. Vehicles are returned to the initial station, not allowing for one-way-trips, or alternatively only to other stations (e.g. Autolib in Paris, www.autolib.eu). Free-floating concepts allow the return of a car anywhere in a given operating area (e.g. DriveNow, www.drive-now.com) which is mostly the city centre and the provider buys on-street parking licenses for each vehicle. Free-floating concepts do not require in-advance bookings and make carsharing more flexible and spontaneous. On the downside, availability cannot be guaranteed to the same degree as with reservations [3].

Carsharing intends to combine advantages of privately owned cars without the associated fixed costs and obligations. This has proven ecological, social, and economic advantages since private car-ownership and car-usage are reduced [1]. However, it still is a niche offer and little known.

Combining carsharing and electromobility can encourage both concepts as they are mutually beneficial. For example, the limited range is not problematical for customers in carsharing as well as many people can try the new technology without committing to it. Further, electric vehicles boost the sustainable advantages of carsharing. Hence, carsharing can be a trigger for the diffusion of BEVs and vice versa [1]. In general, two or more innovations are often packaged together to facilitate their diffusion because they have functional or perceived interrelatedness. This is called a technology-cluster or innovation-package [4]. Mobility providers around the world prepare for this innovation-package of technology- and service-innovation.

Having laid this background, the question is raised what influences the diffusion of this innovation package and in order to give providers a prescription to support the successful diffusion of carsharing and E-carsharing in specific.

This work studies diffusion of innovation literature to provide a theoretical basis from which success factors for the adoption of carsharing with (and without!) electric vehicles can be identified in order to be able to plan for an effective introduction of this innovation.

2 OVERVIEW ON THE DIFFUSION OF INNOVATION

For Joseph Schumpeter innovation is the fundamental force behind economic development. According to him, the innovation process consists of three steps: (1) the invention or idea, (2) the development of the invention into a marketable product, the innovation, and (3) the diffusion process where products get spread through an economy and adopted and imitated [5]. In this work, the focus lies on how the second step – an innovation in the form of a business model – reaches the third step, its diffusion.

Innovation is defined as "an idea, material, or artifact perceived to be new by the relevant unit of adoption" [6], "not what innovators do but what customers adopt" [7], or "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" [4].

This strongly implies that innovation is about adoption, which is defined as "a decision to make full use of an innovation as the best course of action available" [4]. Referring back to Schumpeter, this adoption follows a process in an economy, the diffusion. According to Rogers, "diffusion is the process in which an innovation is communicated through certain channels over

time among the members of a social system" [4] and is consequently a process of individual adoptions.

Even when innovations have obvious advantages, it is not easy to get them adopted and it is a common problem for individuals and organisations to speed up the rate of adoption [4]. Moreover, Mansfield showed that the speed of diffusion is positively related to the profitability of adoption [8]. According to Wejnert and Faiers the adoption rate depends on the decisions actors make. Variables influencing the decision to adopt an innovation can be grouped into three major components: environmental context, characteristics of adopters, and attributes of the innovation [9, 10]. This research relies on this framework and thus, an overview on it is given as follows:

Environmental Context

Innovations are not independent from their environmental context. Their successful transfer depends on their fit with the new environments which they enter during diffusion. Four environmental context variables are proposed:

(1) Geographical settings affect adoption by influencing the applicability of the innovation to the existing infrastructures as innovations can be adopted only when they are suitable to the environment of the adopter.

(2) Variables of societal culture such as belief systems (values, norms, language, religion, and ideologies), cultural traditionalism, cultural homogeneity, and socialisation of individual actors influence adoption of innovations.

(3) The impact of political conditions on adoption primarily concern political systems, along with the regulations and norms inherent in the legal systems that control actors' behaviours.

(4) Variables related to global uniformity, including institutionalisation, global technology, and world connectedness via modern communication systems or media effects [9].

Characteristics of Adopters

Diffusion and marketing theory is often concerned with individual characteristics since they play an important role in adoption [11]. Here, six sets of variables modulate the adoption of innovations:

(1) The societal entity of adopters. However, in this work this can be factored out since the focus is on individual adoption only.

(2) The familiarity with the innovation. This is influential because people are naturally cautious in approaching novelty and therefore the rate of adoption of an innovation increases as its novelty decreases.

(3) Status characteristics of adopters- They refer to the prominence of an actor's relative position within a network/society.

(4) Socioeconomic characteristics of the adopter. Here, economic variables often account for more variance in adoption than sociodemographic variables or an actor's social position.

(5) The relative position in social networks. This determines adoption since timing of adoption typically depends on the interaction of social units in a process of communication.

(6) Personal characteristics of individual actors. Self-confidence, risk-taking propensity, and independence are suggested because they modulate the extent to which an individual adopts an innovation without waiting for the security of observing others [9].

Attributes of the Innovation

Transforming the objective, measurable innovation attributes into innovation attributes as perceived by adopters is the subject of this category [12] because it offers explanations of its rate of adoption. Rogers proposes five innovation attributes that influence an individual's perception:

(1) Relative Advantage "is the degree to which an innovation is perceived as being better than the idea it supersedes". This might include economic factors (initial cost, cost of use, saving of time/effort), status aspects (social prestige, trend), and comfort (decrease in discomfort, immediacy of reward, low risk) [4].

(2) Compatibility "is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." An innovation can be compatible/incompatible sociocultural values and beliefs, previous adoptions and ideas, or client needs for the innovation [4].

(3) Complexity is defined as "the degree to which an innovation is perceived as relatively difficult to understand and use." Subdimensions could be the simplicity of understanding and using the innovation as well as availability of support [4] .

(4) Trialability is defined as "the degree to which an innovation may be experimented with on a limited basis" [4]. Trialability should refer to the physical dimension, the interface dimension, and the informational dimension [13].

(5) Observability is defined as "the degree to which the results of an innovation are visible to others". This relates to the tangible aspect as well as the informational aspect of an innovation [4].

To sum up, three determinants of adoption were discussed: environmental context, characteristics of adopters and attributes of the innovation. Figure 1 depicts the three determinants discussed in this chapter, their interrelatedness and their underlying variables:

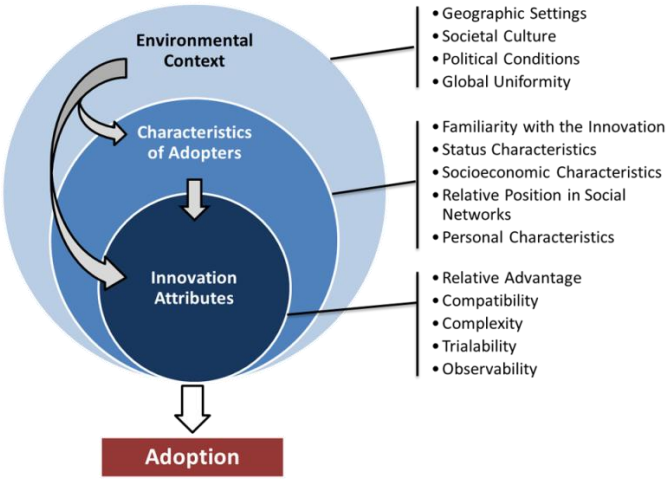

Figure 1: Determinants of Adoption and their Underlying Variables

3 METHODOLOGY

The proposed analysis framework is based on theoretical assumptions raising the following questions:

- What are specific adoption determinants for E-carsharing?
- How relevant are adoption variables proposed by literature and are there different variables not mentioned in literature?
- Are there differences in stakeholders' perspectives?
- What are opportunities and challenges for the diffusion?

The case study, defined as "an empirical enquiry that investigates a contemporary phenomenon within its real-life context" [14], is particularly suited for the questions raised in this work and was chosen as appropriate research strategy.

To conduct the research, multiple stakeholders with different perspectives on E-carsharing are approached. Because this innovation is only currently emerging, stakeholders of conventional carsharing and/or electromobility are also interviewed as they are likely to be future stakeholders of E-carsharing.

In order to offer a broader perspective, companies, experts and customers are interviewed as depicted in figure 2:

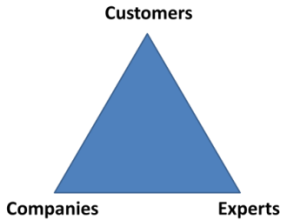

Figure 2: Stakeholder Triangle

This triangulation implicates the fact of viewing something from different perspectives, just like in trigonometry where an exact location of a point can be found if it is viewed from two other known positions [15].

This study relies on 34 interviews in total, conducted in Germany, Netherlands, UK, France, Switzerland, Austria and USA, thereof: ten interviews with carsharing-providers of which six have experience with BEVs (thereof four CEOs and 6 executives) three interviews with manufacturers of BEVs (one CEO, two strategy executives), nine interviews with customers of electromobility and carsharing, and twelve interviews with other stakeholders from governments, suppliers, infrastructure providers, universities or industry-experts (professors or executive level employees).

4 SUCCESS FACTORS FOR CARSHARING WITH ELECTRIC VEHICLES

4.1 Adoption Determinants

Environmental Context

For the adoption of E-Carsharing the environmental context plays a crucial role and first ***geographical settings*** are examined.

Adoption depends on where adopters live because mostly this is the starting- or end-point of a carsharing trip. Therefore, stakeholders agree that **population density** is critical. To what extent **absolute population** matters is perceived differently as free-floating services are limited to major cities, whereas station-based offers also occur in areas with smaller populations. Additionally, it is relevant where people go. The **main movements within an area** have to encompass a range of journey purposes, utilising vehicles throughout the day by a variety of users and e.g. not only for commuting. Consequently, adoption happens in areas with a mixture of uses and is predetermined to urban areas.

The idea of carsharing entails not relying on private cars anymore. To do so reliably and cost-effectively, mobility needs are met by using multiple modes of transportation. The availability of multimodality is consequently vital for adoption and more specifically this includes the **quality of public transportation**, **cycling infrastructure**, and **walkablity** of an area. The latter two imply that **topography** plays a certain role.

This means, where private cars are not used often enough, carsharing works. A factor that might obstruct private car-usage is **expensive or limited parking**. This is true for station-based and for free-floating systems. A station offers free and guaranteed parking which is a main advantage. For free-floating systems this might even have adverse effects if providers do not solve this problem by acquiring parking licenses/spaces for their fleet. The spatial nature of a city influences the necessity of a car, so a low **average vehicle travel distance** is in favour of adoption. For example, this applies in Portland, Oregon (USA) where carsharing flourishes with the lowest mileage travelled per vehicle in the United States. The same is true for high **traffic density** as people are more willing to give up their own car due to congestion or in **tourism** regions where potential adopters come by train/airplane and cannot use their private car to travel locally.

Furthermore, for E-carsharing access to a **charging infrastructure** is important. Depending on range and usage, cars might not be charged daily but the better the infrastructure, the more adopters trust the system and the easier the logistics behind the charging-process becomes for providers. This goes in hand with **climate conditions** as too cold winters and too hot summers influence performance and range of BEVs noticeably.

Second, ***societal culture*** is examined. Interviewees disagreed about how relevant culture is for the adoption of E-carsharing, but most agreed it is at least semi-important, particularly for communication.

It was identified that ownership/sharing is perceived differently. For example, in Swiss culture carsharing is perceived as favourable since "sharing" is quite common, e.g. people share washing machines with their neighbours. Therefore, the **status of ownership** and **collectivism** play a role in the adoption of E-carsharing. In addition, the specific **status of cars** as well as **status of public transportation** influence adoption. **Ecological awareness** also motivates people to give up their cars as well as **openness** and **liberalism**. However, it must be noted that the "sharing" aspect differs between offers. Modern providers rather argue with flexible car use to stress the advantage of having a car without having to own it and also, without the sacrifice that comes with sharing.

Depending on the provider, sometimes also premium vehicles are used in carsharing. The **status of premium cars** differs between locations and providers must consider this. Furthermore, **economic development** is influential. For example, in certain low-income areas of Berlin premium cars are prone to vandalism and in developing countries publicly available cars might be stolen for parts.

Not specific to E-carsharing but for innovations in general is the perception of chances/risks and so the degree to which **uncertainty avoidance** matters.

Third, there is strong consensus among stakeholders that ***political conditions*** are influential for the adoption of E-carsharing.

Regulations can help or prevent adoption, depending on cooperation. It is important for adoption that **private car-ownership is disincentivised** and E-carsharing receives either **non-financial incentives** (e.g. preferred parking, bus lane usage) or **financial incentives** (e.g. tax incentives, free charging). General **policies** such as requiring that housing projects must provide parking for carsharing are also influential. At the moment, the use of BEVs in carsharing is not profitable without subsidies, and governments are eager to support E-carsharing to lower emissions and create jobs.

Furthermore, **standardisation of technological solutions** (e.g. for charging) and **promotion efforts** (e.g. government as anchor adopter of E-carsharing such as in Karlsruhe, Germany) support adoption. However, politics is perceived as reactionary to societal trends rather than being proactive.

Fourth, ***global uniformity*** is explored. Here, mainly global trends were identified as factors for the adoption of E-carsharing:

1. **Oil price**, rising prices make private car-ownership unattractive
2. **Change of preferences**, ownership becomes less important, leading to collaborative consumption and different status symbols
3. **Sustainability**, drives BEVs and the idea to replace cars
4. **Urbanisation**, people move to cities which benefits the carsharing concept
5. **Connectivity**, the diffusion of smartphones allows for mobility services such as E-carsharing
6. **Convenience**, hassle-free services are increasingly preferred over products with ownership-duties
7. **Individualisation**, people differentiate themselves through innovations and boost their image through BEVs and the possibility to draw on a variety of cars
8. **Increased travelling**, supporting the effectiveness of a global mobility service rather than relying on a relatively immobile private car

Adopter Characteristics

Adopter characteristics determine adoption and the literature proposes that ***familiarity with the innovation*** is influential. In the case of E-carsharing however, adopters are usually unfamiliar with the innovation but they quickly understand the innovation because they were partly **familiar with the technology used** (apps, internet) and their adoption decision is based on a word-of-mouth recommendation, because they are **familiar with other users**. This lowered their initial insecurity and consequently this was followed by an individual consideration if the concept pays.

Another proposition in the literature is ***status characteristics*** of adopters. However, it is not possible to determine an actor's ***relative position within a network*** in this research. In general, companies perceive the status of adopters as **high**.

Moreover, ***socioeconomic characteristics*** determine adoption. The age of an adopter is young on average, but exceptions prove the rule. Consequently, no impact of age on adoption is found. **High education** appears crucial for whether people adopt E-carsharing. The **income is mixed**, but above average, possibly related to education. The interviewees were not in agreement about whether gender is influential for adoption. Some stated that typically men adopt whereas others say the opposite. Additionally, an adopter must have a **driving license** and the **size of the family** plays a role with one child being the likely limit.

When it comes to ***personal characteristics*** of adopters, they are mostly described as **technology affine**, **networked**, **communicative**, **open**, **ecologically aware**, **risk taking**, **confident**, **independent**, and **rational** as most adopters are driven by economic reasons. Since carsharing is its modern realisation is in a relatively new stage, this reflects on early adopters and it must be observed how these adopter characteristics change over time.

Innovation Attributes

The ***relative advantage*** of E-carsharing mostly refers to the comparison with private car-ownership but for some adopters the comparison is to not having access to cars at all. For them, the possibility of **accessing cars for transportation** is beneficial. Overall, the **saving of money** (e.g. fixed costs, maintenance, gas, and parking fees) appears as the primary motivation, followed by **comfort** and **convenience** of the offer that **saves time** (in comparison with public transport or through guaranteed parking spaces). Additionally, there are **no ownership duties** and E-carsharing can be used **flexible**, **spontaneous**, and **independent** from others. A further advantage is the possibility of access to a **variety of cars**. The powertrain of the car plays only a little role. BEVs only enhance the **image** of the offer which is perceived as sustainable and innovative as well as they might help to **benefit from regulatory advantages** (e.g. use of bus lanes). **Ecological advantages** play a secondary role for most people.

When it comes to ***compatibility*** to sociocultural values and beliefs, it was found that **cars have to be reliable**, **modern**, **fun**, **well-equipped**, and from a good **brand**. Furthermore, BEVs must be truly "green" and charged with **renewable energies**. Adopters expect **no commitment** (no base fees) and **the possibility to plan**/reserve a car in advance as well as **spontaneity** and **flexibility**. Furthermore, it is appreciated that E-carsharing creates social links/a **community** (e.g. by the integration of ridesharing, online-communities).

Compatibility with previous adoptions and ideas is manifested in the following positions. First, E-carsharing **cannot be worse in performance/comfort than conventional carsharing**. Adopters do not accept compromises due to BEVs and expect the same functionality (trunk space, 4 seats) and performance (power, winter-performance). Furthermore, **multimodal integration** must allow an easy transition between modes e.g. into public transport, bike-sharing, or car-rental. Ideally, the service shows alternatives and respective time, cost and ecological effects. Another point is the compatibility with **phones** (e.g. for booking-app or personalisation through integration in car-entertainment/navigation) and existing **payment methods** as adopters do not want to change their habits.

Compatibility of E-carsharing with client needs for the innovation is mainly assured through **availability**. Cars should be within 300-500m walking-distance. This is crucial for the offering, one company reacts to this by giving a mobility guarantee and in case a reservation is cancelled, mobility is guaranteed by taxi/public transport. Interestingly, this never happened but gives the adopter a feeling of safety. Having a premium 100% availability service for emergencies is a further option. Similarly, **reliability of service and technology** are necessities. This means adopters expect a **car always to be charged** at least 60-70% to overcome range anxiety as well as reliable **information about range**. As with multimodality, adopters do not accept their mobility to be limited and expect

bigger operating areas that include airports and suburban areas and **attractive pricing for longer-term use-cases** (e.g. daily/frequent-user rates). For many customers the purpose of car-usage only starts beyond these limits. The offer should also be available in as **many cities** as possible to rely on it globally. The range of BEVs is perceived as sufficient for carsharing but can also be a limitation for some trips for which reason a **mix of conventional-carsharing and E-carsharing** is preferred. Further, for free-floating concepts some **reserved parking spaces** in dense areas and **information on parking** and **free-of-charge search for parking-spaces** are expected. However, this does not mean that free-floating is in disadvantage, as **no fixed stations** allowing for **one-way trips** are expected as well. Adopters rather want the best of both worlds, being flexible and allowed to go wherever needed whilst not worrying about parking. Finally, adopters expect **cleanliness** and good **support quality**.

Low ***complexity*** is strongly valued by adopters. Primarily this concerns the **ease of use**, including **simple handling** and **simple charging** (e.g. inductive). One company provides free **training** for BEVs, e.g. how to charge the car, alternatively also training on different car types is perceived useful. Additionally, **transparency about price structure, limits of the operating area, parking, liability in case of damage, and range** are expected. The offering has the image of being complicated and there is little knowledge about it. Information and **transparent communication** could help to change this. Lastly, **registration** processes are complex and signing-up has to be easy, e.g. one company allows for registration at train stations or post offices through cooperation.

Trialability is relevant for new technology as people are **curious about BEVs** and E-carsharing is a way to test them. In general, people appreciate the opportunity to **test many different cars** but so far **registration cost** is a hurdle to try the offer. Some companies offer **trials** and **introduction sessions** where the concept is explained and test drives are possible.

As the innovation is barely available yet, ***observability*** plays an important role. Potential adopters are afraid of the new technology, have range anxiety, and uncertainty must be overcome. One company approaches this by having **on-street charging-stations** only and none in garages and they put their **stations where visibility is guaranteed**. This is a promising way as **subtle appearance** (inconspicuous stickers on cars) is highly valued. Stakeholders agree that the biggest hurdle for the adoption of E-carsharing is little **awareness** and **understanding of the concept**. Being observable is crucial and adopters should want to be observable and not feel ashamed.

To sum up, adoption of E-carsharing depends on a vast variety of factors. Moreover, they are often not simply positively/negatively correlated to adoption. For example, quality of public transportation must be good so that people give up their private car, use public transportation, and complement it with E-carsharing. If the service is too good however, people can solely rely on it as E-carsharing profits from filling gaps in public transportation systems. The same is true for many other factors such as population density, income etc.

Furthermore, from this research a quantitative ranking of success factors cannot be derived. However, it appeared that some factors were more often mentioned and more stressed by interviewees, this "top 6" includes:

- Absolute population of a city
- Existing charging infrastructure
- Quality of public transportation
- Education level of potential customers
- (Regulatory) possibility to park on-street
- Availability of the vehicles

Most of the identified factors also apply to conventional carsharing. Electric vehicle specific factors (e.g. charging) supplement these findings and make it generally applicable to conventional and E-carsharing.

4.2 Relevance of Adoption Variables Proposed by Literature

As chapter 5.4.1 reveals, all adoption variables proposed by the literature appear relevant. Only status characteristics of adopters could not clearly be determined in this research.

Moreover, adopters' characteristics match Rogers' generalisations of an early adopter [4] almost completely when it comes to socioeconomics and personality values and there are also parallels in communication.

In addition to the proposed determinants, **available technology** influences adoption. Potential adopters might have certain expectations that influence their decision about whether to adopt. These expectations do not necessarily fit technological reality. For example, absolute transparency about parking or range are limited through available technology.

Moreover, **competition** influences the adoption of E-carsharing. First, on an innovation level, there are alternatives for similar mobility needs as covered by E-carsharing. The availability and price of alternatives influence the adoption of E-carsharing as it might not have a relative advantage over existing solutions. Second, on an individual company level, existing competition might help to diffuse the innovation as communication of E-carsharing is critical and efforts are shared and multiplied with competition. The same is true when it comes to lobbying.

4.3 Different Perspectives of Stakeholders

Overall, on most topics there is broad agreement. However, there are differences in perception between station-based and free-floating offers. As discussed, for customers the provision of a guaranteed parking space through station-based offers is a main advantage whereas spontaneity and flexibility are valued as well. This goes in hand with the conflicting need to have the possibility to plan but the wish for freedom of not having to plan necessarily. It was found that the consolidation of both views might resolve this conflict in the future as some free-floating companies already react by providing reserved parking spaces as well as some station-based companies allow for flexible one-way drives through cooperation with car-rentals.

Furthermore, there are different opinions about whether these two concepts are competitors or even complementary to each other. Free-floating is too new and a definite answer is not clear yet.

There are also contradictory statements between stakeholders when it comes to factors that are not clearly positively/negatively correlated to adoption, e.g. most companies and experts say that good public transportation is needed whereas customers say E-carsharing is beneficial when public transportation is bad, e.g. at night or in badly serviced areas.

Another conflicting view is about the limits of the offer. Customers expect a more comprehensive service and not only a niche product covering a small percentage of their mobility needs. Multimodal integration is neglected by most companies and very important for adopters. Most of the stakeholders agree that current pricing makes the concept unattractive for many use-cases. Here, companies create themselves a niche in which they

would not necessarily have to be in. Some companies have already realised that and start to react (e.g. cooperation with car-rentals or public transportation, attractive longer-term pricing) whereas others even say that price is not important. This shows that there is limited understanding of adopters, who are mainly cost-driven and for many of them car-usage only starts to make sense where current carsharing-offers end.

Additionally, experts think sustainability is a main driver for adoption, but it seems that sustainability only matters as a secondary factor once everything else is fulfilled. No customers mentioned sustainability as primary motive, only as a side-benefit.

Finally, experts also conflict with companies when it comes to the influence of politics. Some experts warn that cities might perceive E-carsharing as a threat and substitute to public transportation. Politicians themselves did not mention such considerations, and companies argue that public opinion will decide whether politics is supportive or not. Certainly however, regulations will play a key role for the diffusion of this innovation, either positive or negative.

4.4 Challenges and Opportunities

The application of the analysis-framework to E-carsharing revealed relevant success factors. However, these success factors are very holistic and must be specified for different markets, customer groups and companies. Consequently, the depicted variables are not a "recipe" to follow; they rather give a broad overview of what could be relevant for the diffusion of the innovation in general.

However, stakeholders foresee challenges, of which most are also faced by conventional carsharing. With E-carsharing there are even more challenges but also new opportunities. Both are balanced against each other in the following paragraphs.

Challenges

First, stakeholders agree that the business model of E-carsharing is similar to conventional carsharing. Success factors show that customer expectations are very high and it matters little if BEVs are used or not. So far, E-carsharing providers experience curious customers that try out BEVs once, followed by a reduction of carsharing usage by more than 50% compared to conventional vehicles. Ecological advantages are welcome but secondary. Previously, the same experience was made with natural-gas vehicles.

Two reasons were identified. First, current offers ask customers to sacrifice convenience or even charge a price-premium. Second, people are afraid of new technology and are not provided with enough information and training (e.g. on charging).

The reasons why providers lower their standards are multifarious. Range is approved to be sufficient for carsharing usage; however, charging needs to be performed more often than refuelling and takes many hours. Additionally, to encounter range anxiety cars should be relatively fully charged for every customer (60-70%, see chapter 4.1). Charging time limits availability and flexibility as well as bigger fleets are necessary to ensure availability. To overcome this, expensive fleet management actions are necessary, e.g. cars have to be manually picked up and transferred to charging stations or, alternatively, customers must be heavily incentivised to encourage them to drive to charging stations on their own [applicable for free-floating carsharing only]. This increases costs and so do the potential need for a charging infrastructure, acquisition cost for vehicles, and depreciation due to uncertainties about the battery-life.

Providers face the need for parking spaces with charging infrastructure, ideally not in garages to ensure observability. Therefore, a pure free-floating concept with BEVs will be impossible with current technological conditions. Data shows however, that the trend goes to a mix of free-floating and station-based concepts anyway. Disadvantageously, once decisions about locations for stations are made, it is expensive to move them with the charging-infrastructure.

Customers also face a charging-process that is "different" from refuelling and it is advisable to provide training. Further, no large variety of BEVs is available and they are mostly unattractive.

Opportunities

BEVs might have lower variable costs; however, this does not make up for high acquisition costs. However, E-carsharing gives a possibility to try out BEVs and helps to take fear from people and create transparency. The sustainability factor of E-carsharing facilitates marketing, provides a very good image, and makes adopters "feel good" by letting them tangibly participate in change. This is important for customers and moreover, politics. Many studies show the economic, ecologic and social benefits of carsharing and electric mobility; therefore, it is sensible for governments to support the diffusion of this innovation. In many countries BEVs and E-carsharing receive incentives which could benefit providers and customers equally.

Additionally, it can be seen as opportunity that governments and companies around the world push the technological advancement in electromobility. This will lead to better products and lower prices in the future.

5 PRESCRIPTIONS FOR THE SUCCESSFUL DIFFUSION OF CARSHARING WITH ELECTRIC VEHICLES

It is suggested to overcome the two main challenges of cost-induced sacrifices in convenience and technology-fear by business model design and marketing.

To cope with competitive forces, Porter suggests focusing on three potentially successful strategies of cost leadership, differentiation, or focus as indicated in figure 3:

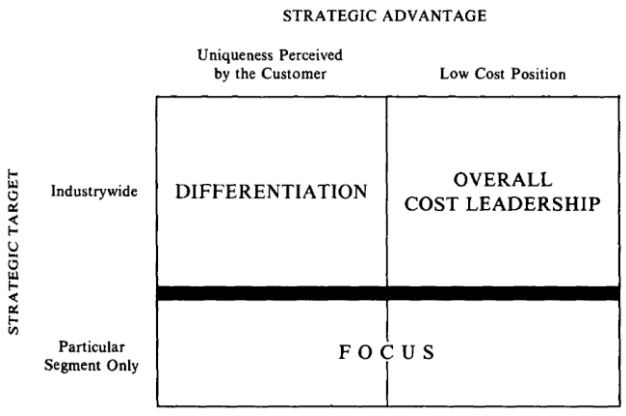

Figure 3: Porter's Generic Strategies [16]

For E-carsharing it seems (currently) impossible to be cost leader or to act industry-wide. Consequently, a focus-strategy which achieves differentiation by being perceived unique by particular segments is proposed. The success factors identified in this research help to achieve this. Focus is created through the consideration of the environmental context and adopter characteristics which influence the determination of target

markets and customers. Differentiation is mainly aided by success factors stemming from the innovation attribute dimension.

Rather than asking customers to lower their expectations, customers need incentives – especially as there will always be some sacrifices due to disadvantages customers will face with the immaturity of BEVs compared to conventional vehicles. To (over-) compensate for this, the offer has to be made as attractive as possible for potential adopters. This will increase costs in addition to the already mentioned high costs but the following strategy might lead to self-sustaining success. Within the rate of adoption, there is a point at which an innovation reaches critical mass as the steepness of the grey S-curve in figure 4 reveals.

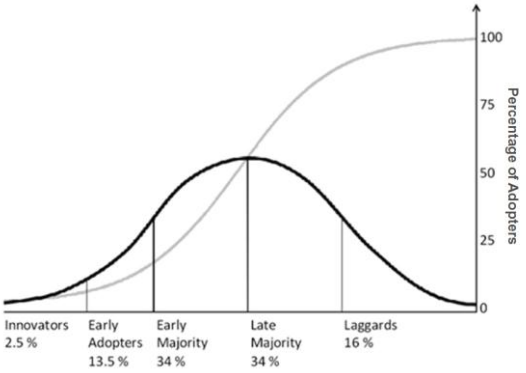

Figure 4: The Diffusion of Innovations. The number of adopters depicted in a frequency histogram follows a bell-shaped Gaussian-curve (black). When cumulating this, the number of adopters over time (the rate of adoption) follows an S-curve (grey). Based on [4].

At this point, enough individuals adopt an innovation so that continued adoption is self-sustaining. One way to achieve this is to create a unique desire for the innovation and moreover, special benefits for early adopters which go in hand with the focused and differentiated strategy that is proposed. Again, success factors aid this design of adopter-friendly business models.

Once this critical mass is reached the spiral might continue as politics follows societal-trends and might create more attractive regulatory conditions. If governments do not set appropriate framework conditions for this innovation, which is part of a local transportation networks, the described "circulus virtuosis" might turn into a "circulus vitiosus" – a vicious circle of high costs and complex processes. Fulfilling these prerequisites however, will lead to lower costs and scale-effects whilst also technology-costs will decrease. Consequently, the mass market can be targeted and E-carsharing becomes widely adopted, lucrative and successful. Only then the concept can unfold its multifarious economical, ecological and social benefits to society (see also [1]).

Efforts in creating adopter-friendly business models to enter this "spiral-of-success" must be supported by marketing, especially as people are afraid of new technology and have little knowledge/awareness about it and the carsharing-concept. Moore suggests focusing on one adopter-group at a time, using each group as a base for marketing for the next group. Consequently, innovators and early adopters must be targeted first because they have very different characteristics from the mainstream market. This is the gap or chasm that innovations must cross to reach the lucrative mainstream market. Innovations that cannot cross this "chasm" will die or remain niche and there are several strategies to avoid this [17]. In later works, Moore also explains how to capitalise on profit-rich niches in order to reach mainstream markets beyond the chasm [18].

In practice, each carsharing provider must follow these prescriptions individually and align these guidelines with its specific strategy, market environment, and customer expectations. A provider that promises premium comfort will act different from a provider that gives a 100% mobility guarantee in order to define its own unique selling point. This individual alignment and interpretation of the findings of this research are essential, as no general all-purpose-fit guideline for success can be derived. This purpose of this paper is rather to raise awareness on what to focus more than how to solve the challenge to support the diffusion of (E-)carsharing.

6 CONCLUSION

Stakeholders agree that carsharing and E-carsharing have a long-term future, and it might be a solution for future mobility. E-carsharing is likely to benefit from global trends such as climate change and the change of status symbols. There are proven benefits for regions which will have to support the introduction of E-carsharing [1] but its diffusion also depends on companies which should design adopter-friendly business models.

The findings and recommendations of this research can assists with the diffusion by identifying success factors from which adopter-friendly business models and framework conditions can be derived. However, the identified success factors are very holistic and must be specified for different markets, customer groups and companies and are not a "recipe" to follow but rather give a broad overview of what could be relevant for the diffusion of the innovation in general. Some factors appeared as very relevant and were more often mentioned and more stressed by interviewees, this "top 6" includes:

- Absolute population of a city
- Existing charging infrastructure
- Quality of public transportation
- Education level of potential customers
- (Regulatory) possibility to park on-street
- Availability of the vehicles

Additionally, the case study revealed that, even though market research was mostly conducted, adoption determinants are not specifically considered as success factors for E-carsharing and offers do not always meet customers' expectations. Furthermore, since E-carsharing has not been profitable under the conditions it has been tried to-date, it is advisable to choose target markets very carefully based again on the identified success factors for the environment and the adopter him/herself. However, without local support from other stakeholders, particularly politics, risks are very high because E-carsharing entails much novelty (technology & concept) that usually decreases its rate of adoption [9] and it currently faces high costs.

This work proposes to face these challenges by focusing on specific markets and by satisfying adopter's needs in a unique way [16], supported by adopter-group specific marketing [17]. This focused and differentiated strategy is needed since a broad market scope and cost-leadership are currently not achievable. The identification of success factors determining the adoption of carsharing with electric vehicles supports the design of adopter-friendly business models to execute this strategy. This might help to reach a critical mass of adopters from which point further adoption is self-sustaining [4]. Politics should follow the trend and increase support as they act as key enabler for this spiral-of-success. These factors combined with decreasing costs of technology and scale-effects enable E-carsharing to diffuse further into the mass market and become economically

successful. Only then this innovation can unfold its multifarious economical, ecological and social benefits for our societies. To achieve this, it is critical that companies and governments work together to create adopter-friendly business models and supporting framework conditions respectively.

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