Using, Sharing, and Owning Smart Cars
A Future Scenario Analysis Taking General Socio-Technical Trends into Account

Christina Pakusch, Paul Bossauer, Markus Shakoor and Gunnar Stevens
Department of Management Sciences, Bonn-Rhein-Sieg University, Sankt Augustin, Germany

Keywords: Megatrends, Foresight, Scenario, Trend Analysis, Shareconomy, Ownership, Usership, Digitalization, Self-Driving Cars, Mobility as a Service.

Abstract: The megatrends towards both a digital and a usership economy have changed entire markets in the past and will continue to do so over the next decades. In this work, we outline what this change means for possible futures of the mobility sector, taking the combination of trends in both economies into account. Using a systematic, scenario-based trend analysis, we draft four general future scenarios and adapt the two most relevant scenarios to the automotive sector. Our findings show that combing the trends from both economies provides new insights that have often been neglected in literature because of an isolated view on digital technology only. However, service concepts such as self-driving car sharing or self-driving taxis have a great impact at various levels including microeconomic (e.g., service and product design, business models) and macroeconomic (e.g., with regard to ecological, economical, and social impacts). We give a brief outline of these issues and show which business models could be successful in the most likely future scenarios, before we frame strategic implications for today's automobile manufacturers.

1 INTRODUCTION

What are possible futures of car mobility in Europe 2030-50 and what are the implications at the consumer, business, and societal levels?

In various respects, modern Western societies are mobile societies characterized by highly individualized lifestyles. This mobility is facilitated by transport systems and mobility, with the car as the main means of transport. However, the picture is changing as monomodal, private-car based mobility neither meets the challenges of today`s mobility complexity nor satisfies the needs of individualized lifestyles and the demands of sustainable societies. In contrast, multi-optional offers where users can combine appropriate mobility forms that suit their respective situations seem to be better suited. Computer-based and app-based travel information systems make it easier to plan and perform these multimodal trips. First signs are already visible; in car-focused nations such as Germany the importance of public transport and non-motorized transport slightly increased in recent years (Lenz et al. 2010).

New mobility concepts such as fully autonomous driving are appearing on the horizon. Self-driving cars, in particular, do not present just an incremental innovation in safety and fuel-efficiency. They present a completely new mode of transportation that has the potential of a disruptive innovation (Milakis et al. 2015). They enable completely new mobility services, which affects the choice and use of available transportation options.

The research field of self-driving is fairly new. Most of the work focusses on technological, legal, political, and ethical issues. Only a few papers investigate the design of mobility services and usership models and their impact on everyday mobility (cf. Section 2). This blind spot is partly caused by the fact that automated driving is currently not yet reality and its effects are not yet empirically observable. Investigations into a self-driving-based mobility are therefore, to some extent, uncertain and speculative. However, to actively shape the future, we have to envision possible effects of this trend. Mobility researchers, traffic planners, and business men should take the opportunity to re-think mobility from scratch and develop urban concepts and business models that go beyond switching from private traditional cars to private autonomous cars.

We study possible future development paths by using scenario-based analysis. Supplementing exist-

Pakusch, C., Bossauer, P., Shakoor, M. and Stevens, G.
Using, Sharing, and Owning Smart Cars - A Future Scenario Analysis Taking General Socio-Technical Trends into Account.
DOI: 10.5220/0005960900190030
In *Proceedings of the 13th International Joint Conference on e-Business and Telecommunications (ICETE 2016) - Volume 2: ICE-B*, pages 19-30
ISBN: 978-989-758-196-0

ing scenario studies (Epprecht et al. 2014; e.g. Litman 2014; Milakis et al. 2015), we take a closer look at the general social megatrends of digitalization and usership rather than ownership. We outline how these two megatrends affect the future of car mobility. In particular, we believe that combining both trends constitutes the disruptive quality that impacts the consumer, business, and social levels. Although our analysis shows that it is a megatrend, usership is unlikely to become the dominant consumption mode. Business models and policy instruments should therefore be designed for the situation that owning and using smart cars will co-exist for a long period.

2 RELATED STUDIES

In the last years, the smart car research field has witnessed a boost in work covering topics such as driver assistance systems, connected cars or autonomous, self-driving, or driverless vehicles. Several studies have focused on particular technological issues while others pinpoint to ethical issues and the user acceptance of self-driving cars. Based on these insights, some studies looking at the future have been published recently. They draft scenarios that show how automated vehicles might change future mobility; work that we continue here.

One cluster of future studies focusses on policy instruments and their impact on the penetration rate and speed of adoption. For instance, Milakis et al. (2015) discuss different development paths in the Netherlands with regard to the speed at which automated vehicles are accepted. They assume that technological development and policy directions are the most relevant driving forces. In their scenario, fully automated cars are most likely to be launched between 2025 and 2045, penetrating the market rapidly after their introduction. Litman (2014) also factors policy instruments into his discussion of various paths with regard to market penetration and diffusion of other technological innovations. For his most realistic scenario, he concludes that it will take 10-30 years from market launch until the automated vehicle dominates car sales. In a similar vein, Nieuwenhuijsen (2015) outlines a simulation model that also considers policy instruments such as knowledge sharing, collaborative projects, and public and private technology funding. His model shows that these instruments lead to faster technological progress and hence to a faster market penetration. Yun et al. (2014) ascertain that decreasing governmental regulation and an increasing business model level will facilitate market growth. Their findings are based on a simulation that shows how different technology paths and business models impact the market development of automated vehicles under varying circumstances.

A second cluster of studies focusses on human factors and their impact on business strategies. For instance, Bartl (2015) shows that strategic planning should consider vehicle design and ownership as relevant dimensions that shape car futures. The first dimension ranges from conventional to reinvented design, depending on the level of automation. The second dimension is characterized by two poles: owning versus sharing. Similarly, Epprecht et al. (2014) use expert interviews to identify automated driving and sharing as two visionary forces in the automotive industry. Conducting a scenario analysis, they pinpoint that the user acceptance of car-sharing and usership models will be a key question in the future. In particular, they see current consumer attitudes as a vital barrier to the success of innovative technologies.

This barrier has led to a third cluster of user acceptance studies recently gaining more attention. With regard to autonomous cars in general, a recent study by (Payre et al. 2014) reveals that a large majority of the population have a positive attitude and can imagine buying and/or using them. The literature further shows that acceptance depends on several other parameters. For instance, acceptance increases when users are allowed to take control (EY 2013). Other factors are age and gender, individual personality, pre-experience with partly autonomous cars, characteristics of the innovation, the driving environment, and the manufacturer's reputation (Nordhoff 2014; Rödel et al. 2014). At the same time, other studies report that people are concerned about self-driving vehicles (Howard and Dai 2014). These concerns seems to be cultural and country dependent (Schoettle and Sivak 2014) as well as gender dependent: females seem to be more concerned than males (Schoettle and Sivak 2014).

However, most studies focus on autonomous cars in general but neglect ownership as a relevant category. In particular, the surveys do not differentiate between ownership and usership models but focus on private cars only – whether explicitly or implicitly. Only a few investigations look at self-driving mobility services, e.g., self-driving taxis, in detail (e.g.,(Burns et al. 2013; Hars 2015). Furthermore, empirical studies can only provide a snapshot of the status quo; they fail to consider the long-term process of changing norms and attitudes, changes that affect user acceptance in the long run.

In summary, the literature shows that technological development paths cannot be studied in isolation because they are shaped by various socio-technical factors. These factors include ethical and legal issues as well as economic and design issues. All in all, it is the consumer who will determine what kind of mobility will dominate, and ownership would thus appear to be a category that future mobility studies should take into account. User acceptance can be investigated in empirical studies but only for current users; researchers are unable to consider temporal changes in user attitudes. We therefore want to answer two research questions in this work:

(RQ1) What are the pre- and post-conditions of the broader socio-technical trends of digitalization and usership?
(RQ2) How do these trends impact future car mobility models?

3 METHODOLOGY

To answer our research questions we conduct a scenario analysis. This methodology is an approved instrument for identifying and structuring changes, drivers, and consequences within unknown, uncertain, and changing environments (Mahmoud et al. 2009; Ringland and Schwartz 1998). Various scenario analysis techniques exist. In this paper we adapt the scenario-axes technique (van 't Klooster and van Asselt 2006). This variant covers the four activities: scanning, monitoring, forecasting, and assessing in order to outline possible futures.

We applied these steps as follows: First, we outlined the framing question (at the beginning of this paper), which was shaped by the current car mobility discourse in research, politics, and the mass media. We reviewed general future studies and found that the two megatrends of digitalization and usership economies are often mentioned in literature (Berger 2013; Mont et al. 2014). Hence, we analyzed these megatrends in more detail by placing them into a broader context of general trends in societies without applying them to a specific industry at this point of the analysis. We then identified the pre-conditions that have driven the two trends so far, taking relevant literature into account. Post-conditions under which the trends are going to proceed were also investigated. The assumptions behind these post-conditions were subsequently evaluated with regard to their uncertainty and their impact on the trend. This evaluation process was adapted from the concept of expert assessments. To increase the evaluation's intersubjectivity, three authors independently rated the impact of the assumption. In most cases, the evaluations coincided with little deviation. When there was a higher deviation, the authors discussed their opinions and came to a consolidated conclusion. Based on the results of this evaluation, the two most critical and thus decisive driving forces were derived by selecting the most uncertain assumptions with the highest impact to the trend (van 't Klooster and van Asselt 2006), also taking into consideration other important assumptions. These critical uncertainties serve as the axes for the scenario matrix that classifies the four scenarios. By taking into consideration the assumptions made for the trends and fitting them into the context of the particular scenario, coherent scenario descriptions were developed. Finally, we evaluated the scenarios' probabilities, by using the method we applied in evaluating the post-conditions, selected the most likely scenarios, and interpreted them in terms of car mobility futures. Based on the scenarios implications for the industry were derived on a consumer, business, and social level.

4 TRENDS

4.1 Digitalization

Pre-Conditions
Digitalization describes the socio-technological trend of the *ubiquitous computing* of all areas of life in which people are part of digital ecosystems using smart objects that are mutually connected without loss of information or function (Weiser 1991).

The main driver of this trend is the exponential growth of IT-technology, which can be seen, for instance, in the doubling of the computing power every 18 months (Moore's Law), in the doubling of data transfer rates every six months (Gilder's Law) or in the value of computer networks being proportional to the square of the number of users and machines (Metcalfe's Law) (Laudon and Laudon 2012). This development is supplemented by widespread utilization, general user acceptance, and everyday usage of social web and digital services. Today it is common to have a smart phone and a Facebook account, to buy goods online, or to use location-based services such as Yelp or Foursquare. With the development towards an Internet of Things (Atzori et al. 2010), various systems are becoming increasingly integrated, with social webs, semantic webs, and sensor webs constituting dynamic, cyber-physical systems. Material goods are enriched by digital solutions and becoming cyber-physical. Embedded systems are an integral part of products and services, leading to new or expanded feature sets. These changes are the result of the progress in artificial intelligence (AI) and semantic technologies, which have allowed goods to become smarter and more autonomous.

Digitalization has already changed entire industries within the consumer market. It has led to a whole industries being rapidly transformed, with products and services completely or partly been substituted by digitized ones (Svahn and Henfridsson 2012). Examples can be found in the music industry (Huang 2005), the photography industry (Lucas and Goh 2009), and the newspaper industry (Karimi and Walter 2015).

Post-Conditions

For this trend to proceed, it is important to assume continuing **technological advancement**. Technological progress cannot be expected to stagnate. Government **investments** in and subsidization of Internet and mobile infrastructure build a base for further networking and for developing the artificial intelligence of things. In all probability, governments are going to implement **regulations** to improve Internet security and personal privacy and thereby reduce cybercrime and terrorism to a minimum. Further they will define requirements for secure information systems and clarify liability questions within autonomous systems. They will also continue to outline competition regulations and improve the funding of open standards, making connection of devices and system integration easier.

People's trust in digitalized environments will continue to grow, and they are prepared to **connect** their goods and use smart functions in many areas of their everyday life. It can be safely assumed that, as long as the data is not too sensitive, people will be ready to supply private data to benefit from the convenience these goods provide. The generation connected, or so-called **generation c** (Friedrich et al. 2011), born after 1990, has grown up or will grow up in a primarily digital world. Their familiarity with technology and reliance on mobile communications and their desire to remain in contact with large networks, either private or business ones, will change how everyone works and how they consume.

4.2 Usership

Pre-Conditions

Usership (Nieuwenhuijsen 2015) describes the socio-cultural trend of sharing or using goods on demand rather owning them (Belk 2007). In the literature, these two trends of sharing and using on demand are often described independently (Malhotra and Van Alstyne 2014; Scholl 2006). In this paper, we consider usership to cover both the using and the sharing concepts.

There are different drivers for this trend. First, in the past, ownership had a strong symbolic function, following the dictum "You are what you own" (Belk 1988). But in times of mass-consumption and rising urbanization, owing has lost its means of distinction. As a result, the attitude has shifted in recent years towards alternative forms of property and consumption (Hamari, Sjöklint, and Ukkonen 2015). Second, increasing environmental awareness is driving usership. Here, sharing resources is not tainted by an image of poverty; it now has a positive green image (Botsman and Rogers 2011; Hamari et al. 2015; Tils et al. 2015). Moreover, sustainable consumption serves as a new means of distinction (Soron 2010).

Third, the Internet is often seen as enabler for collaborative consumption services (Sundararajan 2013) as it reduces tremendously the searching and transaction cost of sharing goods and helps to reduce physical interaction. Web 2.0 created yet more forms of sharing (Belk 2014) since the sharing platforms allow suppliers to reach a broader audience and consumers to have access to a broader range of products and services at minimal costs. The trend towards usership is most evident in the case of immaterial goods such as music, films, or software, where owning has increasingly become the exception rather than the rule (Cusumano 2014).

Post-Conditions

Generally, new sharing and service concepts are well known, but they currently play a minor role in people`s everyday life. However, it can be assumed that they will become a general commodity. In particular, the young generation (generation c) is changing its consumer habits (Heinrichs and Grunenberg 2012). The general assumption is that consumer **awareness of sustainability** issues will continue to expand. This assumption is supported by an increasing consumer demand for sustainable goods and food. Further, international agreements such as the United Nations Climate Change Conference 2015 agreed to a strict set of goals limiting global warming. Hence, it is reasonable that sustainable transport modes will be widely promoted by governments in the future. A general abundance of goods and generation c, which embraces the shared economy-thought, may allow a **shift in consumer attitude** from ownership for status reasons to usership to develop. The growing population in conjunction with limited resources will inevitably result in higher **costs** for consumers. Hence there will be a need to forgo individual ownership. The question is in which categories of goods the shift will take place next.

It can further be assumed that the transaction costs of service and sharing economies will decrease because of an increasing **urbanization** (Un-habitat 2010). The higher density of people in urban will make sharing easier to realize because more potential users will be able to collaborate in sharing. Additionally, it will become necessary to share goods in some sectors with limited (mineral) resources e.g., rare earth elements used in the production, but also with limited physical resources such as housing, streets, or parking places. Under the assumption that the governments will set clear **regulations** concerning privacy issues as well as clear regulations, e.g., for liability standards, occupational safety and taxation, consumers are more likely to be more open to using and sharing, and will thus strengthen the trend. Due to their contribution to sustainability, governments will presumably promote and subsidize collaborative consumption.

4.3 Impact Evaluation

The evaluation process has already been discussed in more detail in Section 3. From the evaluation, we were able to identify five driving forces (see Table 1). Each is assumed to be critical, with either a direct or an indirect effect on how the trends continue and/or intensify.

Table 1: Evaluation of Post-Conditions.

Post-Condition		Potential Impact	Uncer-tainty	Total
Digitalization	Technology	7	2	9
	Regulations	5	4	9
	Investments	8,5	3	11,5
	Connection	8,5	6	**14,5**
	Gen-C Attitude	7	2	9
Usership	Sustainability	4,5	4,5	9
	Consumer Attitude	9,5	7,5	**17**
	Costs	7,5	1,5	9
	Urbanization	7	3	10
	Regulation	6	5	11

To assess the level of impact, we considered the post-condition of each factor and how it shapes future developments. To assess the critical uncertainties, we stated how confident we are that each particular condition will come true. By combining both indicators, we could define the critical conditions/uncertainties (Total in Table 1). For the digitalization trend, we conclude that the actual development path of the Internet of Things **connecting** cyber-physical systems (Atzori et al. 2010) is crucial and builds the first critical uncertainty. For the usership trend, we conclude that the acceptance of usership models is primarily dependent on a change in **consumers' attitudes**. Usership will only become a dominant economic model in society if ownership becomes less important for consumers.

5 SCENARIOS

Our scenario development reflects that these two trends play the most vital role in how the future will develop; *connected smart systems* and *usership attitudes* therefore build the axes of the scenario graph. The combination of these two different driving forces with their reasonable possibilities leads to the following set of four scenarios (see Figure 1).

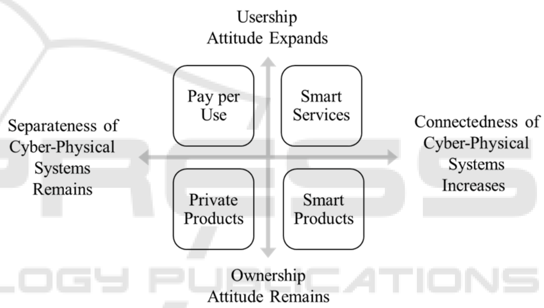

Figure 1: Scenario Matrix.

5.1 Private Products

In a private products scenario, people prefer ownership over usership for goods that are not highly digitally connected. Status symbols are still essential for individuals, even if the goods that provide this status have changed. The importance of expressing one`s individuality through those goods results from increased costs caused by a rising population in conjunction with limited resources. The growing urbanization and a slow but steadily growing awareness of sustainability needs also contribute to higher costs. At the same time, only a few of these goods are integrated, although technological progress has made a broader networking of things possible. But since the high complexity of this market does not allow the government to provide rigorous openness, security, and privacy standards and since data abuse and cybercrime occur, people are not ready to hand over personal and sensitive data.

5.2 Pay per Use

In this scenario, people have a usership attitude. They use and share things instead of buying and owning them. The attitude is supported by people recognizing and accepting the need to reduce waste and environmental pollution. This consumer behavior is also encouraged by the government: the government has set strict climate protection goals and promoted the usership economy by increasing the price of ownership, formulating minimum requirements for shared goods and services, and developing strict data protection laws. Indeed, a high connection and integration of the shared goods and services is possible from a technological point of view, but techniques reach their limits when it comes to ethical questions that a machine is not able to answer. Since people additionally have data protection concerns, society often rejects further connection such as smart services and smart goods.

5.3 Smart Products

In the smart product scenario, the vision of an Internet of Things (Atzori et al. 2010) where all things are smart and connected has become real. This scenario promises great technological progress, a platform for digital innovations, and high security and privacy standards. People set great value on sustainable assets. However, as in the private products scenario, people prefer owning rather than sharing goods, with a preference for high-tech products as status symbols. In the private domain, more and more appliances and devices are communicating and that is leading to a smart environment. In particular, smart technologies are used when they make domestic life more convenient. People are ready to trust technology within their ownership. However, they are still sceptical towards digital, connected services where personal data are collected and externally used by commercial and public service providers. Smart connections are only tolerated if they increase comfort and do not affect the power of disposition and the privacy of personal data.

5.4 Smart Services

As in the previous scenario, the technological vision of an Internet of Things has become real. But here the social vision of service and sharing economies has also become real. Consumer attitude shifts from an ownership to a usership approach. Status-based thinking has been replaced by a pragmatic approach of benefit-based thinking. Reduced power of disposition and control is tolerated if it increases quality and stability of the overall service system and is compensated by other incentives (e.g., service discounts, service upgrading, etc.). Therefore the consumer agrees to disclosing personal data if it does not just improve the provider's resource planning but has a personal benefit, too. Improved efficiency means that smart services also answer the challenges of continued resource limits and sustainability demands. Resource efficiency is not simply an option; it is a necessity for society to prosper and advance. Development is facilitated by an increased urbanization, where more potential sharers are available and sharing becomes easier and the pressure to share increases. Sharing is supported by the government applying share-focused policies e.g., investing in share-infrastructure in urban areas, taking measures to increase sharing, and imposing regulations and standards for privacy and security. These improved sharing conditions are internalized by consumers, thus strengthening their usership and sharing attitude. This change in attitude also leads to a greater desire to stay connected through networks, enabled by technology breakthroughs and government subsidies in investments in high-speed broadband networks. The high privacy standards give society greater trust in new technologies. Digital interactions and collaborations replace major parts of society's face-to-face interactions.

5.5 Scenario Evaluation

We consider the general scenarios smart products and smart services to be the most likely scenarios. Likelihoods of the scenarios were evaluated by assessing them for the two dimensions separately and multiplying them for the individual cells. This step reduces the complexity, but neglects possible interactions between both dimensions.

There are good reasons for assuming an increase in the socio-technological trend, displayed on the horizontal axis, e.g., by the connection, integration, and collaboration the value of the Internet of Things growths squared for all members (Metcalfe's Law). However, several counterforces might hinder or delay this trend. With the further connection of things, the complexity grows exponentially, too. Therefore we consider that high connectedness is more realistic (assessed with 70% probablity) than digital separateness (assessed with 30% probability).

For the vertical axis (usership attitude) both directions are conceivable. On the one hand, a future is possible where the material-oriented attitude remains because of two main reasons: first, usership does not provide the same level of comfort, reliability, or control as owning goods and second, identification with goods still matters. On the other hand, usership economies generally have better resource efficiency. This improved efficiency especially holds in the case of smart services. A complete disappearance of ownership, however, does not seem to be realistic. We therefore assessed an expansion of the usership attitude with 40% probability and the ownership attitude remaining the dominant model as being 60% probable.

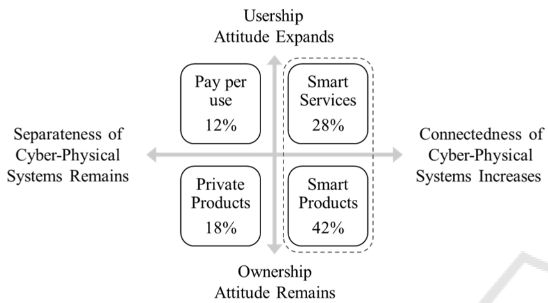

Figure 2: Scenario Matrix.

Based on these assessments, we consider the scenarios *smart products* (42%) and *smart services* (28%) to be the ones that are most likely to occur in the future. In contrast, non-digital private products (12%) and pay-per-use services (18%) will be less important in the future (see Figure 2).

6 CAR FUTURES

In this section, we apply these general consideration to the mobility sector, in particular what this means for possible car futures. We focus on the smart products and the smart services scenarios as the two scenarios with the highest probabilities. As both have similar probabilities, we also believe that the future of the car is given by a mixture of both scenarios. Hence, we also outline what a co-existence of both could look like in the future.

6.1 Smart Private Cars

In terms of mobility, the smart products scenario means that in the future private cars still play a major role in people`s individual mobility. However, future private cars are smart equipped with innovative technological features. The cars are able to maneuver automatically within cities and on highways. They support drivers and provide new driving experiences in various ways. Overall, this scenario describes **an evolutionary development path**, where smart cars are mainly characterized by additional features. The general concepts do not differ significantly from those nowadays. Still, there are subtle but important differences in detail. For better or worse, in this scenario, owners decide individually when to make use of the new smart features and when not to.

On the consumer level, needs will change and requirements will be imposed on smart cars (Litman 2014). We can distinguish between the pragmatic values and the hedonic values a (smart) car has for a consumer (Hassenzahl 2001). The business models need to satisfy the following demands of car buyers. The most important pragmatic value propositions attributed to car mobility are autonomy, independency, and flexibility (Meurer et al. 2014), all of which inherently apply in this ownership-oriented scenario. A special case is linked to those who cannot drive because of cognitive or physical constraints, such as older or disabled people. For this user group, smart cars are a promise of liberty (Litman 2014; Meurer et al. 2014). Comfort is an important reason for choosing cars as a preferred mode of transportation, too (Shove 2003). In this scenario, smart cars aim to gain a comparative advantage by increasing the perceived comfort. Many smart car features fall into this category: the highway pilot, valet parking, or traffic jam assistant (Anderson et al. 2014; Litman 2014; Maurer et al. 2015; Milakis et al. 2015).

Reduced crashes and increased safety is another advantage often mentioned in literature (Litman 2014; Milakis et al. 2015). From a consumer perspective, however, safety is less important than the subjective feeling of safety (Beggiato and Krems 2013). Cooperative concepts that delegate control to an external authority (such as Cooperative Adaptive Cruise Control) might be perceived as less secure and, as a result, be less accepted by smart car owners (Nieuwenhuijsen 2015). Drivers must be able to switch to (semi-) autonomous driving. On the one hand switching it off ensures to meet the drivers' goals of autonomy, perceived control, and perceived safety. On the other hand switching to (semi-) autonomous driving relieves of driving activities that are perceived as annoying and wasteful. In addition to reduced stress while driving (Litman 2014), the value of time (Gucwa 2014) increases and smart cars offer new work opportunities during travel.

Features such as intelligent traffic-aware routing and adaptive cruise control are a further category that improve driving efficiency (Baydere et al. 2014; EC 2011; Litman 2014; Milakis et al. 2015). Here too, such features are only accepted if they do not reduce driver autonomy; they must be perceived as a support not as a burden (Davis 1989). For instance, cooperative concepts such as routing vehicles into platoons (Bergenhem et al. 2012) must be optional. It is questionable whether a driver will use this option, thus perhaps also saving a small amount of energy, if the platoon speed is perceived as too low (or too high in the case of insecure people).

In this scenario, the hedonic value of cars having a symbolic function for their owners remains. They are a means of distinction (Bourdieu 1984), expressing an innovative attitude, a social status, or membership of a peer-group or (sub-)culture. Other common hedonic values attributed to cars and driving are fun (Rödel et al. 2014) and sensation seeking (Nordhoff 2014). Here, an incentive for owning cars is being able to tune them and steer them. Smart cars do not necessarily preclude these options. At best, they provide new opportunities for enjoyment and sensation seeking, e.g., enabling more sports driving, even for novice drivers, and providing software updates that improve the car e.g., by making it more powerful.

On the business level, car manufacturers must face up to new legal restrictions and questions of liability. For instance, they need to build up competencies in cyber-security by attracting talents from outside the traditional automotive industry (Gao et al. 2014) and clarify the issue of liability in the case of an accident (Maurer et al. 2015). In addition to traditional competitors, car manufactures have to compete with new market entrants from the IT and communication industry. In particular, safety and intelligence features will benefit from digital car-to-car and car-to-infrastructure communication. IT companies might therefore have a comparative advantage, and major shifts in the market share might occur. However, in this scenario, lock-in and network effects are smaller than those in the IT sector. In particular, there are too many individual demands and preferences for them all to be satisfied by just one brand. This implies that the private smart car market is not a “winner-takes-all” one (Buxmann and Hess 2015). New niche markets and market segments will also emerge. For instance, smart cars enter the new market segment of providing independent mobility for non- or handicapped-drivers. Cars in this segment reduce the need for motorists to chauffeur non-driving family members and friends or, for those being driven to use conventional public transit or ridesharing services (Litman 2014; Meurer et al. 2014). Another topic relates to brands and the satisfaction of the symbolic value of owning a car. Here, high-tech IT companies as well as premium car manufacturers could benefit from strategic alliances to create brand’s promises of highly innovative and appealing cars with a high comfort level, a high fun factor, and/or a high symbolic value (Maurer et al. 2015).

On the societal level, the main problems presently caused by private car traffic compound in this scenario. Since people are in need of a car, the number of personal cars is going to increase. Especially in some regional areas, the growing population and urbanization have lead to congestion, parking chaos, and increasing air pollution. The current parking problems remain and reach new dimensions. For the individual, valet parking features make parking less stressful. However, as each person wants to have a parking place nearby, parking spaces must be increasingly provided in the cities. Alternatively, to improve the availability, smart parking might be realized by driving around the block autonomously until the driver is back from a (short) stop. Automobile manufacturers have to face and address these problems by taking the rising challenges into consideration. Possible solutions can be the development of self-parking cars, finding free lots or navigating to centralized parking areas, or space-saving cars such as foldable cars (Suh et al. 2013). Car manufacturers also need to launch enhanced eco-friendly cars, either by improving propulsion technologies using renewable energy or through advanced efficiency.

However, autonomous private cars can address other problems. Driving safety is improved whenever the car takes over control during critical traffic situations. Governmental legislation might even require cars to activate driving assistance systems to ensure safe driving and that the laws are obeyed. At the same time, automobile manufacturers face new customer groups such as disabled or older people, or maybe even children. These people are now able to use their private autonomous cars independently.

6.2 Smart Car Services

In terms of mobility, the smart services scenario means that, in future, private cars play no or only a minor part in the daily routine. It shares with the previous scenario that cars are smart and able to maneuver automatically. The aim, however, is not to support drivers but to support passengers who use the new smart mobility services. Therefore the business models of automobile manufacturer will change distinctly. Car manufacturers have to go through a **revolutionary process** and realign their business models.

On the consumer level, individual pragmatic needs differ from the previous scenario only in degree. Perceived safety and perceived flexibility are still important for consumers, in particular having the freedom to go anywhere at any time. The significant difference, however, is the attitude concerning how the need is satisfied. Instead of owning a car, consumers chose the mobility service optimal for the situation (Scholl 2006). As a result, the long-term-oriented mobility decision of buying a car shifts to a short-term-oriented mobility decision and choosing mobility services in line with the situation. Therefore lock-in effects can be reduced in the use of a car so that the transport choices are more volatile. In particular, pragmatic values and hedonic values do not refer to the smart car itself anymore, referring instead to a smart service system. From the consumer perspective, the most important pragmatic service qualities are availability and reliability. In addition, the service must be easy to use without great planning (Scholl 2006) e.g., easy to book and pay for via Smartphones. For disabled and older people, the accessibility of the service system plays a crucial role, for instance, that smart cars can be used with a wheel-chair, luggage can be easily stowed, or assistance is offered – either by service staff or service roboters.

As the hedonic value of driving fun (Rödel et al. 2014) decreases in this scenario, the pragmatic demand for travel time enrichment (Gunn 2001) increases. Hence cars might be equipped as mobile offices or offer special entertainment features or opportunities for relaxation.

In this scenario, consumers become more price conscious when the smart cars rely on a pay-per-use model. For private cars these costs are much less transparent as many costs such as acquisition, repairs, and insurance are indirect. Therefore they weigh up the cost and benefits of service features with regard to the particular situation. Like today – where people usually take buses and only take taxis in exceptional situations – a consumer might accept ridesharing-like smart car services when they are significantly cheaper and only use taxi-like services as an exception. In addition to the practical cost-benefit analysis, selecting these service systems also has a symbolic significance. For instance, using ridesharing-type services expresses a green value system. However, the use of taxi-like and exclusive transport services might serve as status symbol (Scholl 2006).

On the business level, the business models aim to satisfy the outlined demands of mobility service users. Producing and selling cars to private customers will no longer be the prevailing business activity. Instead one promising business model lies in becoming a mobility supplier, offering mobility as an on-demand service. Besides the production of the cars, their prior business activity will shift towards data management and analysis to provide unconditional and convenient mobility.

Car manufacturers who act as mobility suppliers must face new competitors. Since there is no steering wheel and no driver inside the car, there is no longer a difference between self-driving taxis and self-driving car sharing. Companies aim for high occupancy rides and as few empty trips as possible. As an add-on to the general self-driving-technology, the cars are smart in terms of relocating, parking, and optimizing routes based on a customer-relationship database. Although the customers do not own these cars, the cars must satisfy the consistent user needs of being available whenever a user wants to take one and having no recognizable difference in disposability. Using big data from the customer-relationship database helps the companies to predict user demands and routes and automatically plan the operations. The cars must also provide comfort, privacy, and security. These requirements are relatively easy to cover, under the assumption that full security is technologically realizable and that the car is used by one person alone or by a group of people who know each other. Autonomous ridesharing is, of course, also possible: customers use a car service and share their ride with another – probably to them strange – customer. When the database recognizes that two customers want to take (nearly) the same route, the system could suggest sharing the vehicle and offer a discount. This special offer fulfills the economic, ecological, and social needs of those people who think "green" and are convinced sharers.

To meet the situation-dependent user demands, car manufacturers and the mobility suppliers can organize their fleets. They can provide vehicles equipped as offices, vans, convertibles, and small city cars with a different number of seats. Fleets must be large enough to guarantee availability and reliability. Additionally, they can offer different service models such as pay-per-use prices or flat rates.

Another important point of the autonomous mobility services scenario is the trend towards intermodal services that are almost hidden for the customers. Customers chose a route from one destination to another and pay for one ticket per travel. With intermodal services, the transition between the different mobility modes is almost seamless, such as taking the train for a long distance journey and then using a car for the last mile, all with the one ticket. These intermodal mobility services can be offered by individual companies, by holding organizations, or through cooperations between different mobility organizations. The trend towards mobility as a service can lead to an expansion of business models within existing companies. For example, short-range public transportation companies could widen their range of mobility services into different mobility modes and therefore offer intermodal or multimodal mobility services.

On the societal level, this scenario brings numerous changes – challenges as well as opportunities. First, traditional car manufacturers are affected as smart mobility services enable a dramatic reduction in vehicles (Spieser et al. 2014). Second, existing mobility providers, including taxis and other driving services, are threatened by innovative mobility services as they lead to a reduction in driving staff. Jobs will be lost since fully automated vehicles no longer need a driver. These challenges can already be seen in the discussion about permitting UBER (Geradin 2015). Even though other forms of employment will arise through the new business models, the redundancy of taxi drivers is unavoidable. Furthermore, automated cars on demand will raise the level of equality in the mobility sector. Disabled people, older people, and other individuals who are not able to drive independently will be more mobile (Payre et al. 2014). Additionally, personal parking spaces can be saved and open possibilities for new concepts in using urban areas. In this scenario, platooning is easy to implement since people do not insist on their own speed. This leads to additional savings in fuel and infrastructure and overall to an improved utilization of the car and the roads. So sustainability is expected to rise in terms of **economic** and **ecological sustainability**. At the same time, rebound effects can occur. If using the self-driving-service is easily affordable, reliable, and comfortable and people can even do other things during their ride, the total amount of rides could increase significantly (Litman 2014). Negative ecological and economic effects could arise when empty runnings prevail as a result of relocating and optimizing routes and parking. It is also possible that consumers will mainly use autonomous car services instead of sustainable mobility modes such as bicycles or public transport.

6.3 Co-existence of Private Cars and Services

The scenarios surely draft very extreme pictures of the future following strictly one development path – either ownership or usership. We are convinced that there will be a mixture of self-driving private cars and self-driving services. The likelihoods we defined for the different scenarios could also be interpreted as market segments. In the long run, mall different variants will appear. This mixture will cause even greater challenges since all variants must be coordinated. Independent of the challenges, we assume that there are also positive outcomes of the mixture of autonomous private cars and mobility services. Each scenario has advantages for specific cases.

The co-existence of private cars and mobility services reduces both the number of cars within urban areas and the traffic density. This improved traffic situation will lead to private cars still being used for business. Especially in the beginning of autonomous mobility services, it is important to offer the customer both scenarios. The incremental integration of mobility services means that the customers can gather experiences, which, in turn, could raise the acceptance of the mobility services. But still it is important that the customers have a choice of mobility modes. A roll-out concept for autonomous mobility services could be incrementally integrating these services within the taxi or short-range transit sector.

7 CONCLUSIONS

Smart and self-driving cars seem to be the next major leap the automotive industry is trying to achieve. Digitalization challenges the automotive industry to rethink or even change their business models to meet the customer's demands. With regard to this, other studies outline digitalization's challenges (e.g., technological, ethical, and legal) and effects (e.g., on mobility practices, safety, sustainability, and service markets). Our analysis confirms to a large extent the findings of earlier scenario analyses concerning assumed trends, pre-conditions, and possible future scenarios. In this paper, we have demonstrated that future car scenarios should not be studied in isolation but should consider general socio-technical megatrends associated with digital connected systems and innovative usership models. This general view then gives an orientation, informs decision makers, and enables them to re-evaluate the status quo of the trends by continuously checking the critical assumptions. For the digitalization trend to proceed, it is crucial that the digital connection of goods is ubiquitous, which basically depends on society's readiness. For a usership-orientated society to prevail over an ownership-oriented society, consumer attitude must shift. Depending on whether the critical conditions are realized or not, different scenarios occur, with two of them being most likely and suited to meet the needs of individualized lifestyles and the demands of sustainable societies.

With regard to the business development, we have outlined that owner- and usership-oriented smart car scenarios are most likely and can realistically co-exist in the medium to long term. Both constitute different markets with specific characteristics that business models have to consider. For the private market, our analysis shows that smart cars should not just satisfy pragmatic mobility needs but must also address hedonic and symbolic values such as freedom, driving fun, or providing a status symbol. Here the automotive industry is running along an evolutionary development path characterized by mainly technological advancements. For the service market, our analysis shows that hedonic qualities are less important. Instead the competitive position is based on the guarantee of a high service level with regard to availability, flexibility, comfort, usability, and attractive pricing. This combination leads to a revolutionary development with a major impact on traditional business models. But it is questionable if car manufacturers acknowledge theses disruptive changes. Experience shows that traditional technology companies tend to stick to their top seller and react too late (Lucas and Goh 2009).

Concerning scope and limitation, it has to be mentioned that the future scenario analysis is inherently characterized by uncertainty. Unanticipated disruptive phenomena cannot be forecasted. A maximum objectivity was aimed at, but a bias cannot be entirely excluded as conditions and probabilities have been evaluated intersubjectively by the authors. Also the results of this study are only representative for Western societies. Future research should validate the findings by using supplementing methods such as expert interviews, consumer surveys, appropriation studies or different experimental design to identify acceptance and key success factors of innovative business models for the different mobility scenarios.

REFERENCES

Anderson, J.M., Nidhi, K., Stanley, K.D., Sorensen, P., et al., 2014. *Autonomous vehicle technology: A guide for policymakers*. Rand Corporation.

Atzori, L., Iera, A., Morabito, G., 2010. The internet of things. *Computer networks*. 54, 15, 2787–805.

Bartl, M., 2015. The Future of Autonomous Driving, *THE MAKING OF INNOVATION (E Journal)*. 1–7.

Baydere, B.A., Erondu, K., Espinel, D., Jain, S., et al., 2014. *Car-Sharing Service using Autonomous Automobiles*.

Beggiato, M., Krems, J.F., 2013. The evolution of mental model, trust and acceptance of adaptive cruise control in relation to initial information, *Transportation research part F*. 18,47–57.

Belk, R., 1988. *Possessions and self*. Wiley Online Library.

Belk, R., 2007. Why not share rather than own?, *The Annals of the American Academy of Political and Social Science*. 611, 1, 126–40.

Belk, R., 2014. You are what you can access. *Journal of Business Research*. 67, 8, 1595–600.

Bergenhem, C., Shladover, S., Coelingh, E., Englund, C., et al., 2012. Overview of platooning systems. In *Proc. of the 19th ITS World Congress, Oct 22-26, Vienna, Austria (2012)*. 2012.

Berger, R., 2013. *Trend Compendium 2030*.

Botsman, R., Rogers, R., 2011. *What's mine is yours*. Collins London.

Bourdieu, P., 1984. *Distinction: A social critique of the judgement of taste*. Harvard University Press.

Burns, L.D., Jordan, W.C., Scarborough, B.A., 2013. Transforming personal mobility, *The Earth Institute*.

Buxmann, P., Hess, T., 2015. *Die Softwareindustrie: Ökonomische Prinzipien, Strategien, Perspektiven*. Springer-Verlag.

Cusumano, M.A., 2014. How traditional firms must compete in the sharing economy, *Communications of the ACM*. 58, 1, 32–4.

Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology, *MIS quarterly*. 319–40.

EC, (European Commission), 2011. WHITE PAPER roadmap to a single European transport area towards a competitive and resource efficient transport system, *COM (2011)*. 144.

Epprecht, N., von Wirth, T., Stünzi, C. and Blumer, Y.B., 2014. Anticipating transitions beyond the current mobility regimes. *Futures*. 60,30–40.

EY, (Ernst & Young), 2013. *Autonomes Fahren – die Zukunft des Pkw-Marktes?*

Friedrich, R., Peterson, M., Koster, A., 2011. The rise of Generation C, *strategy+ business*. 62,1–3.

Gao, P., Hensley, R., Zielke, A., 2014. A road map to the future for the auto industry, *McKinsey Quarterly, Oct*.

Geradin, D., 2015. Should Uber be allowed to compete in Europe? And if so how?, *And If so How*.

Gucwa, M., 2014. Mobility and energy impacts of automated cars. In *Proc. of the Automated Vehicles Symposium, San Francisco*. 2014.

Gunn, H., 2001. Spatial and temporal transferability of relationships between travel demand, trip cost and travel time, *Transportation Research Part E: Logistics and Transportation Review*. 37, 2, 163–89.

Hamari, J., Sjöklint, M., Ukkonen, A., 2015. The sharing economy: Why people participate in collaborative consumption, *Available at SSRN 2271971*.

Hars, A., 2015. Flotten selbstfahrender Elektrotaxis – Eine Szenarioanalyse. In Proff, H. (ed.) *Entscheidungen beim Übergang in die Elektromobilität*. Wiesbaden: Springer Fachmedien Wiesbaden. pp. 615–32.

Hassenzahl, M., 2001. The effect of perceived hedonic quality on product appealingness, *International Journal of Human-Computer Interaction*. 13, 4, 481–99.

Heinrichs, H., Grunenberg, H., 2012. *Sharing Economy : Auf dem Weg in eine neue Konsumkultur?*. Lüneburg.

Howard, D., Dai, D., 2014. Public Perceptions of Self-driving Cars. California 2. In *Transportation Research Board 93rd Annual Meeting*. 2014.

Huang, C.-Y., 2005. File sharing as a form of music consumption, *International Journal of Electronic Commerce*. 9, 4, 37–55.

Karimi, J., Walter, Z., 2015. Corporate Entrepreneurship, Disruptive Business Model Innovation Adoption, and Its Performance. *Long Range Planning*.

Laudon, K.C., Laudon, J.P., 2012. *Management information systems: managing the digital firm.*

Lenz, B., Nobis, C., Köhler, K., Mehlin, M., et al., 2010. *Mobilität in Deutschland 2008.*

Litman, T., 2014. *Autonomous Vehicle Implementation Predictions*.

Lucas, H.C., Goh, J.M., 2009. Disruptive technology: How Kodak missed the digital photography revolution, *The Journal of Strategic Information Systems*. 18, 1, 46–55.

Mahmoud, M., Liu, Y., Hartmann, H., Stewart, S., et al., 2009. A formal framework for scenario development in support of environmental decision-making, *Environmental Modelling & Software*. 24, 7, 798–808.

Malhotra, A., Van Alstyne, M., 2014. The dark side of the sharing economy… and how to lighten it, *Communications of the ACM*. 57, 11, 24–7.

Maurer, M., Gerdes, J.C., Lenz, B., Winner, H., 2015. *Autonomes Fahren.*. Springer-Verlag.

Meurer, J., Stein, M., Randall, D., Rohde, M., et al., 2014. Social dependency and mobile autonomy. In *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*. 2014 ACM. pp. 1923–32.

Milakis, D., Snelder, M., Van Arem, B., Van Wee, G.P., et al., 2015. *Development of automated vehicles in the Netherlands: scenarios for 2030 and 2050.*

Mont, O., Neuvonen, A., Lähteenoja, S., 2014. Sustainable lifestyles 2050. *Journal of Cleaner Production*. 63, 24–32.

Nieuwenhuijsen, J.A.H., 2015. *Diffusion of Automated Vehicles.*TU Delft, Delft University of Technology.

Nordhoff, S., 2014. *Mobility 4.0: Are Consumers Ready to Adopt Google's Self-driving Car?*

Payre, W., Cestac, J., Delhomme, P., 2014. Intention to use a fully automated car. *Transportation research part F: traffic psychology and behaviour*. 27,252–63.

Ringland, G., Schwartz, P.P., 1998. *Scenario planning: Managing for the future*. John Wiley & Sons.

Rödel, C., Stadler, S., Meschtscherjakov, A., Tscheligi, M., 2014. Towards Autonomous Cars. *Proc. of the 6th Int. Conf. on Automotive User Interfaces and Interactive Vehicular Applications*. 2014 ACM. pp. 1–8.

Schoettle, B., Sivak, M., 2014. *A survey of public opinion about autonomous and self-driving vehicles in the US, the UK, and Australia.*

Scholl, G., 2006. Exploring the symbolic meaning of usership, *Ökologisches Wirtschaften*. 21, 2.

Shove, E., 2003. *Comfort, cleanliness and convenience: The social organization of normality*. Berg Oxford.

Soron, D., 2010. Sustainability, self□identity and the sociology of consumption, *Sustainable Development*. 18, 3, 172–81.

Spieser, K., Treleaven, K., Zhang, R., Frazzoli, E., et al., 2014. Toward a systematic approach to the design and evaluation of automated mobility-on-demand systems. In *Road Vehicle Automation*. Springer. pp. 229–45.

Suh, I.-S., Hwang, K., Lee, M., Kim, J., 2013. In-wheel motor application in a 4WD electric vehicle with foldable body concept. In *Electric Machines Drives Conference (IEMDC), 2013 IEEE International*. May 2013 pp. 1235–40.

Sundararajan, A., 2013. From Zipcar to the sharing economy, *Harvard Business Review*. 1,

Svahn, F., Henfridsson, O., 2012. The dual regimes of digital innovation management. In *System Science (HICSS), 2012 45th Hawaii International Conference on*. 2012 IEEE. pp. 3347–56.

Tils, G., Rehaag, R., Glatz, A., 2015. *Carsharing–ein Beitrag zu nachhaltiger Mobilität.*

van 't Klooster, S.A., van Asselt, M.B.A., 2006. Practising the scenario-axes technique, *Futures*. 38, 1, 15–30.

Un-habitat, 2010. *State of the world's cities 2010/2011: bridging the urban divide*. Earthscan.

Weiser, M., 1991. *The Computer for the 21st Century.*

Yun, J., Yang, J., Won, D., Jeong, E., et al., 2014. The Dynamic Relationships between Technology, Business Model and Market in Autonomous Car and Intelligent Robot Industries, *System Dynamics, Delft, The Netherlands*.