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What technology enabled services impact business models in the automotive industry? An exploratory study

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ABSTRACT

The automotive industry is experiencing a phase of rapid innovation, with emergent technologies underpinning the realisation of self-driving cars, increased use of data and data analytics, sensors to enable car components to connect to the Internet-of-Things and the use of alternative energy sources, such as electric vehicles. Such innovations enable novel services, which in turn require actors within the automotive industry to change their business models. In this paper, we aim to identify novel automotive services that impact business models within the automotive industry. We use Q-methodology to explore and analyse the opinions of researchers and experts from the automotive industry. We find that four groups of services are expected to impact the business models in the automotive industry most: (1) personalised services, (2) generic mobility services; (3) shared mobility, and (4) connected cars. These are services at the level of the end-user, while more fundamental technology-based innovations, such as electrical driving, autonomous driving and Internet-of-Things applications, are scattered over different groups of end-user services. From these results, current business models can be analysed, and possible roadmaps for business model innovation can be developed.

1. Introduction

New technology paradigms and technological innovations require players within the automotive industry to rethink their business models (Gao, Kaas, Mohr, & Wee, 2016). For a long time, the automotive industry has focused on optimising production and logistics, with little attention paid to early digital services, such as navigation. However, current technological advancements have forced the automotive industry to rethink their products and services (Svahn, Mathiassen, & Lindgren, 2017). New technologies, such as autonomous driving, Internet-of-Things (hereinafter refers to IoT) and e-mobility enable novel services like mobility-on-demand, personalised driving experiences and advanced safety measures (Cohen & Kietzmann 2014; Lengton et al., 2015).

Consequently, enterprises within the automotive industry need to consider changing their business models from a product to a service-oriented model; combining products with services or refining and personalising the service offered. For instance, car manufacturers no longer only sell cars as a product but also provide ‘mobility-as-a-service’, (Mohagheghzadeh & Svahn, 2016), which entails that users subscribe to a transportation package rather than buying a car in a one-off transaction (Jittrapirom, Marchau, van der Heijden, & Meurs, 2018). The shifting focus from products to services leads to new value propositions to consumers, requires new value creation activities, new partnerships, and asks for new revenue models. ‘Value proposition’, ‘key activities’ and ‘revenue

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models' are core components of business models (Osterwalder & Pigneur, 2010). In other words, novel service offerings will require changes to existing business models in the automotive industry.

Business models describe how a company creates, delivers and captures value (Amit & Zott, 2001). While there is considerable literature regarding business models (for an overview see Wirtz, Pistoia, Ullrich, & Göttel, 2015), few conceptualisations make an explicit link between technological innovation and business models (Baden-Fuller & Haefliger, 2013; Chesbrough & Rosenbloom, 2002). We posit that services play an essential role in understanding this link: new technologies (e.g. sensors and connectivity) enable new services (e.g. self-driving cars) which in turn require new business models for their exploitation (e.g. subscription to self-driving taxis). Yet, the extent to which business models have to be revised differs greatly between different technological innovations and related services. On one extreme end of a continuum, technological innovations and services require a complete overhaul of existing business models. For instance, car manufacturers that move from selling cars to offering self-driving cars in an as-a-service model need to change their value proposition, distribution channels and revenue models. On the other extreme end of the continuum, a new service may merely require an incremental refinement of one component in the business model (e.g. a new pricing model).

The objective of this paper is to explore what types of services, enabled by disruptive, interoperable and pervasive technological innovations, will impact business models in the automotive industry most. We do so by identifying those services currently affecting business models in the automotive industry and those that will, according to experts, do so in the near future. We only focus on services related to the transportation of people. Our analysis provides an in-depth insight into what types of services impact current business models and require actors in the automotive industry to start reconsidering their business models.

We use the Q-methodology as our research methodology, an instance of a qualitative method for identifying patterns in the opinion space of experts (Brown, 1996; Van Exel & de Graaf, 2005). The method is exploratory and intended as a starting point for discussion and theory; hence it requires no ex-ante theoretical framework. Academic researchers specialising in transportation and mobility form our pool of experts, the so-called P-set, and the opinion space is confined to opinions concerning how technological transformation of the automotive industry impacts the sectors services and subsequent business models. From this, we make recommendations on what should be the focus of business model research in the automotive industry, and what meaningful types of services may be distinguished.

This paper contributes to the understanding of the possible, and alternative effects of technological innovation on business models in the automotive industry, as well as to a broader understanding of how novel technological innovations lead to innovative service concepts, their constituting business models and their relationship with the near future. First, such understanding can be used as a frame of reference for future studies on how technology disruption and service impact business models. Second, such understanding informs practical tools for designing business models (Amshoff, Dülme, Echterfeld, & Gausemeier, 2015; Eurich & Mettler, 2017; Laurischkat, Viertelhausen, & Jandt, 2016; Remané, Hanelt, Tesch, & Kolbe, 2016).

This paper first provides background on business models, technology and the automotive industry, including how service concepts affect business models. Next, it presents the methodology in more detail, followed by the results. It concludes with a discussion of the implications of the findings for current business models and potential future research based on the limitations.

2. Background

Since the 1990s, as a result of digitalisation, scholarly attention to business models has been growing (e.g. Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013). However, the business model concept is still not clearly defined, and a clear consensus regarding the elements of a business model is not available (Alt & Zimmermann, 2001; El Sawy & Pereira, 2013; George & Bock, 2011). As a concept, business models were introduced over sixty years ago by Bellman, Clark, Malcolm, Craft, and Ricciardi (1957). Yet, the concept was scarcely used in research over the following decades. After the advent and spread of the World Wide Web, business models gained the attention of both practitioners and academics. The term became relevant to diverse scientific fields ranging from strategic management (e.g. Amit & Zott, 2001; Linder & Cantrell, 2000) to information systems (e.g. Ballon, 2007; Osterwalder & Pigneur, 2010). The former focused on the implementation of strategies in business models and the latter on business models' ontologies and business model design. DaSilva and Trkman (2014) argue that the term 'business model' was used extensively concerning technology-oriented start-ups mainly because these enterprises, as newcomers, did not have a clear and realistic grasp of their economic performance in times that new digital economics were under discussion.

Definitions of business models have evolved to include numerous refinements and interpretations. Contemporary academics define business models as the core logic of how an enterprise creates value (Kallio, Tinnilä, & Tseng, 2006; Linder & Cantrell, 2000). Osterwalder and Pigneur (2002) added the concepts of value capture and delivery to their definition. Amit and Zott (2001) argued that a business model is a design that represents the elements needed to create value from new business opportunities, for both enterprises and customers. Chesbrough and Rosenbloom (2002) put forward the idea that a business model connects technical potential with economic value. Another perspective is that business models can be seen as a reflection of an enterprise's strategy (Casadesus-Masanell & Ricart, 2010; Leem, Suh, & Kim, 2004).

Following this, Wirtz et al. (2015) proposed that strategy can be seen as a guide for the creation of a business model. In another approach to the business model, scholars describe the combination of activities for generating value for an enterprise and its customers (DaSilva & Trkman, 2014; Wirtz et al., 2015). In this paper, we adopt the broadly accepted definition that a business model is a description of how value is created, delivered, and captured for an enterprise and its customers (Osterwalder & Pigneur, 2010; Teece, 2010).

2.1. Business models, technology and services

Business model innovation is defined as 'reconfiguration of activities in the existing business model of a company that is new to the product/service market in which the company competes' (Santos et al., 2009, p. 14). In contrast to traditional strategic management thinking (e.g. Porter, 2008), the notion of business model innovation suggests companies have agency over how they intend to create and capture value (Teece, 2010). Triggers and motivations for business model innovation may come from various sources, both within the company (e.g. to improve company performance) and in its environment (e.g. moves from competitors or novel technologies). In this paper, we focus on business model innovation as caused by changing technologies in the environment of companies.

The relation between technology and business model innovation has been discussed in a sub-branch of the literature. Early discussions on business models stress that technological innovation has no value in itself, only when supported by a viable business model (Chesbrough & Rosenbloom, 2002). De Reuver, Bouwman, and Maclnnes (2009) argue that new technologies necessitate enterprises to redesign their business models. Later, Baden-Fuller and Haefliger (2013) have added that business models are the link between technological innovation and firm performance. The role of technologies for business models is twofold: new technology makes new business models possible (Haaker, Bouwman, Janssen & De Reuver 2017), and innovative models might require new technologies (Clauss, 2016).

It is relevant to point out that most conceptualisations of the business model concept do not explicitly link it with technological innovation. For instance, within the most widely used business model ontology *Canvas*, the components of channels and resources may or may not contain technological innovations (Osterwalder & Pigneur, 2010). In alternative ontologies, such as *VISOR* (El Sawy & Pereira, 2013) or *STOF* (Bouwman, Faber, Fielt, Haaker, & De Reuver, 2008), technologies are an integral part of a business model.

We add here that services play an important role in understanding these linkages. Services are solutions to problems that users face, which may be enabled by technologies or other resources and competences (cf. Vargo & Lusch, 2004). Due to new innovative and transformative technologies, innovative products and services are enabled, which in turn offer new opportunities for value creation, capturing and delivery. As services are enabled by technologies, innovative technologies become valuable once they enable new service offerings. To viably offer these services, business models are needed. As such, offerings are sustained by business models, and introducing novel services may necessitate new business models. In sum, technological innovations enable new services that in turn may require changes in business models.

2.2. The automotive industry

Both digital and non-digital transformative technologies are reshaping the automotive industry, by which we mean the group of enterprises offering products and services related to the development, design, manufacture, marketing and sales of commercial vehicles. Currently, enterprises within the automotive industry are in the process of transforming their business from product to service-oriented enterprises (Dombrowski & Engel, 2014; Lengton et al., 2015; Wedeniwski, 2015). However, digital transformation brings about both opportunities and barriers to business model innovation (Wells, 2015). The shift towards mobility services is changing the industry, which has been historically structured with the car as the primary product, with car manufacturers (i.e. Original Equipment Manufacturers), suppliers and finance companies as the main actors. Currently, boundaries between actors are disappearing, and new entrants are starting to offer core mobility as well as auxiliary services based on consumer needs (Stanley & Gyimesi, 2015).

New technologies are also giving the consumer a more prominent role. Within the new automotive ecosystem, the needs of the customer are placed at the forefront. This leads to environments in which actors collaborate to develop new mobility offerings, in which possession of a car is less relevant than access to transportation means, and in which concerns about ecological impact are taken seriously.

Thanks to new technologies, various types of novel services are emerging in the automotive industry. Besides the core service of mobility, cars can be seen as providing a platform by which to communicate with other objects. New services are emerging based on an interaction between vehicles (e.g. collision-warning systems), between vehicles and road infrastructure (e.g. road information) and between vehicles and devices (e.g. smartphone integration, payment and even commerce opportunities) (Lengton et al., 2015; Papadimitratos, De La Fortelle, Evenssen, Brignolo, & Cosenza, 2009). These services provide various types of information: mobility information, infotainment, vehicle information and Internet-related services (Viereckl, Ahlemann, Koster, & Jursch, 2015).

Another way to categorise novel automotive services is based on their auxiliary offerings, for example: (a) mobility management allowing for services managing traffic flow (e.g. navigation systems), (b) vehicle management that allows for services regarding better car usage (e.g. information on vehicle contrition), (c) entertainment (e.g. access to social media), (d) safety (e.g. information regarding traffic jams), (e) autonomous driving (e.g. automated parking), (f) well-being (e.g. alerts for medical assistance), and (g) home integration (e.g. enabling devices within the house to turn on when the car is close) (Lengton et al., 2015; Papadimitratos et al., 2009).

2.3. Business models in automotive industry

Traditionally, enterprises within the automotive industry possessed similar business models that followed a structured and linear approach for delivering a tangible product (e.g. vehicle) to the end user. Car manufacturers often have their own network of car dealers, leasing companies, and financing agencies. The primary business model for car dealers has been to sell cars, which are becoming more and more customised. Additionally, car dealers offer personal leasing to consumers, trade second-hand cars, and earn additional revenues from maintenance services and replacement of car parts. Upstream suppliers to car manufacturers range from providers of computer chips and software to providers of components such as bumpers, engines and upholstery. The upstream suppliers have deeply integrated into the supply chain.

New entrants, sometimes from the transportation industry, have started to offer car sharing. Shared mobility services come in different forms such as car sharing; ride sharing; ride hailing services as alternative business models. Mobility needs are fulfilled not only based on ownership but also based on taxi-services. Many complementary technologies offer additional services ranging from navigation, via real-time traffic information, to in-car entertainment and whole fleet management programmes.

Digital technologies disrupt the existing business models within the automotive industry (Hanelt, Piccinini, Gregory, Hildebrandt, & Lutz, 2015). Piccinini, Gregory, Hanelt, and Kolbe (2015) state that there are three main challenges regarding business models within the automotive industry: (a) designing the new business models, (b) creating products or offerings of value, and (c) competing with the offerings of 'newcomers' (i.e. new participants entering the automotive industry after the technology disruption).

Related work is concerned with emerging business models for the automotive industry, focusing on disruptive technologies and new offerings. For instance, Nickerson, Remané, Hanelt, Tesch, and Kolbe (2017) created a framework for car-sharing business models, as an example of servitisation, and found that even the largest car-sharing companies follow different business models. Regarding electric cars, Kley, Lerch, & Dallinger (2011) develop a morphological box comprising a wide variety of business models concerning vehicle, battery, infrastructure and system services. Other researchers regarding electric cars propose different business models (see Budde Christensen, Wells, & Cipcigan, 2012; Laurischkat et al., 2016) and connected cars (e.g. Baker et al., 2016). Next to economic value, many of these business models focus on ecological values, re-use and leasing.

For our research, we aim to understand which new mobility and auxiliary services are impacting the automotive industry and thus their role in the revision or creation of novel business models.

3. Q-methodology

Q-methodology, also known as Q-sort or Q-technique (Petit dit Dariel, Wharrad, & Windle, 2013), is a research method that systematically focuses on human subjectivity (Brown, 1996). Human subjectivity can be explained as the way humans form and express their opinions and perspectives on a specific subject (Brown, 1993; McKeown & Thomas, 2013). The fundamental basis of the Q-methodology is that while opinions are heterogeneous, possible patterns and structures can be identified. Q-methodology is used in various disciplines such as technology innovation (Petit dit Dariel et al., 2013), information systems (Bouwman, Bejar, & Nikou, 2012) and transportation (Van Exel & de Graaf, 2005). Q-methodology follows a different approach to traditional survey research, whereby the columns represent the participants (the 'P-set') and the rows represent their opinions, behaviour or attitudes (the 'Q-sample'). Collecting these statements is a crucial task because the validity of the results depends highly on the 'representativeness' of these statements (also known as concourse) concerning the subject under study. Hence, the Q-sample should be composed of different groups of statements, to ensure that each perspective is being treated equally.

In this study, we focus on technological innovations that enable new mobility and auxiliary services which drive business model innovation. Our Q-sample comprises technology-enabled mobility services that may or may not affect business models in the automotive industry. Given the wide variety of mobility services, the Q-methodology is an appropriate approach for exploring patterns and reducing complexity in opinions. In this way, the method allows patterns to be identified that can guide our conclusions rather than evaluating each statement individually. One benefit of Q-methodology is that it identifies patterns present in a small sample of subjects. The identified patterns can be considered as common among similar people (target population).

3.1. Q-sample

An essential step in Q-methodology is selecting the statements for the Q-sample. Van Exel and de Graaf (2005) argue that a set of 40–50 statements is satisfactory. We created a Q-sample of 42 statements that is balanced and follows the shape of a normal distribution (Van Exel & de Graaf, 2005).

To select these 42 statements, we followed four steps. In the first step, we collated a significant amount of automotive-related services as discussed in academic publications (e.g. Papadimitratos et al., 2009) and commercial publications and white papers (e.g. publications from European Union, Deloitte, Accenture, IBM, FME, GSMA), as well as websites (e.g. Drive.com, techradar.com, phy.org). We explored databases extensively, comparable to the approach of a systematic literature review; however, we used more generic databases such as ProQuest and the Internet in general. The keywords for our search were combinations of 'automotive industry', 'digitalisation', 'new services', 'new applications', 'mobility', 'future mobility trends', 'mobility services', 'add-on applications', 'transportation', 'shared mobility' and 'energy'. Additional keywords were derived from the automotive service categorisations in existing literature (Lengton et al., 2015; Papadimitratos et al., 2009). This procedure resulted in a list of 150 services.

In the second step, all 150 services were presented in a logical order, based on a qualitative clustering approach as proposed by Miles and Huberman (1994). They were clustered based on the main technological innovations enabling the services. This approach resulted in the following groups of services:

(a) Autonomous driving, i.e. services related to the use of autonomous cars (or driverless cars, self-driving cars) that 'support' the car to operate independently without the need for human input.
(b) Internet-of-Things related services, i.e. services based connecting in-car as well as remote physical and digital objects to the

Table 1
Statements used in the Q-methodology survey.

Autonomous driving	Internet-of-Things	E-mobility
The car is suitable for mobility-on-demand (i.e. urban car fleets located near strategically distributed transport hubs)	Supplementary in-car entertainment services (e.g. access to social media)	Use of geothermal energy to generate electricity for cars (i.e. energy generated and stored in the earth)
You can access a car whenever you like instead of owning one	Embedded Wi-Fi hotspot (i.e. the car can function as a hotspot to connect portable devices)	Self-charging electric vehicles
The car learns the behaviour and preferences of the driver(s) (e.g. mirrors, chair, music preferences etc.)	Full integration of smart devices (e.g. smartphone, smartwatch, wearable)	Electric car services (e.g. EV rental services)
Car system is integrated with systems at home (e.g. the alarm is turned off when the car gets close to home)	Advanced navigation systems integrated into the car	Energy saving systems services
Real-time data processing (e.g. local accident information, information to avoid traffic jams)	Driving performance (e.g. on-board diagnostics, warning systems)	Hybrid car systems (i.e. combines a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system)
Vehicle-to-vehicle connectivity (e.g. cars exchanges traffic information with each other)	Health/emergency related services (e.g. e-call system, request for specific medical assistance)	Eco-friendly car (e.g. limiting CO2 emissions)
Self-driving car (e.g. car can drive without continuous attention from driver)	Localisation services (e.g. parking spot locator)	The car automatically joins a powertrain (e.g. cars with same speed and direction keeping relative distance)
Remote control services (e.g. software updates are installed remotely)	Automatic optimisation of travel time (e.g. based upon traffic jams, road conditions)	The energy source switches to improve air quality (e.g. car will switch to electricity in urban neighbourhoods)
Driving-support systems services (e.g. vibrating the steering wheel if the driver loses focus)	Driving performance (e.g. on-board diagnostics, warning systems)	Use of battery electric car (i.e. use of chargeable batteries)
The car can sense its surrounding (e.g. can slow down on icy roads)	Initiating actions through voice command (i.e. hands-free calls)	Use of noise reduction technologies
Vehicle-to-infrastructure connectivity (e.g. the car communicates with traffic lights, pedestrian crossings)	Remote maintenance management (e.g. automatic scheduling of appointments based on in-car diagnostics)	Smart stop-and-go to save energy (e.g. turn car engine off and on at traffic lights automatically)
The car is customised for disabled people (e.g. accelerate with a button instead of feet)	Information on the weather and outside conditions	Use of renewable energy sources (e.g. air, solar)
The car can take over from the driver when unsafe conditions arise	Pay-as-you-go insurance	Energy efficient designed car services that can contribute to the sustainable energy transition
Self-parking related services (e.g. no driver input required when parking)	Fatigue detection systems (e.g. the car can detect if the driver is falling asleep)	P2P (peer to peer) service for charging electric cars (e.g. you can share private charging stations with other people)

Internet, and

(c) E-mobility, i.e. services that contribute to the development of electric-or hydro-power cars designed to shift away from the use of fossil fuels and carbon gas emissions.

In the third step, duplicate services were removed from the list. The Q-set needs to cover the breadth of topics in the discourse, and overlap between items is, in principle, not problematic for the method. Yet, we combined duplicate services as much as possible such that we could cover the breadth of the 150 services found. We combined services with different names but similar or identical offerings. For instance, services described as driving performance, monitor vehicle performance, onboard diagnostics, and car maintenance diagnostics offer almost identical value to users; hence, we grouped them under the statement ‘Driving performance’. Ultimately, 42 services were selected that represent the broad range of core mobility and auxiliary services within each category.

In the final step, a pre-test was executed to check the clarity and understandability of the statements, and to obtain further feedback to avoid potential ambiguous expression and misinterpretation of the meanings. Based on the pre-testing, we shortened the statements and added, if necessary, illustrative examples (see Table 1). The whole procedure was done based on a continuous interaction between all the authors.

3.2. P-sample

In Q-methodology, participants compare and rank-order opinion statements, forcing them to express their choice, feeling and/or underlying beliefs. This procedure is different from more conventional approaches, such as survey studies, which rely on rating each individual item in a questionnaire. To obtain meaningful results, Q-methodology requires a broad opinion space and a sample representative of a richness of perspectives. Therefore, we select participants that have diverse involvement in the automotive industry, and who work on different technologies and areas of expertise.

We selected academics that conduct research on innovative technologies or new ways of operating within the automotive industry. Academics may have a more comprehensive time perspective than practitioners and provide a greater overarching spectrum of ideas regarding the industry at stake, resulting in a broader diversity of opinions.

In selecting our participants, we face an important trade-off regarding their knowledgeability. On the one hand, we seek participants who have informed opinions on the impact of new technologies on automotive business models. On the other hand, especially insiders within an industry may be so immersed in ongoing debate that they are disproportionally influenced by hypes and novelties within the sector. Hence, a limitation to be considered is that the more our participants are experts due to their immersion in the industry, the more they may be susceptible to trends and hypes of a temporary nature.

The participants were recruited from the network of involved researchers and participants at the 2016 European Association of Research in Transportation symposium. In the end, 30 participants completed the survey, which is an acceptable number in Q-methodology (McKeown & Thomas, 2013; Watts & Stenner, 2005). Participants vary in terms of research experience (83.3% with 3–10 years of experience; 6.6% over ten years (no specific answer given by 10%) and European region (South: 40%; Central: 30%; North: 10%), while 20% were non-Europeans. The majority of the participants (70%) work in another country than their country of origin. As we mentioned before the participants were recruited from a conference focusing on transportation. Therefore, the participants were academics in the transportation domain. More specific, the participants indicted that their expertise are in the areas of traffic flow analysis, network design optimisation, transportation choice modelling driving behaviour, operation research, and traffic management. We attempted to control for knowledgeability of experts by explicitly asking them whether they are aware of new technologies, such as the Internet-of-Things, e-mobility, shared mobility etcetera. During these discussions the researchers clarified the main concepts such as the IoT, shared mobility, personalisation. Several potential participants were excluded due to insufficient knowledge.

We informed the participants that the 'impact' relates to the extent to which business model components will change due to the services. We asked participants to rank the statements based on their personal opinion. We allowed them to change the scores throughout the process, and explained that statements with similar meaning do not necessarily get similar scores due to the forced distribution. The statements had to be sorted on a linear scale, with high impact (+4) to no impact (−4) extremes. Statements in the middle of the scale are labelled neutral (Valenta & Wigger, 1997). We used a paper and pencil approach: participants were asked to place 42 cards containing the statements on a hardcopy of the scale (see Fig. 1 for an example). The principal author was present during the whole procedure and explained if required but did not intervene proactively. For instance, participants were encouraged to ask clarifications regarding the descriptions of the statements. To increase reliability, the researcher provided the same explanations to each participant.

3.3. Data analysis

For analysis purposes, the ranking of statements by respondents is converted to numerical values (Valenta & Wigger, 1997). Next, to identify patterns in the rankings of respondents and to reduce the complexity of the data, exploratory factor analysis is employed (Bartholomew, Knott, & Moustaki, 2011; Gie Yong & Pearce, 2013). We used the statistical software XLSTAT, created as an add-in for Excel. Varimax rotation was applied to achieve an orthogonal rotation. We retained four factors with eigenvalues exceeding 1. The final step of Q-methodology is to classify the respondents based on their factor loadings. Following the formula from (Brown, 1980) significant factor loadings ($\alpha < .01$) should exceed 2.58 * ($1/\sqrt{N}$) whereas N indicates the number of statements. Hence, factor loadings with an absolute value exceeding .39 are significant in our study. In case participants load significantly on multiple factors, we retain only the highest loading factor (Kroesen, 2012).

4. Results

Table 2 provides the four factors resulted from the factor analysis. The rest of the subsections discuss the four perspectives that

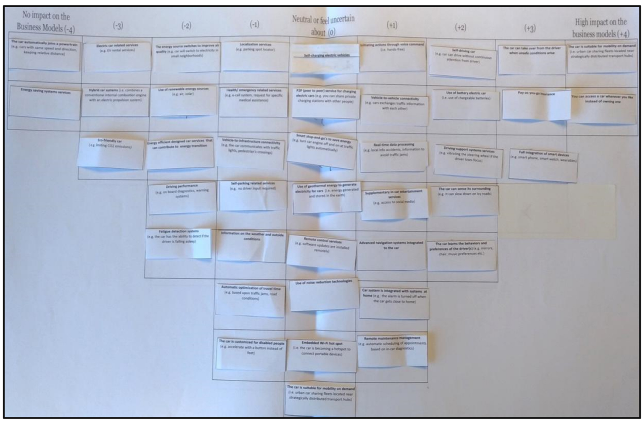

Fig. 1. Pen and paper approach: participants were asked to place 42 cards with the statements on a hardcopy of the scale. Participants were asked to sort the statements (Valenta & Wigger, 1997) by ranking the 42 statements on a scale, ranging from 'no impact on business models' to 'high impact on business models'.

Table 2
Statement with highest and lowest impact.

Factor 1 Personalised services	Factor 2 Generic mobility services	Factor 3 Shared mobility	Factor 4 Connected cars
Highest impact			
Automatic adaption to drivers' preferences (2.10)	Self-driving (2.20)	Access over ownership (2.73)	Real-time data processing (2.10)
Voice command actions (1.65)	Smart devices integration (2.01)	Mobility-on-demand (2.09)	Remote control services (1.60)
Surrounding sensing (1.62)	Entertainment services (1.34)	Self-charging (1.73)	Navigation systems (1.27)
Access over ownership (1.39)	Eco-friendly cars (1.01)	Pay-as-you-go insurance (1.62)	Vehicle-to-infrastructure connectivity (1.27)
Home systems integration (1.10)	Access over ownership (1.00)	Self-driving (1.52)	Vehicle-to-vehicle connectivity (1.19)
Mobility-on-demand (1.07)	Vehicle-to-vehicle connectivity (0.97)	Vehicle-to-vehicle connectivity (0.78)	Surrounding sensing (1.10)
Remote maintenance (1.03)	Real-time data processing (0.94)	Self-parking services (0.78)	Electric car services (0.85)
Self-driving (1.00)	Electric car services (0.92)	Vehicle-to-infrastructure connectivity (0.61)	Travel time optimisation (0.81)
Lowest impact			
Fatigue detection systems (-0.77)	Smart stop-and-go's (−0.90)	Energy saving services (−0.82)	Home systems integration (−0.74)
Emergency related services (−0.84)	Outside conditions information (−1.00)	Renewable energy systems (−0.82)	Mobility-on-demand (−0.83)
Digitalised control panel (−1.05)	Decision making by the car (−1.02)	Smart stop-and-go's (−0.84)	Energy efficient services (−0.91)
Navigation systems (−1.18)	Disabled people customisation (−1.17)	Hybrid car systems (−1.16)	Entertainment services (−1.20)
Powertrain join (−1.42)	Emergency related services (−1.33)	Eco-friendly cars (−1.20)	Noise-reduction technologies (−1.21)
Smart devices integration (−1.47)	Geothermal energy (−1.51)	Outside conditions information (−1.20)	Embedded Wi-Fi (−1.30)
Embedded Wi-Fi (−1.58)	Self-charging (−1.54)	Voice command actions (−1.46)	Remote maintenance (−1.94)
Entertainment services (−1.64)	Adapting in drivers' preferences (−1.55)	Noise reduction technologies (−1.47)	Peer-to-peer services (−2.08)
Pay-as-you-go insurance (−1.34)	Pay-as-you-go insurance (−1.58)	Energy efficient services (−1.57)	Voice-command actions (−2.35)

Note: Standardised factor loadings between brackets.

constitute the factors. Below we discuss the factors concerning perspectives.

Perspective 1: personalised services

Nine respondents hold the first perspective, represented by factor 1. This perspective (denoted as personalised services) ranks services highest that put the user central. The services that rank most positive are those developed for users' personal driving preferences and daily life (e.g. home systems integration). More specifically, respondents within this factor score positive on the personalisation of the driving experience. Furthermore, the respondents highly rank statements regarding driving experience, such as voice commands, sensing of the surroundings and remote maintenance services: services linked to an improved driving experience. Low impact viewed statements were related to supplemental or add-on services like the integration of smart devices, embedded Wi-Fi connection, navigation systems and localisation services. Also, advanced digital services are more 'general-purpose' services that are not tailored or personalised to the individual user. One could argue that this perspective favours services that put the user at the centre rather than the car as a product. Hence, these services are expected to shift the core of value creation and capturing to servicing individual users rather than selling mass-produced cars or general-purpose services. In other words, this perspective relates to servitisation and improved user experience.

Perspective 2: generic mobility services

Generic technological developments of self-driving, smart device integration and electric cars score higher on the second perspective, represented by factor 2 (denoted as generic services), which is shared by three participants. More specific technologies like self-charging, decision making by the car and personalisation rank the lowest. An interesting observation is that some of the low-ranking specific technologies (e.g. decision making by the car) are enablers for some of the high-ranking ones (e.g. self-driving). A potential explanation is that experts with this perspective expect that broad trends (e.g. self-driving, smart device integration) affect the business model of the automotive industry – whereas the specific services enabling these trends (e.g. decision making by cars, smart stop and go's) have a less direct impact. This perspective seems to emphasise that the major effect on business models will come from a change to self-driving, rather than specific technologies. The core of the expressed opinion is that self-driving, as an auxiliary service, will affect the business model of the automotive industry.

Perspective 3: shared mobility

The third perspective, represented by factor 3 (denoted as shared mobility) is supported by ten participants and represents a consensus towards the importance of shared mobility services. Statements that rank highly on this factor are mobility-on-demand, which was explained to respondents as the possibility to access vehicles that are stored in hubs nearby the user, and access over ownership, which is related to the idea of having access to cars rather than owning them. Other related services that rank high are pay-as-you-go insurance, self-charging and self-driving, which could be considered as enabling services for shared mobility, entailing less responsibility for individual drivers themselves. According to this perspective, the car is becoming less of property and more an enabler of a transportation services upon request. Lowest ranking services are related to energy efficiency, noise reduction, 'eco-friendliness' and energy savings. These experts hold the opinion that flexible mobile services on demand will affect business models most, whereas energy-related services will have a lower impact.

Perspective 4: connected cars

The fourth perspective, represented by factor 4 (denoted as connected cars) shows a strong preference of the experts for advanced services that allow cars to connect to each other and the environment, based on IoT capabilities. More specifically, this perspective shows a focus on services allowing communication between the driver, the car and its surroundings, for instance by the processing of real-time data. Highly ranked services are vehicle-to-infrastructure and vehicle-to-vehicle communication, advanced navigation systems, and travel time optimisation. Autonomous driving and entertainment services do not receive high scores from this perspective, even though connected car services enable these. This fourth perspective also indicates that already available services such as voice command actions and embedded Wi-Fi are not considered to effect business models within the automotive industry. The highest impact on the business model is expected through product and service bundling, enabled by functionalities closely related to automated IoT infrastructure and communication services based thereupon.

5. Discussion

Our study contributes four empirically informed perspectives regarding automotive service categories that are expected to impact business models in automotive industry: (1) enhanced personalisation services to improve user experience in combination with servitisation, (2) generic mobility services, (3) shared mobility enabled by a combination of servitisation and sharing, and (4) product and service bundling enabled by IoT based connected cars. On a more conceptual level, our findings show that business models in the automotive industry will be impacted by (1) servitisation in general, combined with enhanced user experience, (2) auxiliary services of self-driving, and (3) the bundling of products with IoT infrastructure and enabling services. These service types, according to our experts, shape the future of the business models within the automotive industry.

Our findings differ from existing classifications of mobility services (see Section 2), which are often more deductive typologies, focusing on technology characteristics. Our applied Q-methodology allows for a more inductive, exploratory approach to describe distinct groups of mobility services.

Reflecting on the perspectives elicited in the Q-methodology study, we can make six observations regarding the future of the business models within the automotive industry:

First, the elicited perspectives cover only part of the three broad technological areas (autonomous driving, Internet-of-Things, and e-mobility) that we identified at the start of the study (see Section 3). Autonomous (or self-driving) and IoT-enabled services are represented by a specific perspective. One of the perspectives elicited comprehensively covers the area of autonomous driving innovation. The elicited perspective on connected cars is related to the broader area of Internet-of-Things, as connected cars offer enabling services such as connectivity and remote data computing. Our findings show that there is no clear group of experts that think electric driving specifically will affect business models in the industry, which is in contrast with existing, technology-driven literature (e.g. Kley et al., 2011). These findings are significant as they imply that business model studies on the automotive industry should not necessarily focus on the three main technological innovations that industry reports currently focus on.

Second, we find that servitisation is ingrained in two of the four perspectives, i.e. enhanced personalisation of user experience and shared mobility. In the first perspective, personalisation services were also apparent, focusing on users rather than cars. The third perspective focuses on shared mobility. Both perspectives represent the trend from selling cars as a product towards offering mobility (on demand) as a service to individual users. For business models, both perspectives have major implications. Personalisation represents a break in the automotive industry from a focus on high-volume customisable products towards individually tailored user experiences. Besides changes to the value proposition, also the delivery mechanisms, revenue models and channels change.

Third, the perspectives represent different levels in which technologies become manifest. Only the fourth perspective of connected cars is focused on bundling of IoT based technology services: connectivity and data processing services. In two of the perspectives, technologies are not as explicit but are still clearly related to the services, as enhanced, personalised user experience and shared mobility are both enabled by technology. An interesting finding is that one of the perspectives clearly distinguishes higher-order generic services (e.g. self-driving) from lower-level enabling services (e.g. decision making by cars), even though these would logically contribute to each other. This shows a stark difference in how experts participated in this research project reason about technology, services and business models. The degree of technology-mindedness explains, to a large degree, these differences between perspectives, which in turn provides insight into the relationship between technological innovation, services and business models, highlighting differences in how experts reason about these dependencies.

Fourth, the perspectives are useful for informing domain-specific business model tooling in the automotive industry. The perspectives can be used as a starting point for a domain-specific (i.e. automotive industry) business model innovation process, and more specifically to elaborate research from business model design (e.g. Abdelkafi, Makhotin, & Posselt, 2013; Cohen & Kietzmann 2014) to the business model implementation phase.

Fifth, the grouping by experts can be used for identifying domain-specific business model patterns or taxonomies in the automotive industry. The literature on business model patterns is currently emerging (Abdelkafi & Täuscher, 2015; Amshoff et al., 2015; Remané et al., 2016), but they remain mostly unspecified for the automotive industry. Thus, the technology disruption that affects the automotive industry and the way they offer services urges mobility related enterprises to explore specific business model patterns based on their existing business models as well as their strategic choices.

Sixth, the results indicate that there is no clear group of experts who expect the highest impact from energy or electric driving services. All services related to energy are ranked as having a low impact. This does not imply that these services do not affect business models, but only that other services will affect the business model more. Perhaps it is assumed that electric cars and future hydrogen-powered cars will induce only incremental changes such as replacing one key partner with another (e.g. petrol provider with an electricity provider) while the role of energy provider remains essentially the same.

6. Conclusions

This study explores what types of technology-enabled services have the most significant impact on current business models within the automotive industry. We found broadly four perspectives on mobility services that experts believe to affect business models: personalisation and enhanced user experience services, generic mobility services, shared mobility, and IoT-enabled connected cars. The elicited perspectives show the relevance of servitisation, service bundling and auxiliary services in understanding how business models in the automotive industry will change. The perspectives also illustrate how experts have different perspectives on the abstraction level of technology-induced business model change.

The expert views elicited in our exploratory Q-methodology differ significantly from classifications mentioned in the popular press and technology-oriented academic literature. Our findings help to inform scholars, consultants and strategists focusing on the future of the business model within the automotive industry. Furthermore, our study can inform the development of business model tooling for business model innovation in the automotive industry and provide roadmaps to realise future business models.

A limitation of our research is related to the term 'impact'. We are aware that 'impact' can take multiple forms: from a single change improvement at a business model component to a change of the whole architecture. Also, an impacted business model does not necessarily imply that the old business model has become obsolete, but rather that it is likely to be subject to change. However, in the empirical part of our research we did not distinguish the different forms. The different forms of impact could be tackled in future research.

A limitation in any Q-study is that the number of items has to be constrained to a number that is feasible for participants, typically 40–50. Therefore, for instance for the perspective of shared mobility, our set contains certain dimensions (e.g. access to cars instead of ownership, availability of cars in nearby hubs) but not others (e.g. ride sharing, ride hailing). Another limitation of the study is the sample. The specific group of academic experts might be more technology-oriented than business researchers. However, as technologically advanced services only compose one of the four elicited perspectives, we consider this bias as marginal. Another limitation may be that new services may emerge in the coming years that lead to new insights and opinions.

Declarations of interest

None.

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