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Abstract

Digital technologies are transforming the automotive industry, and disrupting traditional business models based on ownership of cars. With the emergence of connected cars, mobility services and servitization, questions arise on how these enabling technologies affect the ecosystem. In this paper, we propose a research agenda for the digitalized automotive ecosystem. In this research agenda we raise research questions on the impacts of digitalization on business models (i.e. how to move from traditional to digital business models, how do new business models transform the ecosystem and how to construct new revenue models), digital platforms (i.e. who controls data from connected cars, how to open up and govern data platforms, and how to deal with platform competition) and consumer issues (i.e. what mobility services do consumers prefer, and how to guarantee safety, security and privacy).

Keywords: Internet of things, digital technologies, automotive industry, digital platforms, research agenda

1 Introduction

Digital technologies like Internet-of-things (IoT) are about to transform the automotive industry in ways that could disrupt established players' business models (KPMG, 2014). Digital technologies enable multi-modal solutions, in which cars ownership is no longer central but the core is mobility services, appealing to trends like eco-lifestyle, personalization and sharification (Seeger & Bick, 2013). While business models in automotive industry have long focused on cars as products, competition will increasingly revolve around services created through digital platforms. Offerings will increasingly focus on transportation needs and modalities, energy efficiency, collection of data on footprints and driving behavior, Bluetooth and 5G network dedicated system integrators. Besides enabling new service offerings, digital technologies also enable new actors to enter the traditionally closed automotive industry. As a result, traditional players like car manufacturers, car dealers, leasing, and insurance

companies and fuel providers will face new entrants like app providers, platform providers and specific service providers (e.g. Google Car, Apple iCar and Uber) (Hanelt et al., 2015).

From an academic point of view, automotive industry digitalization implies that cars will become a platform on which a number of services run (Mohaghegzadeh & Svahn, 2015). The digitalization of the automotive industry gives rise to many research issues that are related to (1) collaborative, changing and multi-level BMs as a result of servitzation for existing and new players, (2) the role of data platforms and platform competition, and (3) the consumer side of new ownership and payments models, security and privacy issues. In this paper, we develop a research agenda for investigating the impact of digitalization on business models, digital platforms and consumer issues. Our research agenda is based on reviewing the as-yet limited set of academic and industry papers on automotive industry, digitalization and connected cars.

The paper is organized as follows. Section 2 provides a background on automotive industry, digitalization and IoT. Section 3 discusses, based on existing literature, how these trends raise new research questions in relation to business models, data analytics, ecosystem and consumer issues. Section 4 concludes the paper.

2 The automotive industry, digitalization and IoT; setting the stage

Digital technologies have long been adopted by automotive players, ranging from back office automation to localization technologies and in-car entertainment systems (Hanelt et al. 2015). However, new digital technologies will fundamentally change the automotive industry and makes the affected participants to rethink their position in the market, and explore new opportunities improving their offerings (Viereck et al., 2015; Kavis, 2015). As objects ranging from clothes (wearables) to vehicles (e-bikes, smart cars) are being connected to the Internet, the so-called Internet of Things is emerging (Miorandi, 2012; Westerlund, Leminen & Rajahonka. 2014). IoT enables enterprises, within this new dynamic business environment, to create value by providing innovative products and complementary services (Kyriazis & Varvarigou 2013; Turber et al. 2015).

The automotive industry the mobility provider is shifting from being product to service oriented with the basic product –the car- only to be an enabler for delivering services (Vargo & Lusch, 2004). New value propositions relate to self-driving, parking and lane assistance options, based on a combination of sensor and GPS technologies, and real time data processing. Complementary services enabled by mobile and sensor technology are car diagnostics, preventive maintenance or automated emergency calls. More enhanced the car as a platform can also be related to ecommerce activities. As with many other industries, automotive industry is moving from a well-defined and structured ecosystem, with car manufacturers as central actor, to a flexible networked ecosystem with open boundaries (IBM, 2015). Consumers are co-designers for new services and new entrants are offering innovative products and services such as app driven electrical cars (BMWi3), Supplementary in-car entertainment systems (Apple CarPlay, Andorid Auto, and Google sponsored Open Automotive Alliance) like remote diagnostic, tracking and tracing systems and location based advertisement are already reailty.

So, the car is becoming a platform on which add-on services run. Connected car platforms typically have a layered model. On the lowest level the client systems are represented based on embedded sensors and other peripheral equipment. On the connection level use is made of 3G/4G/LTE networks as well of

WiFI 802.11p, and specific DSRC (dedicated short range communication) roadside communication protocols. On top we find Internet access to public, private or enterprise cloud systems. Together they provide a connected car platform (Golestan et al., 2015).

3 Research issues

Business models in a digitalized automotive industry

Digitalization in the automotive industry is disrupting existing business models (BMs) (Hanelt et al. 2015). Traditional BMs were based on a linear, mechanical value chain focused on delivering a product, i.e. a more or less sophisticated, conventionally, fuelled cars, offering after sales maintenance services via a dealer network. Core competences of car manufacturers are therefore based on engineering, design and electronics, while software components were purchased from suppliers. The automotive industry leads to a changed ecosystems in which other parties have to find their role, not only as app or technology provider, but also transaction providers and others (Hanelt et al., 2015). There has been limited prior research on BMs for digitalized automotive industry. Based on a Delphi study with nineteen experts, Piccinini & Gregory (2015) present a list of relevant BM challenges: (1) creating valuable new digital co-created products and services, (2) competing with rival (service) offerings from new entrants, and (3) designing new business models. They find that legal, regulatory, security and privacy issues are least relevant. Fleisch et al (2015) suggest BM changes based on analysing 55 IoT cases. Digitalization of automotive industry gives rise to research issues like

- *How can existing players gain the required resources and capabilities to conduct BM innovation?* As a consequence of digitalization automotive manufacturers need additional resources and capabilities, for instance know-how on software engineering, big data, social media, mobile technology and on security and privacy, either internally or on arm's length.
- *How can existing players move from their current BM to a new BM?* On a more generic level tension of working in two rather different BM concepts, i.e. the traditional automotive paradigm vis-à-vis the digital paradigm (as also confirmed by Piccinini & Gregory, 2015). Clearly this asks for an ambidextrous approach, combing exploration and exploitation.
- *What new BMs emerge and how ecosystem partners will innovate their BM? How can car automotive industry actors work together to develop new propositions and BMs?* When moving from car-as-a-product to mobility services BMs, new actors become part of the ecosystem. The system integration and governance role can be fulfilled by the automobile manufacturer or by any other party in the ecosystem, for instance a public transport provider. In the case of enhanced ecommerce services , the ecosystem changes in a different direction, for instance petrol stations can play a role in delivering services to the end consumer.
- *What are new revenue models for BMs in a digitalized automotive industry?* Changing value propositions offer new opportunities for revenue generation. For instance, congestion pricing for parking or new insurance fees based on data about driving behavior. When cars are no longer owned as a product, new pay-per-use pricing models can be offered. Other revenue models become possible as well for peripheral actors, as for instance petrol stations can ask for a commission, while transaction and/or payment provider can create revenues based on user and transaction profiles. Digitalization can also lead to cost reduction, for instance due to co-creation in the design process and plant design for a production line supported by virtualization (Hanelt et al., 2015).

Data platforms in connected cars

Connected cars generate massive amounts of data, which raises issues on how to collect, orchestrate and distribute data to service providers. Mikusz et al. (2015) discuss BMs for three specific platforms that collect, process and sell data from connected cars, i.e. Audi Connect, BMW Connect Drive and Mercedes Connect. In their analysis, data platforms are closed and access is only given to preferred partners, (e.g. Audi to Google, BMW to DoubleSlash and Mercedes to TomTom). Mohaghegzadeh & Svahn (2015) discuss how to develop open in-car platforms starting from Volvo's existing organizational and technological resources, to be made available via Google's Android platform. The project stalled because an open platform would imply that core strategic data and knowledge on drivers behavior should be made available as well. The research of Mohaghegzadeh & Svahn (2015) clearly show the trade-off companies have to make regarding platforms, i.e. giving away critical knowledge based on user data vis-à-vis offering new apps via an open platform.

We suggest the following research questions due to platformization in the automotive industry:

- *Who controls the digitalized automotive ecosystem and its data sources?* Most digital services generate vast amounts of data. An important question therefore is who controls the data and act as an orchestrator, because data have an economic value. New value propositions and revenue models can emerge form reusing data.
- *Should data platforms be open, closed or hybrids? How to arrange governance?* As seen in the example of Volvo, car manufacturers tend to keep their platforms closed. At the same time, disclosing data can lead to generativity of mobility services. How to find a balance between open and closed platforms?
- *Where to locate the platform?* Connected cars platforms could be hosted on various locations: in the car, on an independent platform managed by a system integrator, or on the periphery being self-controlled by consumers.
- *How to deal with platform competition?* Platforms are offered by car manufacturers but also by operating system vendors like Apple and Google. A core concern is how car manufacturers should respond to threats of being `enveloped' into the platforms of operating system vendors (cf., Mohaghegzadeh and Svahn 2015).

Consumer issues: acceptance, security and privacy

Consumers are affected by digitalization of the automotive industries in various ways. First, a range of new value propositions is becoming available. A concern is what consumers actually desire from their 'connected car' experience or from eMobility solutions. A research issue is therefore:

- *What digital mobility services do consumers prefer and wish to pay for?* The question is what consumers want next to the core mobility service, and what is their willingness to pay for complementary or supplementary services.

With the amount of data collected due to IoT, security and privacy are core topics (Viereckl et al., 2015). Distant monitoring system can contribute to preventive maintenance, warning systems for engine problems, brake or tire problems, even helping to increase save drive behavior based on navigation support, automatic speed adjustments, real-time information on traffic flows, road conditions, possible accidents and based on peer2peer communication automatic sensor-based systems for keeping distance et cetera (Evans-Pughe, 2005), but there is also a downside, car become vulnerable

to hackers, for instance via infotainment applications or remote access. This leads to the research issue:

- *How to guarantee security and safety of consumers?* Car-to-car communications and connections have to be stable and secured and give priority of safety information over entertainment data. At the same time critical software based systems have to be impossible to be hacked by outsiders. Authentication systems have to be in place. However one of the big issues is that the lifecycle in the automotive industry is up to 20 years, so solutions should hold for a long time (Koushanfar et al., 2012). An interesting question is where to embed security, in the car (e.g on an independent platform, by a transaction provider under control of the users, for instance on a smart card).

Privacy of consumers is also affected. Privacy is a core topic when for instance data is provided on driving behavior for services customization or price discounts for car insurance (De Reuver et al., 2016; Ohlsson et al., 2014). Weinberg et al. (2015) argue that providers should proactively consider privacy objectives, in order to build trust and to foster customer relationship. Data theft or unauthorized access require cyber security solutions for car IoT systems to guarantee trust (Dutton, 2014). With regard to privacy the question becomes relevant who owns and controls the data (Dutton, 2014). Data and access to data on customers and on customer behavior is considered to be a critical asset, and many providers and ecosystems will claim that they are the owners of the data (Weinberg et al.,2015).

- *How to balance privacy of consumers and opportunities of new mobility services?* At the upside smart transport systems can lead to avoiding congestions and efficient driving, at the downside it offers the opportunity to install road pricing and limiting drivers choice. In the same grain data on driving behavior can impact insurance companies pricing policies. Even affordance of safe connected car systems versus people who cannot afford to buy advanced cars might lead not only to a kind of digital divide but to uneven distribution of physical vulnerability. This leads to question with regard to appropriate government policies.

4 Conclusions

In this short paper, we developed an initial research agenda for digitalization in the automotive industry. Based on notions of connected cars, IoT, servitization and platformization, we suggested research issues on business models, platforms and consumer issues. While the practical relevance of these research issues alone already warrants pursuing the topics, we also argue that the complex nature of the automotive industry can lead to new theoretical insights. The current transformation in automotive industry provides an apt example of physical and digital convergence. Differing clock speeds between the rapidly evolving IT industry and the slow car industry provides challenges for developing new BMs and platforms, as do the unbalanced life-time cycles. The physical safety and digital threats on security provide an opportunity for conducting security and privacy research.

The literature we reviewed for this paper comprises of a limited number of conference and working papers that are rather diverse and focus on more or less unrelated topics. We interpret this as an indication for the lack of maturity of this research domain. Some papers are addressing the tension between the cyber physical systems (CPS) mainly from a business model and ecosystem perspective. Typically these papers originate in Germany and Sweden, two counties with a well-developed automotive industry. As next step, we plan to validate our research agenda with a focus group of experts from both the information systems and transportation domain.

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