Digital Vehicle Ecosystems and New Business Models: An Overview of Digitalization Perspectives

Christian Kaiser
Virtual Vehicle Research Center
Austria
christian.kaiser@v2c2.at

Alexander Stocker
Virtual Vehicle Research Center
Austria
alexander.stocker@v2c2.at

Gianluigi Viscusi
École Polytechnique Fédérale de Lausanne (EPFL)
Switzerland
gianluigi.viscusi@epfl.ch

ABSTRACT

The ongoing digitalization of passenger vehicles entails a rearrangement of stakeholder power relations within the automotive industry. A bunch of innovation-friendly IT start-ups - the majority of them from outside Europe - has already put energy into the development of novel quantified vehicle services for various beneficiaries, including drivers as well as third parties, challenging the traditional role of vehicle manufacturers. They gather data on how vehicles are used and offer digital products and services exploiting this data. Thereby new business models have been created within the automotive industry, causing an interesting power struggle between the various stakeholders. This paper provides a short overview on the role of the digitalization phenomenon in general, the impact of digitalization in the automotive domain through quantified vehicle start-ups and new business models, as well as a brief investigation of the position of vehicle manufacturers and their digital service strategies – all of them concluded in a comparison of value creation for business model elements.

CCS CONCEPTS

• Social and professional topics → Professional topics • Computing and business; Automation; Economic impact

KEYWORDS

Digital Vehicle, Quantified Vehicle Services, Vehicle Generated Data, Connected Vehicle, Business Models, Digital Business Innovation

1 Introduction

Digitalization is an important driver of service and business model innovation in the vehicle domain. Digitalization challenges are currently often subsumed under the more popular term 'connected vehicles'. Taking a look on digital services and mobile applications, it emerges that connecting vehicles closer to their human drivers is an increasingly requested topic of research. Such include e.g. the detection of behavioral patterns from data collected during self-tracking activities (e.g. conclude from heart bpm value and GPS positions if a sport activity is performed), which can be transferred to vehicles, too. As vehicles capture sensory data about themselves and their environment during operation and thereby reveal how they are used by a driver, they can become 'Quantified Vehicles' [44]. Quantified vehicles represent one key result of digitalization in the automotive industry, where incumbents have to face a key set of competing systemic challenges spanning from innovation capability, focus, and governance. In particular, digitalization has enabled digital entrepreneurship [36] providing less bounded entrepreneurial processes and outcomes and less predefinition in entrepreneurial agency, as shown also by the rising number of start-ups focusing on quantified vehicles [24,45].

Considering the development process of successful business models based on exploiting vehicle operation data, there is currently a friendly competition between the major players from Information and Communication Technology (ICT) industry against the vehicle manufacturers on the supremacy of digital ecosystems. ICT start-ups have already successfully transferred the *quantified-self* [37,47] phenomenon to vehicles and have launched apps and services to generate a whole new market, while vehicle manufacturers are currently in the transition process from vehicle manufacturers towards integrated mobility and data service providers [24]. Thus, the digital ecosystem for the incumbents and start-ups, which are competing in the quantified vehicles market, have to consider industry transformation in general, impacting on the overall digital information assets available as well as on the sustainability of business models.

This paper aims to explore different approaches on developing platform oriented and sustainable business models for the occupation of digital services, probably the most lucrative components in the future automotive industry, between the incumbent vehicle manufacturers and the emerging tech start-ups. In particular, this paper aims to identify the main actors and roles in emerging digital ecosystems of vehicle usage data platforms and their contribution to eventually define an information infrastructure for an automotive industry centered around 'quantified vehicles'.

After this introduction, the paper will provide a summary on digitalization as well as its implications for the automotive domain ranging in Section 2, whereas Section 3 outlines the applied research approach. Section 4 discusses relevant digital challenges of vehicle manufacturers and the increased

Platform Economy & Business Models workshop at i-KNOW '17 October 11–12, 2017, Graz, Austria

competition on the way to digital services including recent activities within the startup ecosystem. Section 5 concludes with an outlook and a classification of value drivers and business model elements for each stakeholder investigated in this paper.

2 Background and Motivations on Digitalization

Digitalization is a sociotechnical process that leverages the technical process of the encoding of analog information in a digital format (digitizing) applied to broader social and institutional contexts, transforming their sociotechnical structures, thus rendering digital technologies infrastructural [48,58]. Furthermore, digitalization depends and results in digital artefacts characterized by attributes such as *editability*, *interactivity*, *reprogrammability / openness*, *distributedness* [25], also implying a shift in product design moving from modularity to generativity [29,56,57].

Quantified vehicles represent one of the key results of digitalization in the automotive industry, where incumbents have to face a key set of competing concerns systematically interrelated as shown by Svahn et al. [46] through the case of Volvo: *innovation capability* (existing versus requisite), *innovation focus* (product versus process), *innovation collaboration* (internal versus external), and *innovation governance* (control versus flexibility). In particular, it is worth noting that from a strategy perspective, the digitalization enforces *internetworking* to be considered as "those business processes/activities conducted or mediated online by and between employees, customers, suppliers and partners of firms, using internet-based technologies accessed through internet-based infrastructures." [15:224]. Besides incumbent's digitalization enabled by digital entrepreneurship providing less bounded entrepreneurial processes and outcomes and less predefinition in entrepreneurial agency [36], as shown also in the case of the specific industry, we consider a rising number of start-ups focusing on quantified vehicles.

Taking these issues into account, the role of information and its value are a central challenge in the competitive scenarios emerging from digitalization as well. Consequently a key issue is related to evaluation of the digital information asset of a company as well as its information capacity defined as the current stock of understandings informed by a given installed base [51]. The key questions are: *What data do I have? How is the quality of data? Can I exploit it in their full potential? What can I infer from it given my current systems?* According to Viscusi & Batini [51] information capacity represents the potential of a digital information asset defined and evaluated independently from its usage, determining not only its economic value, but also the enabling capabilities.

Considering the development process of successful business models based on exploiting vehicle data, there is a competition between the major players from ICT industry against the vehicle manufacturers on the supremacy of digital ecosystems. ICT start-ups have already started to apply the quantified-self phenomenon to vehicles and have and launched apps and services to generate a new market, while vehicle manufacturers are currently in the transition process from vehicle manufacturers towards integrated mobility and data service providers [24,45]. Yet, the digital ecosystem for the incumbents and start-ups competing in the quantified vehicles market have to consider another industry transformation, impacting on the overall digital information asset available as well as the sustainability of business models.

At the state of the art, the need to build on an appropriate ICT infrastructure, the open system integration of the energy landscape led to its definition as "Internet of Energy" [5,27]. As a consequence of the "Internet" metaphor, the energy related challenges and concerns have been alternatively interpreted as a consequence of lack of information "to enable and motivate economic and behaviorally driven solutions" [55]. Consequently, "energy informatics" (EI) has emerged as a new field within information systems (IS) research to analyze, design, and implement systems increasing the efficiency of energy demand and supply infrastructure [55]. According to Dedrick [16] researchers have framed the impacts of IT on the environment as first, second, and third-order effects:

- *First-order effects*: direct impacts from IT hardware during the product lifecycle, including production, use and disposal of computer equipment.
- *Second-order effects*: impacts of ICTs on other processes such as transportation or industrial production, influencing their environmental impact.
- *Third-order effects*: are longer term and more dynamic impacts, occurring when widespread use of ICTs leads to changes in lifestyles and economic structures.

Third order effects are relevant when considering the increased use of social media transformative potential for green IS on the demand side, encouraging better practices reducing the burden on the environment such as, e.g., the emerging carpooling and ridesharing applications impact on transportation coupled with the Internet of things [30]. According to Malhotra et al. [30] this two- way, sensor-driven communication is blurring the boundaries between the production side and the demand side. Furthermore, EI and IS and interdisciplinary strategies for quantified vehicles may provide models to assess the value of information, in particular the social value of related open data, adopting classification frameworks such as the one proposed by Viscusi et al. [53].

Over the last twenty years, actually after the massive access to the Internet and the World Wide Web, the interest in the strategy concept of business model has grown, thus becoming a key element for competing in markets characterized by extensive use of ICTs and currently transformed by digitalization. In general terms a business model describes the rationale of how an organization creates, delivers, and captures value [39:14].

However business model is a multifaceted concept, still raising debate in academia as to its definition, Massa et al. [32] provided a systematic view on the different perspectives pointing out that business models can be considered as i) attributes of real firms (*how firms do business*), ii) cognitive/linguistic schema (*how the way firms do business is interpreted by organizational members*)

and iii) formal conceptual representations/descriptions of the former two issues. As for formal/ conceptual representations/descriptions, Al-Debei & Avison [2] identified four key dimensions of a business model: *value proposition*, *value architecture*, *value network*, *value finance*. Whereas as for business models as attributes of real firms it is worth mentioning, especially for the case we consider of automotive industry and quantified vehicles, the definition by Zott & Amit [59], who conceptualize a business model as *"a system of interdependent activities that transcends the focal firm and spans its boundaries. The activity system enables the firm, in concert with its partners, to create value and also to appropriate a share of that value"*[59:216]. This definition is particularly useful for understanding business models of companies interested in quantified vehicles when linked to the above concept of internetworking and current pervasiveness and strategic relevance of digital platforms [17,18,40,57].

As argued by Nambisan [35:217], IT can act as either an *operand resource* "(often tangible and static) that an actor acts on to obtain support for executing a task", or as an *operant resource* "(often intangible and dynamic) that act on other resources to produce effects". Accordingly, in a case a digital platform can be considered an enabler of innovation processes and outcomes; whereas, in the other case, it acts as a trigger, informing rather than being informed by the users. Considering the automotive sectors and especially quantified vehicles, despite the "analysing" stance of the main market players, a set of traditional and new business models can be applied [44], in particular the infomediary one [1,41] can be adopted under a utility perspective [42] and extended from data collection for, e.g., marketing purpose to data useful for social value, as capability and functionings they enable [52,53], and finally for sustainability issues. Besides environmental and societal issues, business sustainability refers to "business models and managerial decisions that create value over the short, medium, and long terms, based on mutually beneficial interactions between the company's value chain and the social and environmental systems on which it depends" [28:18]. Furthermore, according to Boons & Lüdeke-Freund [14:14] a business model perspective may contribute to a sustainable innovation agenda to overcome internal and external barriers. Also, Schaltegger et al. [43:6] points out that a business model for sustainability "helps describing, analyzing, managing, and communicating (i) a company's sustainable value proposition to its customers, and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries." Thus, considering the automotive industry and the potential transformation enforced by digital innovation and quantified vehicles, business model innovation can open different horizons and path impacting the sustainability of companies, although how they can innovate their business models toward greater sustainability still need to be significantly addressed in research and practice [21:221]. Still, business model innovation in automotive industry asks for understanding the different ways the various actors can follow to innovate their business models; in particular, as pointed out by Massa & Tucci [31:424], *business model design* in newly formed organizations, which refers to their "entrepreneurial activity of creating, implementing and validating a business model", and *business model reconfiguration* in incumbent firms, encompassing the reconfiguration and eventual acquisition of organizational resources to change an existing business model.

3 Research Approach

This paper is aimed to provide an overview of innovative ICT start-ups towards establishing new services and sustainable business models. Besides that, selected digitalization initiatives of German and Italian vehicle manufactures are analyzed. The authors conducted a lightweight online market research approach analyzing information available on the Web. They used a combination of the terms car, vehicle, connected, quantified, start-up and vehicle in search engines to capture the current developments in the start-up domain.

After having identified major quantified vehicle start-ups, two authors studied the start-up websites in detail to find out more about their visions and goals as well as about their business models, products and services. Two out of the three authors reviewed the websites of all start-ups and discussed their knowledge with the third author afterwards to come to a common understanding. The information was then validated in discussions within the AEGIS project[2] consortium as well. Furthermore the authors used crunchbase.com to capture additional meta-information on business and funding, where the authors revealed interesting facts on investments into tech start-ups as well as of strategic partnerships.

As for the manufacturers for the countries considered, the authors carried out a market research on the websites of industry organizations, press news, and magazines, apart from policy documents from European Union organizations. They especially paid attention to review the current digital services of vehicle manufacturers by taking into account the content on the various product websites, which is expected to be up to date.

4 Results: Digitalization in the Automotive Industry

4.1 Overview

Digitally-enhanced driving is an emerging topic, which can be counted to the heavily used umbrella terms 'connected cars'/'connected vehicles' or 'connected driving'. According to a definition from PWC [49] in their 2016 connected car report, connected vehicles are defined as vehicles that have access to the Internet and a variety of sensors, and that are thus able to send and receive signals, sense the physical environment around them, and interact with other vehicles or entities. According to this report, revenues in the automotive industry (will) shift from hardware to software, from products to services, and from old to

[2] https://www.aegis-bigdata.eu/ last accessed 25.08.2017

new economy. The report highlights four trends changing the automotive competition:

- *radically new technology at low price* (increase in vehicle to infrastructure connectivity (e.g. through 5G), increase in computing speed to operate artificial intelligence for self-driving, evolution of low cost sensors to make a vehicle aware of its surroundings),
- *shorter innovation cycles by new high-tech entrants* (non-traditional tech companies to offer new services as add-ons to automobiles and disrupt traditional vehicle value chain, Apple to invest $10 billion into an iCar, Google's self-driving vehicles to drive more than 1,5 million miles, data-centric business models depend on revenues from ongoing services and the sale of information),
- *new mobility concepts and increasingly urban customers* (urban residents to lose interest in owning vehicles, millennials in cities to face affordability issues, movements towards vehicle sharing and ride sharing, expectations of highly sophisticated levels of connectivity and services), and
- *evolving regulatory and policy constraints* (policy and regulations to lack behind the technological process, expect regulators to respond with laws ensuring the safety of driverless vehicles, cities to discourage the use of non-electric private vehicles).

The PWC report further differentiates three main categories for technologies and services for connected vehicles:

- Consumer services such as internet and cloud based digital services that add to driving experiences,
- Connected vehicle packages with feature to improve or help managing the vehicle's operation, and
- Supply-side technologies as underlying systems connecting the vehicle to the wider world.

Another report from McKinsey [22] on the connected vehicle trend estimates a global market size of 170 billion EUR to 180 billion EUR for vehicle connectivity in 2020. This report foresees connectivity to trigger a redistribution of automotive revenue pools except vehicle operations – based on a survey of 2000 vehicle buyers. McKinsey perceives human-machine-interface (larger screens, multiple screens, innovative UIs, Augmented Reality), vehicle condition data (for offering maintenance and insurance services), and dynamic real-time geo-information (oligopoly of TomTom, Here, and Google) to become key control points in this redistribution. This report has identified five different groups of vehicle buyers: maxed-out vehicle enthusiasts, integration and entertainment lovers, safe and secure navigators, purists/minimalists and price conscious traditionalists, each group with own preferences and attitudes towards connectivity-related features. Along with the preliminary market analysis a 1st competition analysis is provided.According to the McKinsey report, the connected vehicle ecosystem of the future will be highly influenced by additional players including digital players, telecom players and insurers.

- Vehicle manufacturers explore ways to exploit the connected vehicle into the provisioning of a software operating system to serve as a platform for a potential app store, as well as into the development of specific apps and services.
- Automotive suppliers want to establish direct relationships with the end customers of vehicles produced by vehicle manufacturers who they supply.
- Digital players adapt their smartphone platforms to vehicle-specific customer needs and to integrate their infotainment into vehicle systems.
- Telecom players see new opportunities in terms of infrastructures, while SIM cards are installed in vehicles.
- Insurers expect new opportunities while e.g. offering telematics-based coverage options.

We can expect a huge power struggle between all players – including vehicle manufacturers – on who will reap most value from the connected vehicle market. According to the problem statement of the AutoMat project[3] coordinated by Volkswagen Research, the automotive industry has not yet been able to successfully establish an ecosystem for smart driving applications equivalent to that of smartphone manufacturers [24]. In its prior problem statement, the AutoMat project mentions three reasons why vehicle manufacturers are currently struggling: (i) Brand-specific business approaches dominate, and as a consequence there is a lack of brand-independent vehicle lifecycle data, (ii) current proprietary vehicle services focus on the individual customer, which results in privacy concerns, and few ideas exist how anonymized vehicle data can be used to establish other services, and (iii) the implied or required collaboration between vehicle manufacturers on vehicle data and services is considered risky in terms of competition.

4.2 The Business Models of US Start-ups

The IT industry of the USA has already lined up a series of tech start-ups backed by risk capital, reaching more than 20 million USD in some cases, demonstrating how high investors perceive the market value of an ecosystem built on exploiting vehicle data [24]. The majority of start-ups including automatic.com, automile.com, dash.by, moj.io, vin.li, zubie.com to name a few capture vehicle operation data through the On-board diagnostics (OBD) interface of the vehicle which is originally intended to provide a repair technician access to the status of the various vehicle subsystems and diagnostic information.
These connected vehicle start-ups have specialized in capturing, storing, and analyzing large quantities of vehicle operation data and offering digital services in smartphone applications to motivate the driver for sharing valuable driving data. The majority of start-ups are currently capable of automatically extracting interesting driving events using computational intelligence including e.g. hard brakes, hard accelerations or speeding to name a few. These events are hidden in the gathered vehicle operation data (time series data) and have to be revealed

[3] http://automat-project.eu last accessed 17.08.2017

through applying big data analytics. Mobile applications running on the driver's smartphone then pull the results from the start-up's datacenter and then visualize them on the driver's smartphone or tablet. The majority of these start-ups provide mobile apps connected to the OBD interface of the vehicle via Bluetooth with very similar functionality to the driver: These include for instance means to drive smarter by unlocking diagnostics and real-time data and greener by using the app for gaining an overview on how driving habits influence fuel consumptions (dash.by), make the vehicle smarter by revealing insights of vehicle data and providing driving stats (automatic.com), or delivering real time location, trip history, maintenance alerts, engine diagnostics and driving insights (zubie.com).

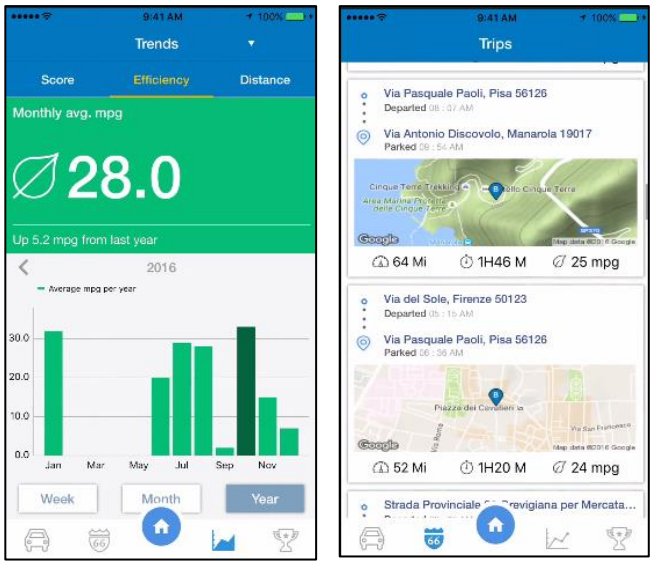

Figure 1: Exemplary snapshots of dasb.by's mobile app.

Another interesting tech-startup recently receiving amongst others a huge investment from BMW i Ventures is Zendrive.com [13]. Zendrive is taking advantage of the sensors built into modern smartphones to capture smartphone sensor data while driving, and provide cloud-enabled driving analytics aiming at safer drivers as well as on safer roads by using gamification features. According to the business information platform crunchbase.com a bulk of investors of these start-ups stems from the insurance industry, too.

4.3 Digital Services of Vehicle Manufacturers

German vehicle manufacturers including AUDI, BMW, DAIMLER, and VOLKSWAGEN currently offer some digital/connected services. These services allow for instance accessing some vehicle functions through the drivers' smartphone via mobile apps (e.g. lock/unlock the vehicle), vehicles conducting (semi-) automatic calls for emergencies in case of a detected accident, roadside assistance, or allowing (stolen) vehicle location via mobile apps to name a few.

Their offer surely is expected to increase, taking also into account new strategic partnerships as well as investments into connected vehicle start-ups. For instance BMW i Ventures[10] heavily invests into tech start-ups aiming to facilitate safer driving including e.g. Zendrive.com (providing smartphone-powered driving analytics including statistics and gamification), or Nauto.com (multi-sensor device to monitor the driving behavior including statistics especially for safety relevant events. Moreover BMW [11] has recently teamed up with IBM in its activity to deploy the vehicle data platform and to enhance it with analytics features [23].

The following subsections summarize information on USP and the different services captured from the various product websites of German vehicle manufacturers and published studies like Karlsson et al. [26]:

4.3.1 AUDI

"*Innovative services and functions that connect drivers with their Audi and the world: that is Audi connect. myAudi and the Audi connect services make driving even more relaxing and safer.*" Source: [8]

"The term "Audi connect" covers all applications and developments that connect Audi vehicles to their drivers, the internet, transportation infrastructure and other vehicles. Audi is continually building up its lineup of products and services in this technical area – with new solutions such as the Audi connect SIM and the traffic light information service for the US market." [9]

4.3.2 BMW

"BMW Connected is a personal mobility assistant which facilitates everyday mobility and assists drivers in reaching their destinations relaxed and on time. Mobility-relevant information such as recommendations for optimal departure times are available remotely via smartphone or smartwatch and can be seamlessly transferred into the vehicle."

BMW ConnectedDrive [12]:

- Remote Services: Locking and unlocking the vehicle, indicate the vehicle's location by honking the horn or flashing the lights, or on a map in the app. Activate the vehicle's climate control immediately or on schedule.
- Concierge Services: Select travel destinations and get information, connect with call-center agents to look for nearest services or to book services, addresses sent directly to navigation system.
- Real Time Traffic Information: Information about the current traffic situation, calculate expected delays and recommend detours, on street parking information.
- Intelligent Emergency Call: If an airbag is deployed, the BMW Call Centre is contacted via an accident-proof telephone unit permanently installed in the vehicle, precise position of vehicle is communicated including relevant accidental data.

- Digital Services: With BMW CarData a vehicle owner can view the key vehicle data and share them with third parties if required.

4.3.3 DAIMLER

"Mercedes me is your package of innovative services, products and lifestyle offers from Mercedes-Benz, Daimler and our cooperation partners – including access to your vehicle via smartphone, of course."

Mercedes me' connect services [33,34]:

- Vehicle Setup: Remote Retrieval of Vehicle Status, Remote Door Locking and Unlocking, Programming of Charge Settings and Pre-Entry Climate Control, Personalization.
- Vehicle Monitoring: Geofencing, Vehicle Tracker, Parked Vehicle Locator, Route Planning for plug-in hybrid vehicles.
- Parking using a smartphone app: Geofencing, Vehicle Tracker, Parked Vehicle Locator, Route Planning for plug-in hybrid vehicles.

4.3.4 VOLKSWAGEN

"VW Car-Net® makes your Volkswagen more like a friend. It gives advice, helps you along the way, entertains you, and watches out for you. It connects you to the world outside all from the comfort of your driver's seat. VW Car-Net is your partner in drive."

VW Car-Net [54]:

- Via app-connected drivers can access select smartphone apps right from their dash.
- Guide & Inform Services via SiriusXM® Traffic subscription and SiriusXM® Travel Link

4.3.5 Fiat Chrysler Automobiles (FCA)

In order to not exclusively look at German vehicle manufacturers, at the glance some of the main initiatives by the Italian-controlled multinational corporation Fiat Chrysler Automobiles (FCA), oriented towards consumers and dealers are discussed in the following. As for consumers, it is worth mentioning the Uconnect® navigation, entertainment (with CarPlay [6] to use iPhone while driving by putting his applications and functions on the vehicle's built-in display) and communication system that allows drivers to being connected while driving and paying attention to the road and related events [19]. Moreover, apart from CarPlay and iPhone, FCA is collaborating with Google to integrate the Android open-source platform with the Uconnect 8.4-inch connected system [8].

Considering now dealers, The *FCA Dealer Digital Programme* is a collection of tools, process, and support channels aiming at coordinating the action by the different partners and acting in the digital space in order to enable the engagement of local in-market shoppers to increase selling [20]. Furthermore, the FCA Dealer Digital Websites are the only sites having traffic directly from the brand website's dealer locator, thus increasing through this connection their visibility in search results on the main search engines such as e.g. Google also through the support of FCA Dealer Digital Advertising (DDA) Programme [20], a one-stop shop for digital advertising campaigns connecting dealers to Certified Providers with national coverage and extensive digital Automotive industry expertise helping dealers in digital marketing and sales. This connection to the brand websites is aimed not only to increase marketing and selling activities, but also to improve integration with FCA in terms of timely updates of assets, campaigns, pricing and inventory. However, this integration, each Dealer Digital Website site, can be customized according to the value proposition of the dealer brand [20].

The FCA effort in digitization of customers' experience and dealers services represents the basis for moving from connected to self-driving vehicles as shown by the partnership with Google and the announcement in the spring of 2016, that they would build 100 self- driving Chrysler Pacifica hybrids minivans, formerly tested in Arizona, California and Michigan. Furthermore, Google's self-driving vehicle project, Waymo, has announced in April 2017 a program on larger scale in Phoenix program using the FCA 500 Pacifica minivans, allowing hundreds of people in Phoenix applying on Waymo's website to ride in the vehicles in order to get feedback on the experience. [7]

5 Conclusion

Digitalization is an unstoppable trend in the automotive industry in general and increasingly observable by the driver. In modern passenger vehicles, drivers can connect to the cloud, where services to drivers and other stakeholders are provided. Thereby three approaches have been discovered:

- Brand dependent assistance services, which provide access to vehicle functions and services via smartphone. Users thereby get access to vehicle functions via apps.
- Brand-independent apps and services, often as components of data ecosystems with several stakeholders, which provide transparency on driving data to be used e.g. in driving behavior analytics.
- Strategic alliances of vehicle manufacturers with ICT firms (e.g. BMW teams up with IBM) to establish services & business models on how to make value out of vehicle data.

As pointed out by Zott & Amit [60] digitalization is strictly connected to product innovation and its acting both at business and customers/users side asks for new ideas and business models *design* in the case of start-ups and/or *reconfiguration* for vehicle manufacturer [31]. Following the perspective by Amit and Zott [3,4,59] of business model as an activity system that defines the way a company does business, whose elements are *content* (the *'What?'*), *structure* (the '*How?*'), and *governance* (the *'Who?'*) and its value drivers are *novelty*, *lock-in*, *complementarities*, and *efficiency*,

Table **1** identifies business model's elements and value drivers for start-ups and vehicle manufacturers (termed OEM for Original Equipment Manufacturers, in gray) discussed in previous Sections. Vehicle manufacturers seem more oriented towards governance and the exploitation of complementarities as value drivers (thus confirming a platform orientation as business model [40]), with Volkswagen targeting novelty for

customers through business model innovation at content level and FCA using it for efficiency and lock-in at dealers level. As to this issue, the resulting ecosystems show a relevance of digital (entrants) players as partners and a focus of FCA on the inclusion of dealers as a key part of its value constellation [38] rather than value chain, through internetworking. As for the start-ups, the ones considered appears to focus on 'structure' as business model element by mostly targeting (quite surprisingly) efficiency as value driver instead of novelty, thus having an execution orientation rather than a differentiation one to digital business [50].

Table **1.** Business model elements and source of value creation for vehicle manufacturers and start-ups in automotive

Company/Initiative	**Type**	**Value drivers**	**Business model element**
Audi/Audi connect	OEM	Complementarities	Governance
Automatic	Start-up	Efficiency	Structure
Automile	Start-up	Efficiency	Governance
BMW / BMW Connected	OEM	Complementarities	Governance
Dash	Start-up	Efficiency	Structure
FCA/Uconnect	OEM	Complementarities	Governance
FCA/ Dealer Digital Programme/ Digital Websites/Dealer Digital Advertising	OEM	Efficiency/Lock-in	Content
Mercedes Benz-Daimler/ Mercedes Me	OEM	Complementarities/Novelty	Governance
Metromile	Start-up	Efficiency	Structure
Mojio	Start-up	Complementarities	Structure
Vinli	Start-up	Complementarities	Structure
Volkswagen/VW Car-Net	OEM	Novelty	Content
Zendrive	Start-up	Efficiency	Content
Zubie	Start-up	Efficiency/Complementarities	Structure

Acknowledgement

The AEGIS project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 732189. The document reflects only the author's views and the Commission is not responsible for any use that may be made of information contained therein.

References

[1] A. Afuah and C. Tucci. 2000. *Internet Business Models and Strategies*. McGraw-Hill College, Boston.

[2] Mutaz M Al-Debei and David Avison. 2010. Developing a unified framework of the business model concept. *European Journal of Information Systems* 19: 359–376. https://doi.org/10.1057/ejis.2010.21

[3] Raphael Amit and Christoph Zott. 2012. Creating value through business model innovation. *MIT Sloan Management Review* 53, 3.

[4] Raphael Amit and Christopher Zott. 2001. Value creation in E-business. *Strategic Management Journal* 22, 6–7: 493–520.

[5] Hans-Jürgen Appelrath, Orestis Terzidis, and Christof Weinhardt. 2012. Internet of Energy - ICT as a Key Technology for the Energy System of the Future. *Business & Information Systems Engineering* 4, 1: 1–2.

[6] Apple. 2017. *CarPlay*. Retrieved from https://www.apple.com/ios/carplay/available-models/

[7] Associated Press. Fiat Chrysler, Google Begin Offering Rides in Self-driving Cars. *VOA*. Retrieved August 15, 2017 from https://www.voanews.com/a/fiat-chrysler-self-driving-cars/3824581.html

[8] Audi. 2017. Audi Connect. Retrieved August 14, 2017 from http://www.audi.com/en/innovation/connect.html

[9] Audi. 2017. Audi connect and infotainment. Retrieved August 14, 2017 from https://audi-illustrated.com/en/CES-2016/Audi-connect-und-Infotainment

[10] BMW. 2017. BMW i Ventures. Retrieved August 14, 2017 from www.bmwiventures.com/portfolio

[11] BMW. 2017. BMW Cardata.

[12] BMW. 2017. BMW Connected Drive. Retrieved August 14, 2017 from https://www.bmw.com/en/topics/fascination-bmw/connected-drive/overview.html

[13] BMW Group. 2014. BMW i Ventures announces strategic investment in Zendrive. Retrieved August 14, 2017 from https://www.press.bmwgroup.com/usa/article/detail/T0196902EN_US/bmw-i-ventures-announces-strategic-investment-in-zendrive?language=en_US

[14] Frank Boons and Florian Lüdeke-Freund. 2013. Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production* 45: 9–19. https://doi.org/https://doi.org/10.1016/j.jclepro.2012.07.007

[15] Peter J Brews and Christopher L Tucci. 2007. The structural and performance effects of internetworking. *Long Range Planning* 40, 2: 223–243.

[16] Jason Dedrick. 2010. Green IS: Concepts and issues for information systems research. *Communications of the Association for Information Systems* 27: 173–184.

[17] Thomas Eisenmann, Geoffrey Parker, and Marshall Van Alstyne. 2011. Platform envelopment. *Strategic Management Journal* 32, 12: 1270–1285. https://doi.org/10.1002/smj.935

[18] Thomas R Eisenmann, Geoffrey Parker, and Marshall W. Van Alstyne. 2006. Strategies for Two-Sided Markets. *Harvard Business Review* October: 1–12. https://doi.org/10.1007/s00199-006-0114-6

[19] FCA. 2017. u-connect. Retrieved August 15, 2017 from https://www.driveuconnect.eu/en/features/controls

[20] FCA. 2017. FCA Dealer Digital Programme. Retrieved August 15, 2017 from http://www.fcadealerdigital.com/

[21] Nicolai J Foss and Tina Saebi. 2016. Fifteen Years of Research on Business Model Innovation. *Journal of Management* 43, 1: 200–227. https://doi.org/10.1177/0149206316675927

[22] Andreas Habeck, John Newman, Michele Bertoncello, Matthias Kässer, Florian Weig, Martin Hehensteiger, Julian Hölz, Ralf Plattfaut, Chad Wegner, Michal Guminski, and Zexiong Yan. 2014. *Connected Car, automotive value chain unbound.*

[23] IBM. 2017. IBM Integrates with BMW CarData to Enable New and Innovative Services for Drivers. *News Releases*. Retrieved August 14, 2017 from www-03.ibm.com/press/us/en/pressrelease/52595.wss

[24] C Kaiser, A Stocker, Gianluigi Viscusi, A Festl, P Mörtl, and M Glitzner. 2017. Quantified Cars: An exploration of the position of ICT start-ups vs. car manufacturers towards digital car services and sustainable business models. In *2nd International Conference on New Business Models (NBM2017)*.

[25] Jannis Kallinikos, Aleksi Aaltonen, and Attila Marton. 2013. The ambivalent ontology of digital artifacts. *MISQuarterly* 37, 2: 357–370.

[26] Per-Henrik Karlsson, Hong Kyu Ahn, and Byeongmin Choi. 2016. *Connected CAr*. Retrieved from https://www.ipsos.com/sites/default/files/2016-06/022.1-connected-car-a-new-ecosystem.pdf

[27] Stamatis Karnouskos and Orestis Terzidis. 2007. Towards an information infrastructure for the future Internet of energy. In *Communication in Distributed Systems (KiVS), 2007 ITG-GI Conference*, 1–6.

[28] Florian Lüdeke-Freund, Lorenzo Massa, Nancy Bocken, Alan Brent, and Josephine Musango. 2016. *Business models for shared value: Main Report*. Network for Business Sustainability South Africa.

[29] Kalle Lyytinen, Youngjin Yoo, and Richard J Boland Jr. 2016. Digital

product innovation within four classes of innovation networks. *Information Systems Journal* 26, 1: 47–75. https://doi.org/10.1111/isj.12093

[30] Arvind Malhotra, Nigel P Melville, and Richard T Watson. 2013. Spurring Impactful Research on Information Systems for Environmental Sustainability. *MIS Quarterly* 37, 4: 1265–1274.

[31] Lorenzo Massa and Christopher L. Tucci. 2014. Business Model Innovation. In *The Oxford Handbook of Innovation Management*. https://doi.org/0.1093/oxfordhb/9780199694945.013.002

[32] Lorenzo Massa, Christopher L. Tucci, and Allan Afuah. 2017. A Critical Assessment of Business Model Research. *Academy of Management Annals* 11, 1: 73–104. https://doi.org/https://doi.org/10.5465/annals.2014.0072

[33] Mercedes. 2017. Mercedes Me. Retrieved August 14, 2017 from https://www.mercedes-benz.com/en/mercedes-me/

[34] Mercedes. 2017. Mercedes Me Connect. Retrieved August 14, 2017 from https://www.mercedes-benz.com/en/mercedes-me/connectivity/

[35] Satish Nambisan. 2013. Information Technology and Product / Service Innovation : A Brief Assessment and Some Suggestions for Future Research. *Journal of the Association for Information Systems* 14: 215–226.

[36] Satish Nambisan. 2016. Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship. *Entrepreneurship Theory and Practice*: n/a-n/a. https://doi.org/10.1111/etap.12254

[37] Gina Neff and Dawn Nafus. 2016. *Self-Tracking*.

[38] R Normann and R Ramìrez. 1994. *Designing interactive strategy: from value chain to value constellation*. Wiley,Chichester.

[39] Alexander Osterwalder and Yves Pigneur. 2010. *Business Model Generation*. John Wiley & Sons.

[40] Geoffrey G Parker, Marshall W Van Alstyne, and Sangeet Paul Choudary. 2016. *Platform revolution: How networked markets are transforming the economy-and how to make them work for you*. WW Norton & Company.

[41] M. Rappa. 2001. Business models on the web: Managing the digital enterprise. Retrieved from digitalenterprise.org/models/models.html

[42] M. A. Rappa. 2004. The utility business model and the future of computing services. *IBM Systems Journal* 43, 1: 32–42. https://doi.org/10.1147/sj.431.0032

[43] Stefan Schaltegger, Florian Lüdeke-Freund, and Erik G Hansen. 2016. Business Models for Sustainability. *Organization & Environment* 29, 3: 264–289. https://doi.org/10.1177/1086026616633272

[44] Andrew Shipilov. 2016. Why Aren't Automakers Embracing Digital Business Models? *Harvard Business Review*, December 30.

[45] Alexander Stocker, Christian Kaiser, and Michael Fellmann. 2017. Quantified Vehicles. *Business & Information Systems Engineering* 59, 2: 125–130.

[46] Fredrik Svahn, Lars Mathiassen, and Rikard Lindgren. 2017. Embracing digital innovation in incumbent firms: How Volvo cars managed competing concerns. *MIS Quarterly* 41, 1: 239–253.

[47] Melanie Swan. 2013. The quantified self: Fundamental disruption in big data science and biological discovery. *Big Data* 1, 2: 85–99.

[48] David Tilson, Kalle Lyytinen, and Carsten Sørensen. 2010. Digital Infrastructures: The Missing IS Research Agenda. *Information Systems Research* 21, 4: 748–759.

[49] Richard Viereckl, Dietmar Ahlemann, Alex Koster, Evan Hirsh, Felix Kuhnert, Joachim Mohs, Marco Fischer, Walter Gerling, Kaushik Gnanasekaran, Julia Kusber, Juliane Stephan, David Crusius, Henning Kerstan, Trent Warnke, Manuel Schulte, Jonas Seyfferth, and Edward H. Baker. 2016. *Connected car report 2016: Opportunities, risk, and turmoil on the road to autonomous vehicles*. Retrieved from http://www.strategyand.pwc.com/reports/connected-car-2016-study

[50] G. Viscusi. 2015. Digital business innovation: roadmaps and attitudes from a FutureEnterprise perspective. *Génie Logiciel* 115: 36–41.

[51] G. Viscusi and C. Batini. 2014. Digital Information Asset Evaluation: Characteristics and Dimensions. In *Smart Organizations and Smart Artifacts SE - 9* (Lecture Notes in Information Systems and Organisation), 77–86. https://doi.org/10.1007/978-3-319-07040-7_9

[52] G. Viscusi and C. Batini. 2016. Information Production and Social Value for Public Policy: A Conceptual Modeling Perspective. *Policy & Internet* 8, 3: 334–353. https://doi.org/10.1002/poi3.121

[53] G. Viscusi, M. Castelli, and C. Batini. 2014. Assessing social value in open data initiatives: a framework. *Future Internet* 6, 3: 498–517. https://doi.org/10.3390/fi6030498

[54] Volkswagen. 2017. Volkswagen car-net. Retrieved August 14, 2017 from http://www.vwcarnetconnect.com/

[55] Richard T. Watson, Marie-Claude Boudreau, and Adela J. Chen. 2010. Information systems and environmentally sustainable development: energy informatics and new directions for the is community. *MIS Quarterly* 34, 1: 23–38. https://doi.org/Article

[56] Youngjin Yoo. 2013. The Tables Have Turned: How Can the Information Systems Field Contribute to Technology and Innovation Management Research?. *Journal of the Association for Information Systems* 14: 227–236.

[57] Youngjin Yoo, Richard J Boland, Kalle Lyytinen, and Ann Majchrzak. 2012. Organizing for Innovation in the Digitized World. *Organization Science* 23, 5: 1398–1408. https://doi.org/10.1287/orsc.1120.0771

[58] Youngjin Yoo, Kalle J. Lyytinen, Richard J. Boland, and Nicholas Berente. 2010. The Next Wave of Digital Innovation: Opportunities and Challenges: A Report on the Research Workshop "Digital Challenges in Innovation Research" (June 8, 2010). *SSRN*. Retrieved May 12, 2017 from https://ssrn.com/abstract=1622170 or http://dx.doi.org/10.2139/ssrn.1622170

[59] Christoph Zott and Raphael Amit. 2010. Business model design: an activity system perspective. *Long range planning* 43, 2–3: 216–226. https://doi.org/10.1016/j.lrp.2009.07.004

[60] Christoph Zott and Raphael Amit. 2017. Business Model Innovation: How to Create Value in a Digital World. *GfK Marketing Intelligence Review* 9, 1: 18–23. https://doi.org/10.1515/gfkmir-2017-0003