European Commission

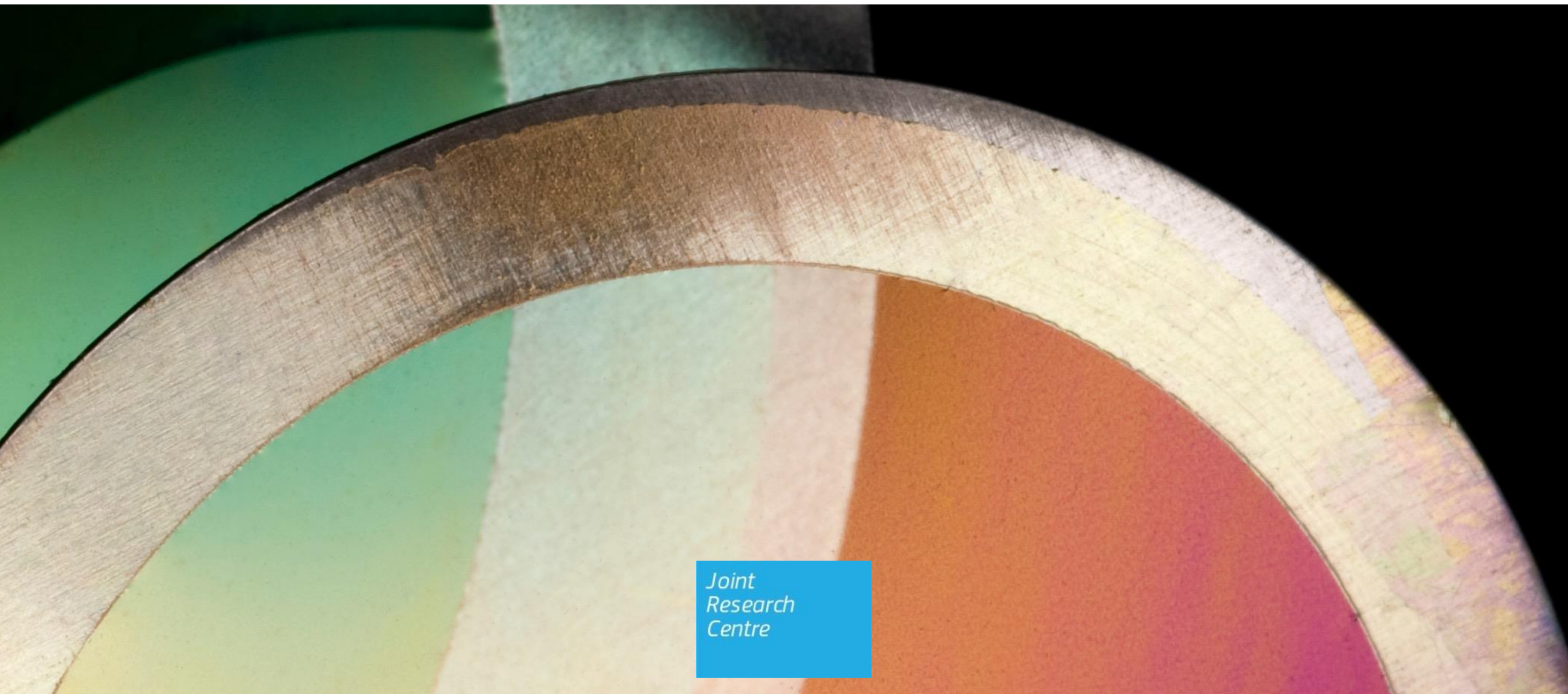
JRC TECHNICAL REPORTS

JRC Digital Economy Working Paper 2018-06

Access to digital car data and competition in aftersales services

Bertin Martens
Frank Mueller-Langer

September 2018



Joint Research Centre

This publication is a Working Paper by the Joint Research Centre, the European Commission's in-house science service. It aims to provide evidence-based scientific support to the European policy-making process. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication.

Contact information
European Commission, Joint Research Centre
Address: Edificio Expo. c/Inca Garcilaso, 3. 41092 Seville (Spain)
E-mail: bertin.martens@ec.europa.eu
Tel.: +34 954488318

JRC Science Hub
https://ec.europa.eu/jrc

JRC112634

ISSN 1831-9408 (online)

Seville, Spain: European Commission, 2018

How to cite: Bertin Martens and Frank Mueller-Langer; Access to digital car data and competition in aftersales services, Digital Economy Working Paper 2018-06; JRC Technical Reports.

Table of Contents

Abstract

This study looks at car data markets from an economic perspective. We start from several options for the technical characteristics of data access points that have been discussed among stakeholders in the automotive industry. We examine the structure of data markets that are likely to emerge from these characteristics and the implications for the welfare of manufacturers, aftermarket service providers and drivers. Car manufacturers face competition in car markets and aftersales services. However, they can design the car data architecture to ensure their exclusive access to the data. That would give them a monopoly in the market for car data from their brand. They can use this to increase their leverage on aftersales services markets. Our baseline scenario is the Extended Vehicle proposal that manufacturers prefer. This ensures their data access monopoly and enables them to maximizes revenue from data and data-driven aftersales services. It reduces welfare for drivers and aftersales service providers. Two technical variations on the baseline scenario reduce manufacturers' leverage over data server governance and their monopolistic power. That could reduce social welfare losses and transfer more surplus to drivers and service providers, compared to the baseline scenario. Other scenarios examine alternative data access gateways, for instance by keeping the OBD plug open and by applying real time data portability under the GDPR. These scenarios may offer some scope for regulators if they wish to keep alternative data access channels open in order to stimulate competition in aftersales services markets. However, they entail additional hardware and switching costs for consumers, compared to the baseline and are therefore partial and imperfect substitutes. In two final scenarios we examine the market position of B2B data marketplaces and consumer media services platforms. The potential for data aggregation across car brands and other sources creates some possibilities for these platforms to provide a counterweight to monopolistic behaviour by the manufacturers. However, manufacturers' control over the data supply and access to the in-car human interface ensures that they retain substantial leverage over these platforms. Regulators may consider creating the conditions for a more level playing field between OEM services and third-party aftersales service providers. As a next step in this research, the general scenario-based observations in this study would have to be complemented with empirical evidence on the data market power of car manufacturers.

1. Introduction

Modern cars are Internet-of-Things devices. They are loaded with digital sensors embedded in mechanical parts and a geo-location tracker. Mobile communication channels facilitate external processing and use of the data by a wide range of service providers. Many parties may want to access and extract value out of these data, including car makers or Original Equipment Manufacturers (OEMs), drivers, OEM-authorized as well as independent aftersales service providers, data market operators and analysts, etc. Car data can be used for several types of services, including navigation, information & entertainment, maintenance & diagnostics and insurance (McKinsey & Company, 2014 & 2015). Revenue from these digital services is estimated at 225 € per car per year and total market size could reach 3.8 bln € per year in the EU by 2021 (Source: Statista. See Fig 1-2-3 in annex). It remains small compared to traditional aftersales maintenance and repair services[1] that are estimated at about 120 bln €/year or 800 €/car/year[2] in the EU, or compared to the EU automotive insurance market where total premium revenue amounts to about 130 bln € per year[3]. However, the main impact of these innovative data services will be to trigger shifts in aftersales services spending over the life-cycle of a car (McKinsey, 2015). Data will play an important role in nudging consumers into buying new offerings for automotive services. Even minor shifts in these markets may re-route billions of euros into other hands. Digital services will increase price competition and drive down prices in traditional services markets. Access to car data will therefore be essential for aftermarket service providers and consumers.

Car manufacturers (OEMs) design the car, including data access points and communication gateways. Under the Extended Vehicle data architecture proposed by the automotive industry (ACEA, 2016a, p 10) all car data would be collected exclusively on data servers operated by the OEM. While OEMs face competition in car sales and aftersales services markets, this data architecture gives them a monopoly on data for cars from their brand. In the absence of alternative data gateways OEMs become the only source of access to the data. Aftersales services suppliers have no other choice than to buy data from OEMs and accept the sales conditions, including prices, for the production of data-driven aftersales services. OEMs can fix a price that maximizes their revenue and strengthens their competitiveness in car sales and in aftersales services markets. They become price setters in a monopolistic market, not price takers in a competitive market. OEMs can be exposed to competition from other data-based services platforms orbiting around the connected car, such as media and infotainment services, navigation services and data marketplaces. However, all these depend on the supply of data from OEMs and on access to the human interface in the car to deliver their service messages to drivers. Alternative data supply channels, such as the OBD plug, may be available but are only partial substitutes for OEM-controlled channels. Service providers are concerned about access conditions and pricing of the data. These conditions will be crucial in shaping a level playing field for competition and new businesses around innovative data-driven aftersales services.

There is an on-going debate about the technical access conditions to car data for several years now (European Commission, 2016; TRL, 2017). That debate has been dominated by the trade-off between cybersecurity and

---

[1] The aftersales market is traditionally defined as a hardware market for car accessories, and physical maintenance and repair services. Here we use a wider definition that goes beyond hardware and includes all aftersales services contracted by drivers following the signature of a purchase, lease or rental agreement for a car. This includes finance and insurance, navigation and driving assistance, media and infotainment services inside the car, etc. In the pre-digital age these service choices were based on very little information. For example, insurance pricing was based on the driver's past track record, not on mileage or driving style. Today, these services are affected by fine-grained car data that can be shared with many interested parties.

[2] of which about 42% is channeled through authorized repair shops linked to car brands and 58% through independent repair shops (Boston Consulting Group, 2012).

[3] See https://www.insuranceeurope.eu/motor

data access. The objective of this study is to complement that technical debate with a more economic look at data access and pricing conditions, market structures and competition, network effects and switching costs that play an important role in economic outcomes. We start from the technical characteristics of data access points and examine the structure of data markets and aftersales services markets that are likely to emerge from these characteristics. Are they competitive or monopolistic, how important are switching costs to circumvent technical barriers, are there any network effects in aftersales services? We then look at the implications of these market characteristics in terms of pricing and economic welfare for OEMs, aftersales service providers and drivers/consumers. This economic perspective adds a new dimension to the trade-off between cybersecurity and access.

We explore various scenarios. In a baseline scenario, similar to the Extended Vehicle concept, OEMs have exclusive access to car data which they may make available at monopolistic prices to aftersales service providers. They offer drivers a limited choice of data services that are bundled with the car. OEMs may invoke security arguments to justify this choice. We then explore variations on this baseline with "neutral server" and "by-pass server" scenarios that weaken the control and oversight of OEMs on the data server. We also investigate two scenarios with alternative data gateways that allow drivers to access the car data directly and transfer them to the service provider of their choice. One of these operates through the existing OBD plug in cars. The other follows a regulatory pathway provided by the portability clause (Art 20) of the EU General Data Protection Regulation (GDPR). Finally, we look at two scenarios that take car data out of OEM brand-based silos and aggregate them in multi-sided data markets that span many OEMs. We are particularly interested in these scenarios because they might increase competition between car brand-specific hardware platforms and broader data supply and services platforms that operate across car brands, such as navigation, infotainment and automated driving services. They generate economies of scope in data aggregation and offer possibilities for aftersales service providers to expand their market reach and for consumers to access a wider variety of services. All these scenarios revolve around two main themes: the extent of technical control of the OEM over the data, and legal ownership and access rights to the data. While the technical debate has been on-going for a number of years already, the legal debate is only starting.

We find that monopolistic behaviour in data markets benefits the OEMs but is likely to diminish welfare for consumers and aftersales service providers. A key issue is whether competition between OEMs and market pressure from consumers, service suppliers and alternative services platforms will be sufficiently strong to attenuate monopolistic behavior and make car data markets and data-driven aftersales services markets more competitive. If not, discrepancies between the private and social value of car data may lead to market failures and require regulatory and/or competition policy intervention. We conclude with some recommendations to promote competition in data-driven services markets.

This is essentially a conceptual paper. There is as yet very little empirical evidence available on these emerging car data markets, let alone accessible. We try to fit the available and mostly anecdotal evidence to the conceptual economic picture that we develop in this study. Future research would need to collect more empirical evidence on market access conditions on the consumer and supply sides of car data platforms, including for data marketplaces, media and infotainment platforms, and OBD services platforms. Who benefits or loses in each of our scenarios is ultimately an empirical question.

The paper is structured as follows. In section 2 we present some basic technical features of the car data ecosystem, including data access points and communication interfaces. Section 3 explores several data access scenarios and their economic implications for different categories of stakeholders, including OEMs, drivers and aftersales service providers. Section 4 discusses some policy implications and formulates four recommendations to increase competition in car data markets.

2. Technical characteristics of the car data ecosystem

2.1. Stakeholders and data access channels

We consider three groups of stakeholders in the emerging digital car data ecosystem:

- Car manufacturers (OEMs) design the car and data architecture. They can design it in such a way that they keep exclusive control over data access. It is costly for buyers to modify this set-up or retrofit additional data hardware. Software may be added or updated more easily, provided the underlying hardware and operating systems can accommodate the upgrades[4].

- Consumers or drivers buy, lease or rent cars. After the purchase they are locked into the specific hardware and software architecture of that car, similar to the situation of a smartphone buyer who is locked either into the Google Android or the Apple iOS platform. Since cars are costly consumers do not switch easily between different cars.[5]

- Suppliers of aftersales services will be affected by the relative openness of the hardware and software design of the car. In the pre-digital age, OEMs had little information on what happened to the car after it left the showroom. Cars would show up at authorised workshops for hardware maintenance but that frequency declines with the age of the car. OEMs could to some extent capture hardware markets by patenting the design of spare parts for example. That avoided market entry by independent suppliers but also increased maintenance costs for consumers. OEMs usually had very limited leverage in aftersales services such as navigation (produced by map publishers), media and infotainment (via a build-in radio), insurance (usually a separate company) or simply gas station services. In the digital age car data play an increasingly important role in all these aftersales services markets. Maintenance and diagnostic services can have access to data from mechanical sensors in the car. Navigation services rely on GPS-tracker data that are matched with a digital map on the screen (i.e., the Human-Machine Interface (HMI)) in the car. Conversely, cars may feed navigation service providers with traffic, weather and parking data from their immediate surroundings. Insurance can be bought on a pay-when & how-you-drive basis, requiring continuous detailed navigation data input. Media and infotainment devices require access to the HMI and can seamlessly connect cars to cloud-based media services and drivers' home and mobile devices. Car data can be used for messaging to nudge consumer decisions about aftersales services and to apply price and quality discrimination in these services. A steady and timely supply of car data creates opportunities to reshape and innovate aftersales services markets. Rational consumers will consider the purchase of a car and aftersales service needs as a bundle of complementary products. However, prices, quantities and qualities of aftersales services may be subject to uncertainty at the time of the purchase decision.

[4] Life expectancy for most of the hardware can easily reach 15-20 years, though some parts will have to be regularly replaced by aftersales maintenance service providers. Rapid technological change implies that the life expectancy of data-driven software is usually shorter. Software can in principle be replaced more easily via downloadable updates. Additional data processing units may be retro-fitted to the car provided that a data access gate to the car’s built-in sensors is available. An open access operating system, as in laptops and smartphones for example, is the more efficient solution.

[5] Individuals or households can decide to buy two or more cars from different brands, or sequentially lease or rent cars from different providers. They may want to connect these cars to a single data platform or use their right to data portability between platforms (GDPR, Article 20).

Access to car data is crucial for the welfare of each of these stakeholder groups. McKinsey (2016) identifies three technical data access points: the HMI or the screen and buttons in the car that are essential for interaction with the driver, the in-car data network that collects data from all mechanical sensors in the car, and geo-location (GPS) data. While drivers' smartphones can easily substitute for the build-in GPS, and to some extent for the car screen, there is no substitute source for the car's mechanical data. The European Commission's C-ITS Working Group 6 (2016) identified three options for access to car data: the on-board application platform (OBAP), the central data server platform (CDSP) and the in-vehicle interface (IVI). Within each of these options, several sub-options can be identified. We discuss the technical characteristics of these three data access channels in the next sections.

These three data architectures require communication between the car and external service providers. Since car manufacturers have no spectrum license to set up their own telecom network this requires intermediary services from licensed mobile phone network operators - that could be considered as another group of stakeholders. Large OEMs receive data from millions of embedded SIM cards when all their cars are connected. Intermediate "middle ware" B2B service providers have emerged that handle large pools of SIM cards, such as Cisco/Jasper and Cube Telecom for example. They manage the technical and administrative aspects of data traffic between the embedded SIM cards in cars and the OEMs' CDSPs. There is strong price competition between telecom operators to obtain preferential B2B contracts with OEMs. That puts OEMs in a powerful market position vis à vis telecom operators. As a result, consumers are locked into a specific telecom provider selected by the OEM[6] and pricing for data plans is monopolistic. For example, GM OnStar connectivity plans are routed through AT&T in the US and Vodafone in Europe. Some premium OEMs offer a generous free data transmissions package. For example Tesla allows for up to four years of free data use.

2.2. The Central Data Server Platform (CDSP)

This is the preferred option of the OEMs and corresponds with the "Extended Vehicle" concept (ACEA, 2016a)[7]. The CDSP takes the data out of the car via a dedicated hardware-locked SIM-card for storage and processing on a server controlled by the OEM. The server collects data directly from the car internal data network[8]. It can also send messages to the in-vehicle HMI[9]. The OEM may delegate server operation tasks to a third party. For example, several OEMs work with IBM BlueMix and Microsoft Azure cloud services, not only to store car data but also to provide data analytics and other value-added services.

OEMs argue that their preference for the CDSP is based on security reasons. The CDSP prevents unauthorised third-party access to the vehicle and vital mechanical functions of the car. Only in these circumstances they

[6] A few OEMs now allow drivers to transmit car data through their own smartphone data plan, for example the latest Audi models. See the description of the Audi MMI app in iTunes https://itunes.apple.com/es/app/mmi-connect/id570608111?l=en&mt=8

[7] See also Daimler-Benz proposals for an Extended Vehicle Standard http://taysad.org.tr/uploads/dosyalar/18-12-2014-01-26-5-Extended-Vehicle---a-proposal-for-sharing-diagnostics-data-in-the-future-Scheiblich-ve-Raith-Daimler-27-11-2014.pdf

[8] The Controller Area Network (CAN bus) is a robust vehicle bus standard, released by the US Society of Automotive Engineers (SAE) and originally designed by Bosch Gmbh. It allows microcontrollers and devices to communicate with each other in applications without a host computer. Modern cars may have dozens of electronic control units for various subsystems. Besides the engine control unit others are used for transmission, airbags, antilock braking/ABS, cruise control, electric power steering, audio systems, power windows, doors, mirror adjustment, battery and recharging systems for hybrid/electric cars, etc. Some of these are independent but communications among others are essential. The CAN standard was devised to fill this need. Electronic interconnection between different vehicle systems can allow a wide range of safety, economy and convenience features to be implemented using software alone - functionality which would add cost and complexity if such features were "hard wired" using traditional automotive electrics. See Wikipedia https://en.wikipedia.org/wiki/CAN_bus

[9] Audio-visual entertainment data are routed through another network in the car, called the MOST (Media-Oriented systems transport). This network can link up to 64 hardware and software media devices and control data traffic between these devices. The MOST can also exchange data with the CAN. See https://en.wikipedia.org/wiki/MOST_Bus

are willing to assume liability for vehicle security and third-party services applications. Others argue however that the CDSP increases risks because it is a "black box" proprietary operating system that relies mainly on limiting access rather than different layers of protections (TRL, pp.137-138). If a malicious hacker gains access to the OEM's central server it could affect many vehicles and not just one. Multi-layered and decentralized security systems at the level of the car, with a hypervisor that prevents write access to critical components may be safer than a centralized system. Continuously tested open source software may also offer more security. The debate in the cybersecurity community on the relationship between open source and security is far from settled (Celasco et al., 2016; European Commission, 2016a; Pattemore, 2016).

The CDSP option leaves OEMs in a privileged market position because they can monitor all data traffic between the car and the server. Alternative server governance architectures have been proposed (European Commission, 2016, C-ITS working group 6) that would weaken the OEM's exclusive control and privileged market overview. A first step would be for the OEM to transfer all car data to a Neutral Server controlled by a third party and not by the OEM. The neutral server operator would then ensure data distribution to service providers who request access to the data. These neutral servers could be thought of as intermediaries or B2B car data marketplaces catering to the needs of data suppliers (OEMs) and data users (aftersales service providers). IBM BlueMix, Caruso[10] and Otonomo[11] are examples of car data marketplaces. In this option OEMs no longer know which service providers access the data. Service providers would still be dependent however on a continuing data supply from the OEM. A further step would be to completely by-pass the OEM and bring the data directly from the vehicle to a Neutral Server, without passing through the OEM server. That would eliminate all OEM leverage over service providers. It should be noted however that changes in the server ownership structure do not necessarily change the behavioural incentives of the owners. Any firm that operates the data server seeks to maximize profits by playing on the data pricing and access conditions. That would drive a wedge between the economic interests of the OEMs and the aftersales service providers. Servers may be "neutral" in the technical sense of reducing the intermediary role of the OEMs but they are not necessarily neutral in the economic sense.

Transferring data between OEMs, servers and service providers requires standardized protocols. Some European OEMs have proposed to create an ISO standard for data transmission between cars and service providers via the CDSP, under the label "Extended Vehicle Standard" (ISO 20078)[12]. The Extended Vehicle transfer protocol would cover read and write access to cars. It is as yet unclear how many car data points would be covered by this standardized protocol, what the access conditions would be and how many OEMs would adhere to it. OEMs and data marketplaces are still experimenting with data transmission protocols. It is not clear to what extent the OEMs and several data management intermediaries have standardised protocols. To date, BMW is the only OEM that has made its car data accessible in an online store, for legitimate and registered users who are willing to pay the access price[13]. Other OEMs are making car data available to aftersales service providers but there is no publicly available information on access conditions.

[10] The Caruso car data platform was established by TecAlliance, a German data processing and consulting company, and a consortium of car parts OEM. The OEM are not involved as shareholders.

[11] Otonomo is a car data market platform that is mainly active in the US car data market and seeking to establish itself in the European market. It is financed by venture capital not directly related to the automotive industry.

[12] For more information on the ISO standard see https://www.iso.org/standard/66978.html There are several competing secure data transmission standards proposals, including by the US Society of Automotive Engineers (SAE) and the World Wide Web Consortium (W3C).

[13] See https://aos.bmwgroup.com/. That data are priced at 0.29 € per retrieval, with discounts for large volume downloads. There is no price differentiation by type of user or data type. BMW claims that all data users pay the same price, including wholesale deliveries to data market places.

In the server system, messaging and feedback to drivers can be routed through the OEM server and/or through the servers of service providers. Messaging works via apps installed on the driver's smartphone and/or on the car screen. These apps can be developed by the OEM or by service providers. They can be delivered through the OEM software platform or through a third-party platform (for instance Apply Carplay or Android Auto). For example the General Motors On-Star and Toyota T-Connect systems allow third-party application developers to install apps directly in the car and access data via the CDSP. TRL (2017, pp 67-69) reports that several major OEMs (Toyota, GM, Ford, PSA) allow external developers to access the data via APIs and provide developer toolkits (SDK), with services apps made available in dedicated app stores.

The data governance principles proposed by C-ITS working group 6 (European Commission, 2016) suggest Fair Reasonable and Non-Discriminatory (FRAND) access. This implies that service providers should have access to the entire set of data collected by the OEMs. We have been unable to verify to what extent this principle is currently applied by OEMs. There is no transparency in the list of data points collected and accessible by car brand, and possibly by vehicle model. GM OnStar claims to give access to 400+ vehicle data points. BMW has published a list of more than 60 data points that it downloads on a recurrent basis. Cars collect much more digital data but most are not transmitted to a server. This avoids transmission costs for data for which there is no clear business use..

TRL (2017) notes that the CDSP option suffers from latency because of delays incurred in sending data from the car to the server, re-formatting the data and onward transmission to the aftersales service provider who uses the data for his commercial services. Servers cannot give real-time data access for time-critical applications. Parallel use of OBAP data processing inside the car and CDSP processing outside the car could disadvantage market participants who operate through the CDSP.

2.3. Media platforms in the HMI

Many OEMs have created the possibility to install popular media and infotainment operating systems in the HMI (e.g., screens and buttons) in the car. These are not OBAPs. They consist mainly of a graphical interface attached to the HMI, not a full car data processing unit. Whatever car data are used by the apps are retrieved from the OEM CDSP, not directly inside the car. From a data security perspective infotainment data are routed via the MOST network[14] that can be separated from other car data.

Popular providers of mobile media devices, such as Apple and Google, have entered the market for car infotainment systems, based on their proprietary operating systems, Apple Car Play and Android Auto. Consumers are familiar with these media brands and operating systems in their home and mobile computing environments. They want connectivity and data synchronisation across several devices, family cars from different brands, and possibly even for rented cars[15]. Mobile media operators such as Apple iOS and Google Android are already offering cloud-base data storage to synchronise media use across consumer devices. This can be extended to cars. This can be done via the user's smartphone or when the car is within reach of a WiFi connection, for instance when parked at the driver's home. OEMs do not feel threatened by media services because they are complements and not substitutes for OEM services; there is no risk of direct competition with the core business of OEMs.

[14] See https://en.wikipedia.org/wiki/MOST_Bus

[15] Rented cars create questions about personal data control rights. In principle, every driver should give his consent for the collection of private data for the duration of his rental contract. He may also request portability of his personal data to another device (Article 20 of the EU GDPR).

Many applications are just on-board versions of popular smartphone media and navigation apps. Bringing well-known infotainment brands into the car may increase the attractiveness of the car for consumers and increase sales. "Mirroring" of smartphone screens on the larger HMI screen inside the car improves connectivity. Many of these infotainment systems already send out location, car identification and smartphone owner identification data, and sometimes more car operating data, to servers of the infotainment service providers or even to Facebook (Stiftung Warentest, 2017).

Under the Fair Reasonable and Non-Discriminatory (FRAND) access conditions to server data, proposed by C-ITS working group 6 (European Commission, 2016) one would expect that Apple and Google application developers would be able to access the full set of car data collected by OEMs on their servers. It is not clear however to what extent these conditions are effectively applied, and what the pricing of that access would be. If they would be able to access all these data, including core mechanical car data, it would enable Apple and Google developers to offer services that compete with the OEM in its core business domains. This may become a gateway for more functionality in future. In the longer run media platforms such as Apple Car Play and Android Auto could become standard operating system in the car's HMI. However, OEMs retain leverage over data access conditions, including pricing, and access to the HMI (see section 3.6 below) under which Apple and Google-based aftersales service providers operate.

2.4. The In-Vehicle Interface (IVI)

The IVI enables access car data directly in the vehicle for export to a third-party server and applications. It by-passes the OEM data server or any neutral server. Access is achieved via the On-Board Diagnostics (OBD) plug that gives open real-time data access. It was originally designed as an interface for emission diagnostics for environmental purposes and subsequently became a regulatory standard for that purpose[16]. It enables professional repairers to check the 'health status' of the car for diagnostic purposes. Data from the OBD port can be captured by plugging a “dongle” into the port. These retro-fitted devices can communicate data over short distances via USB wire, Bluetooth or Wifi to a smartphone and SIM card, or directly over longer distances via an embedded SIM card. Some dongles come with a build-in GPS; others use the GPS in the smartphone to by-pass the car's GPS system. As disadvantage is that OBD-based service providers cannot connect to the car’s HMI screen; the driver’s (smaller) smartphone screen is used as a display. That creates switching costs for users. Some OEMs have enabled MirrorLink[17] technology that re-transmits smartphone screens to the car's HMI screen.

Many business models have emerged around OBD dongle-based services platforms[18]. Some charge a price for the dongle and offer users a choice between a free but low-capacity (2G) data transmission channel, a higher capacity channel via the driver's smartphone, or a subscription fee for a separate SIM-card in the dongle. Some

[16] Directive 98/69/EC of the European Parliament and Council of 13 October 1998 relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directive 70/220/EEC. The OBD II standard (1990) includes parameter, protocol and hardware interface descriptions. There is no standardized OBD dataset however.

[17] See https://mirrorlink.com/

[18] Some examples: In the Nordic countries telecom operator Telia is the exclusive distributor for SpringWorks dongles. Deutsche Telecom distributes Mojio dongles and services in the US and the Czech Republic. Deutsche Telecom and Amazon, as cloud services provider, participate in the capital of Mojio. The Automatic dongle platform in the US sells its dongles via Amazon and Best Buy and transfer data directly via the driver’s smartphone data plan . Vinli in the US has teamed up with Meineke aftersales services. A 4G telecom connection via T-Mobile is optional, though required for the more interesting applications. Xee, a French dongle supplier, has teamed up with Midas and Norauto aftersales service providers to distribute and install the dongle. Automile, a Swedish dongle-based fleet services provider operates as a fully vertically integrated firm with no independent apps providers and no separate telecom plans.

OBD-based service providers have exclusive data transmission and hardware distribution deals with telecom operators. Others distribute their devices via aftersales service providers. Potential investors in OBD services platforms are likely to be discouraged by the growing trend among OEMs to close off access to the OBD port and reduce the number of the data points to the minimum requirements under environmental legislation in the EU.

Despite these disadvantages OEMs seem to perceive the IVI/OBD as a threat to their increasingly valuable data monopoly. Some OEMs are reversing the open data policy with regard to the OBD plug and now bring vehicles to the market that limit OBD data (European Commission, 2016a, p. 74) to the minimum emission-related data that are required under existing regulations. That strengthens the OEM's exclusive control on data access. Moreover, professional maintenance service providers who used the OBD plug to access the car's "health data" can no longer do so directly. Without OBD they can only access mechanical car data via the OEM's proprietary CDSP gateway. That gives OEMs a privileged overview of all maintenance providers and their activities, whether OEM-authorised dealers or independent service providers. Moreover, the OEM can charge for access to maintenance data and in this way transfer part of the surplus from maintenance activities back to the OEM.

OEMs argue that security concerns are responsible for this reversal in their data access policies. The OBD port has indeed proven security flaws that could interfere with car safety[19]. OBD-based applications are not tested and certified by the OEM and are added at the discretion of the owner/driver. There are security solutions available to address these concerns. For example, Vinli[20] offers an OBD plug-in device with security features that disables any "write" access to core vehicle functions. A general problem with all security applications is that they are subject to hacking and may require regular updates of security features in order to protect against the latest detected flaws. OEMs may not be willing to accept these third-party security solutions. Some OEMs have started to offer their own brand of retro-fitted OBD dongles mainly in order to bring older models that still have a long lifetime ahead into their data ecosystem[21].

2.5. The on-board application platform (OBAP)

Under this option the OEM would install a completely independent operating system inside the car, or such a system could be retro-fitted (and operated) by a third party. It would store and process data inside the car, though there are communication links with external data providers too. The operating system and the applications running on the system would have access to the car's internal data. The OEM however would have to approve and certify the application and agree on the dataset that it can access (Celasco et al., 2016; European Commission, 2016c) because the OEM remains responsible for the safety of the system and the integrity of the car's internal data network. TRL (2017) considers that the OBAP gateway to car data is the most equitable solution and is therefore in principle the best candidate to facilitate fair and undistorted competition.

The OEMs' main argument against OBAPs is security concerns with regard to access to the car's internal data. An important issue is to what extent OEMs are willing to buy into a growing number of security solutions for

[19] See this documented example https://argus-sec.com/remote-attack-bosch-drivelog-connector-dongle/
[20] See https://www.vin.li/blog/building-vinli-with-security-at-its-core
[21] For example Mercedes Me https://www.mercedes-benz.com/en/mercedes-me/connectivity/adapter/

the CAN bus developed by third parties, rather than develop their own security solutions[22]. TRL (2017, p 125) argues that many European OEMs are not ready for this and may have to invest considerably in developing safe and secure deep access platforms, unless they are willing to buy into existing solutions. More importantly perhaps, third party security solutions risk driving a software wedge between the OEM-controlled CAN data bus and third party data applications. Unless it is open source software, this additional layer would set a proprietary technology standard not owned by the OEM and possibly a common standard that may be used across many car brands. It would be equivalent to introducing a standardised operating system into the car, similar to Apple CarPlay or Android Auto[23], but completely disconnected from the OEM server and with data directly fed into the system inside the car. It would by-pass the OEM as the exclusive gateway to access the data. This could be a Trojan horse for OEMs. It could create an intermediate data platform where app developers, consumers and aftersales service providers could exchange data. An important counterargument against a proprietary operating system is that cars have a long hardware lifetime. Third parties may not be in a position to guarantee the continuation of data services over that lifetime. Consumers already experience this mismatch between hardware and software life cycles in personal computer and mobile phones for example; it forces them to replace the hardware before the expiry of its useful lifetime. Since cars are far more costly than phones, consumer welfare losses of faster hardware depreciation may be substantial.

Note that this study does not discuss car data systems and data markets for automated or self-driving vehicles. Automated driving systems are far more data intensive then any current car data networks can handle. They are also likely to require different types of data communication systems, both for vehicle-to-vehicle and vehicle-to-infrastructure data exchanges. Most of these data will have to be internally processed in the car in order to make it autonomous. Latency and the risk of interruptions in communications imply that a remote server cannot drive an autonomous vehicle. Consequently, on-board application platforms will become a necessary feature for automated driving systems. It is far from clear at this stage who will install, own and operate these automated driving systems in cars, and which parties will have access to the data. Some large OEMs are developing their own systems. Others may collaborate with firms that are developing their own automated driving systems. We prefer at this stage not to speculate on the data architecture of these systems and possible economic implications for OEMs, consumers and service providers.

---

22 For example the Towersec-Harman (a Samsung company) "Ecushield" technology (https://www.harman.com/security) provides multi-layered protection with hypervisor for access to CAN bus data. It separates infotainment data from the CAN bus and allows for real-time updates to protect against new viruses. Other security solutions create a protection shield encompassing all data networks in the car in a Vehicle Server System that includes the MOST and other networks. The World Wide Web Consortium (W3C) released a recommendation for a Vehicle Information Service Specification architecture in February 2018. See http://www.w3.org/TR/vehicle-information-service/#architecture

23 ACEA (2016a, 2016b), the car manufacturers association, argues that cars are not to be put on the same footing as a smartphone. Cars cannot be rebooted while driving and the private and public security concerns are vastly more important in cars compared to smartphones.

3. The economics of car data markets

Cars have a long life-time as hardware devices and require substantial complementary and unavoidable aftersales expenditure on maintenance costs, gas and insurance to keep the car operational. There are also optional aftersales services that increase user benefits of the car, such as media and navigation services. Cars can run without these optional services. Still, access to car data is important because they can be used to nudge consumers towards specific aftersales services, including optional services. In this section we explore the economic implications of several data access scenarios that mimic the technical options discussed in the previous section. We start with a baseline scenario (1) that follows the OEM's preferred CDSP option. All data are collected on the OEM server and distributed from there to aftermarket service providers. The OEM has exclusive control over the data and decides on access conditions, including monopolistic pricing of the data. We then explore two scenarios that have been discussed under the technical options. In a "neutral server" scenario (2) OEM oversight of aftersales service providers is limited but OEMs maintain their leverage on upstream data pricing conditions. The "by-pass server" scenario (3) completely removes the OEM as an intermediary between car data sources and aftersales service providers. We then move to two scenarios where the choice of data services provider is handed over to car owners or drivers. The IVI/OBD scenario (4) allows drivers to access data directly in the car and gives them a service provider of their choice. A regulatory scenario (5) whereby drivers would claim portability of their car data from the OEM server, or the neutral server, to a service provider of their choice would achieve similar results. We also add a network effects scenario (6) whereby service providers that operate across OEM brand-based data silos create a multi-sided market, either at the level of data marketplaces (6a) or at the level of aftersales services (6b). These multi-sided markets benefit from network effects and economies of scope in data aggregation that OEMs cannot match. However, to the extent that OEMs retain leverage over the supply conditions for the primary data they may appropriate part of that surplus. All these scenarios revolve around two themes: whether or not the OEM has technical control over the data and who has legal ownership and access rights to car data?

A note of caution is needed before we start the debate. The following sections present a conceptual economic analysis of the technical options regarding car data access systems. This is not an empirical analysis because there are hardly any empirically observed data available, mainly because most of these systems and services are still in the very early stages of development. The technical details of car data retrieval systems are also still evolving. A fully fledged quantitative empirical assessment of economic impacts would require a rich dataset that combines variations in access conditions with information on consumer demand, pricing, quality and variety of the services offered. Such comprehensive datasets do not exist yet and we may have to wait quite a while before they become available. Nevertheless, we think that it is useful to do a more abstract and conceptual analysis at this stage, illustrated with some very partial evidence where available, in order to gain some preliminary insights in the factors that play a role and the potential outcomes.

3.1 The baseline scenario: OEMs as exclusive data gatekeepers

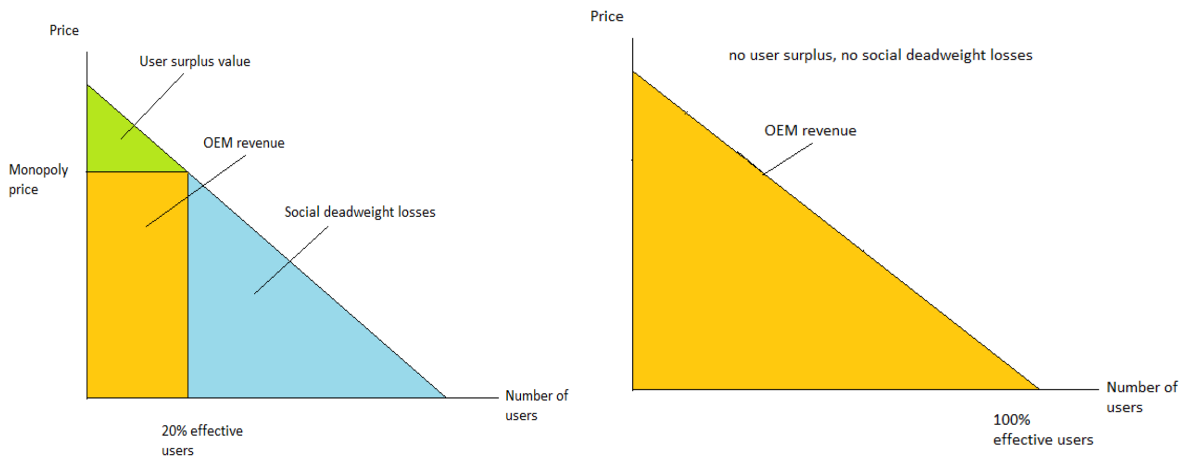
In the baseline scenario OEMs implement the data architecture foreseen under the Extended Vehicle concept. That puts them in a monopolist position with exclusive control over the data generated by cars. Data are collected and stored on a central server (CDSP) operated by the OEM in brand-based data silos. Alternative data access ports (OBD and OBAP) are closed to third parties. The OEM can produce its own aftersales services with the data. It can also grant access to the data to third-party service providers. Indeed, under the voluntary FRAND data governance rules proposed by C-ITS working group 6 (European Commission, 2016)

OEMs would be obliged to give access to any party that has a legitimate claim to use the data. The question then is: under what conditions will service providers have access to the data? We examine these conditions from an economic perspective, not a technical perspective. This would include quantity, quality and pricing of the data. Quantity refers to the number of data points available. Assuming FRAND conditions, one would expect that all data points collected by the OEM would be made available to service providers, though this is by no means clear at this stage. Quality could refer to timing and latency. The frequency of availability, including for time critical data, is not specified in the C-ITS data governance principles. Prices could vary with the quality and quantity of the data. In our economic analysis we focus on prices only.

As exclusive data gatekeepers the OEMs are in a monopoly position in the data market for cars from their brand. OEMs are price setters in this market. They will calculate a monopoly price for the data, taking into account the price-sensitivity of consumers. Figure 1a presents the trade-off between data prices and consumer demand (the number of users as a percentage of total potential users). McKinsey (2016) reports that only about 20% of all drivers effectively use the data services available in their cars. The rest is not willing to pay the price or is not interested in the service. Monopolistic pricing maximizes OEM revenue (the orange area). It reduces consumer surplus value (the green triangle) and leaves a substantial social deadweight loss (the blue triangle). OEMs maximize their benefits but society as a whole faces a substantial loss as data services are underutilized. Monopolistic pricing reduces the quantity and variety of services inside the car.

One way to reduce social losses is for the OEM to apply perfect price discrimination between data users. This is reflected in Figure 1b. Every data or data service user could be charged a different price according to his ability and willingness to pay. Pricing would depend on the relative profitability of aftersales services that depend on the data. Users who obtain high benefits from using the data are charged higher prices. But users with a low value-added and low willingness to pay also get served. For example, a few data points for an instant car crash report for insurance companies have a higher value than a stream of car navigation data points. That increases OEM revenue, eliminates social losses but also eliminates consumer surplus value. In the case of perfect price discrimination all benefits from data accrue to the OEM (as in figure 1b). Price discrimination can be practiced for instance when the sale of digital data takes place via auctions (Bergemann & Bonatti, 2016). Collecting and storing data on a server usually entails high fixed cost (setting up and managing the system) and low marginal costs (additional cost of adding more data). That leaves a large margin for flexibility in the pricing.

Figures 1a and 1b: Monopoly data pricing by the OEM



In practice, the feasibility of price discrimination in data markets depends on the how much information the OEM has about its data customers and the benefits that the data generate for them. Currently, the only online store for car data is the BMW AOS system that was launched in June 2017.[24] BMW charges a flat rate of 0.29 € per data retrieval, irrespective of the customer or the data points that are being retrieved[25]. Discounts are available for large volumes of retrievals. There is no third-degree price discrimination. BMW argues that it would be too complex and costly to negotiate prices with every customer or for every purpose. That pricing reflects the market description in Figure 1a. Some users will be willing to pay that price. Indeed for some applications it may be rather cheap. Other cannot afford that price because it exceeds the value of their usage. As such, BMW is a price setter in the market for its own car data. We could not find information on data pricing schedules of other OEMs. OEM pricing distorts the level playing field for data service providers. Third-party service providers pay a price for accessing the data while the OEMs' own services apps do not. OEMs argue that they bear the cost of setting up the server infrastructure and running the system. This is likely to involve a high fixed cost and low marginal costs. Marginal cost pricing would not be profitable in these conditions.

There is some evidence that drivers are also charged a monopolistic price for access to aftermarket services delivered by the OEM, or through the HMI in the car. We collected some published consumer pricing schedules for data-driven services subscriptions from a sample of OEMs (Table 1 in annex). Prices vary between roughly 200 and 350 USD per year in the US, depending on the composition of the services package. They are considerably lower in the EU at around 100 €/year. These services packages combine maintenance & diagnostics with navigation and infotainment services. There is also evidence of price discrimination strategies towards drivers for access to aftersales services apps. For example, BMW's own services apps cost between 50 and 300 € per year, depending on the package chosen by the driver. Different services bundling options reveal monopolistic pricing and price discrimination by type of driver. That increases OEM revenues while at the same time reducing deadweight losses.

OEMs may argue that their market position in aftersales services apps is not monopolistic because there are competing options and alternative data channels available to drivers. For example, navigation services can easily be delivered through the driver's smartphone, without any need to access the OEM server. Similarly, media & infotainment services can be routed through smartphones as substitutes for the HMI in the car though in many cases they cannot access the car speakers. However, that competition is tempered by switching costs for drivers between alternative channels. OEMs control access to the HMI and force drivers to access alternative services on their smartphone screens. Drivers have to divide attention between the larger HMI screen and the smaller smartphone screen.

In order to estimate the true extent of OEM market power we would not only need data on the pricing of these services but also on the number of effective users, and some data on user characteristics. OEMs have these data but do not make them available for research purposes. We were therefore unable to estimate the price

[24] We cite examples from BMW on several occasions in this paper. That is because BMW is a front-runner in opening a data store and has publicly advertised its pricing schedule. Other OEMs are less forthcoming in publishing that information. This study is not targeting BMW in any way.
[25] See https://bmwcardata.bmwgroup.com/pricing/en/BMWCarDataPriceList.pdf. To the best of our knowledge there are no other OEMs that have publicly announced the terms and (price) conditions for access to their data platforms.

elasticity of demand[26] for app-based services on the driver side or demand for data on the third-party service provider side. If such statistics would be accessible one could empirically estimate the market power of OEMs by means of price elasticities of demand on the consumer and service supplier side of the data market.

OEMs can cope with competition in aftersales services markets as long as they maintain a monopoly on the data that drive these services, and on access to the HMI. Competition will put pressure on profit margins of service providers. On the other hand, OEMs cannot push their monopolistic position too far. High aftersales service costs may reduce the attractiveness of the car to consumers. Competition between OEMs may force them to improve the variety of data-driven services offerings. Parker et al (2017, p 261) and West (2003) note that firms may prefer higher rents from closed systems unless they face competition from rival platforms.

3.2. The "neutral" server scenario

This scenario is the subject of intense debate among OEMs and aftersales service providers. OEMs would transfer their data to a server operated by a third party and no longer have a privileged overview of transactions between that server operator and aftersales service providers. Still, OEMs remain the exclusive source of supply of data for cars belonging to their brand and can continue to practice monopoly pricing of the data.

OEMs would no longer know the customer of the data or the purpose for which they are used. That makes price discrimination difficult and excludes price discrimination strategies as a method to reduce social welfare losses from the OEM's data monopoly position. OEMs will have to revert to the single monopoly price scenario in Figure 1a, with higher social welfare losses. We come back to neutral servers when we discuss the economic implications of data market places in Scenario 6a.

3.3. The "by-pass" server scenario

In this scenario the third-party server would no receive car data via the OEM server but directly from cars. That eliminates the OEMs' exclusive gateway position and, consequently, their ability to charge monopolistic prices for the data. For this reason it is very unlikely that the OEMs would accept such a scenario. OEMs will argue that the by-pass server cuts off their access to the cars and prevents them from checking the cybersecurity system, uploading updates of the firewall and other software, etc. They cannot take responsibility for the integrity of the car data system in these conditions.

We can distinguish two sub-scenarios in the by-pass server. If there is only a single by-pass server, the operator of that server would simply take over the OEM's role as data monopolist and can start charging monopolistic prices. It would not change the market structure. If there are several competing by-pass servers and drivers can chose which server to share their data with, data markets would become more competitive and prices would drop below monopolistic pricing, possibly reaching a competitive price that comes closer to the real cost of collecting, storing and distributing the data.

[26] The price elasticity of demand measures the extent of price sensitivity of consumers. If consumers have alternative choices they will be very sensitive to price changes by one supplier. If they have no alternatives they will be less sensitive to this. Price elasticities can also vary with the income level of consumers.

An advantage of the by-pass server scenario is that it creates a level playing field between OEMs as aftermarket service providers and third-party service providers. They both pay the same price and face the same access conditions for car data.

We will come back to the economic consequences of a competitive data market when we discuss Scenario 5 and data portability which has economic similarities with the by-pass server scenario, at least in the case of multiple by-pass servers where drivers can decide on the destination of their car data.

3.4. Data access via the OBD bus

The OBD is an alternative gateway to access car data. It completely by-passes the OEM server and gives drivers real time access to their car data while driving[27]. OEMs have considerable freedom however in defining the number of data points available through the OBD port, subject to a minimum dataset defined in the regulation. They are currently using this freedom to reduce the set of data points to the regulatory minimum.

Access to the OBD erodes but does not necessarily eliminates the OEM's car data monopoly because switching costs limit the extent of competition. Switching costs between OEM-provided services and dongle platform services can be relatively high. The OBD does not give access to the car's GPS signal, the SIM card or the HMI screen. The car GPS can be easily replaced by a GPS in the dongle or in the driver's smartphone. The smartphone screen can only partially substitute for the HMI screen unless the OEM allows Mirrorlink applications that replicate the smartphone screen on the car screen (at a price). Drivers may not want to switch attention between smartphone and HMI screens. Data transmission to the service provider will be paid by the driver, either through a separate data plan or through the smartphone data plan. There are fixed switching costs (acquiring a dongle) and recurrent switching costs (paying for dongle platform services and possibly for a telecom connection, switching attention between screens in the car). The combination of all these sources of switching costs may not result in strong price competition with the OEM's own services offer. Consumers can use car data obtained via the OBD only for maintenance and diagnostics services. Navigation services provided via the OBD dongle can easily be replaced by navigation apps on a smartphone. The benefits may not be large enough to justify switching costs. This may explain why the dongle services platform market seems to be limited. No OBD-based platforms with significant market shares have emerged so far. The OBD is therefore only a partial substitute for aftersales services through the OEM platform.

An important advantage of OBD-based aftersales services platforms is that they are in a position to generate economies of scope in data aggregation across OEM brand-based data silos. Conversely, service providers can use these platforms to offer aftersales services across OEMs. There may be additional economic value in cross-brand aggregation because joined analysis of the merged data may provide more insights than separate analysis of each brand-linked dataset. However, the market seems to be very fragmented with a number of rather small and local operators.

3.5. Portability of car data

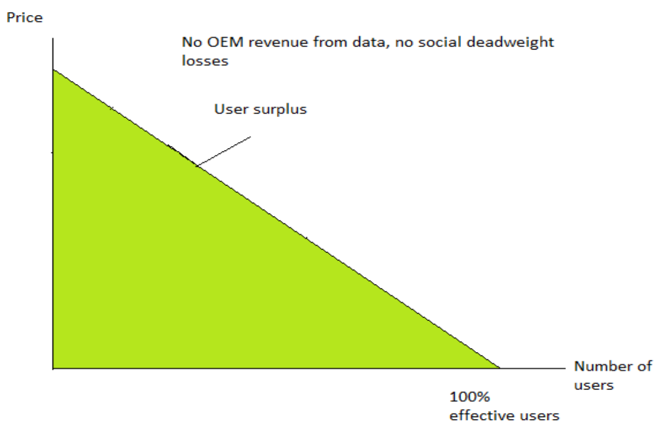
[27] Atomic, a US-based producer of OBD dongles and services, explicitly advertises its dongles as real-time access to car data. See https://www.pubnub.com/blog/2015-08-17-streaming-vehicle-data-and-events-in-realtime-with-automatic-part-1/

The OEMs' stated objection against data access via the OBD plug is security concerns, not the potential erosion of their data monopoly. However, there is also a secure route for drivers to directly access their car data: data portability directly from the OEM central data server.

Article 20 of the EU GDPR makes personal data portability mandatory. It says little about the modalities of that portability other than that the data should be provided "in a structured, commonly used and machine-readable format" and "the right to have the personal data transmitted directly from one controller to another". Drivers could invoke Art 20 to ask their OEM to transfer their car data from the OEM server, or a neutral server, to another "controller" or data service provider of their choice. The Extended Vehicle Standard makes it easy to transfer the data in a standardized format that should be readable by any service provider who adheres to this standard. The GDPR remains silent on the frequency of portability and does not specify if it should be possible in real-time. However, there is a precedent for real-time portability in a completely different sector: banking and financial services. The second EU Payment Services Directive (Directive (EU) 2015/2366, PSD2) mandates access of third-party payment services providers to personal bank account data held by banks, at the request of the holder of the account, by means of APIs. The Directive's purpose is to increase competition in the payments industry. Using data portability from OEM servers to third-party service providers could serve the same purpose of increasing competition in data-driven aftersales services markets.

The economic impact of by-passing the OEM and handing over car data to the driver / owner of the car are presented in Figure 1c (below). In principle, it would eliminate the OEM's data monopoly and the monopolistic rents that come with that monopoly, including OEM data pricing leverage on downstream provision of aftersales services. In reality there are other hurdles to be overcome. Even if the driver can extract his data from the OEM server and transfer them to the service provider of his choice, how can that service provider deliver his services to the driver? He can do so via the driver’s smartphone and in many cases that may be sufficient. However, it involves again switching costs for the driver. The driver may prefer the services to be delivered to the in-car HMI screen. Access to that screen is exclusively controlled by the OEM who will charge a monopoly price for that access, for instance via the Apple and Android operating systems. Figure 1c is therefore over-simplistic because it assumes that there are no costs associated with the transfer of data from the OEM server to the service provider or with the delivery of services to the driver. Moreover, there may be some costs associated with portability. The PSD2 Directive puts caps on bank data transfer charges to non-bank payment service providers. Caps may also be put on OEM data transfer charges in order to prevent monopolistic pricing.

Figure 1c: Drivers decide what to do with their data



It is important to underline that the welfare effects presented in Figures 1a, 1b and 1c are only static welfare effects, i.e. shifts in welfare between data holders (OEMs) and data users (drivers and data service providers). They do not capture dynamic welfare effects over time when revenue is re-invested in innovation that leads to the production of new services and new applications of the data.[28] OEM revenue can be re-invested. Consumer/driver surplus is not monetised and cannot be invested. However, if the consumer passes on the data free of charge to service providers this may increase monetized revenue for the latter and contribute to investment in innovation. Moreover, the fact that data markets are more competitive in these consumer-oriented scenarios may stimulate innovation.

OEMs face a trade-off between opening access to their data to spur the development of innovative services and strengthen their competitive position in the market, and retain their monopoly profits from exclusive control over the data. An appropriate balance between these two goals would require that each party relinquishes some of its rights. In traditional innovation economics, intellectual property rights (IPRs, e.g., patents or copyright) would deal with the balance between innovation incentives and welfare gains for users of the innovation (see for example Parker et al, 2017). In a data context where the value of an innovation crucially depends on continuous access to data owned by another party this model may have to be adapted. Pricing policies on both sides of the market may need to be agreed between the platform operator and the service supplier. Ultimately, this is an empirical question that cannot be settled by means of theoretical reasoning only. But it may take many years before the data to test these assumptions can be collected.

Fundamentally, Scenarios 3, 4 and 5 raise the question of data ownership and access rights. Who owns and has access rights to car data? The driver/owner owns the car as a hardware device but does he also own the data generated by the car? In the EU there is very little legislation that says anything on data ownership and access rights (see Duch-Brown et al (2017) for a more detailed discussion). The GDPR gives a number of rights to data subjects including the right to consent, to access the data and retrieve the data, but it stops short of giving an ownership right to personal data. The EU Database Directive (DBD) defines a sui generis right to "produced" data but not to data that are "obtained" as a by-product of other activities. Whether car data are obtained or produced remains an open legal question that has not been put to the test yet. In the absence of legally defined data ownership rights the current situation is characterized by de facto ownership or residual control rights by the OEM, backed up by technical protection measures (TPMs), not by legal rights. The OEM collects the data, subject to the driver's consent in the case of personal data, and closes alternative access gates (including the OBD). Comparing Scenarios 1 and 2 with 3, 4 and 5 demonstrates that a change in de facto ownership can have important economic implications.

3.6 Third-party data service producers with network effects

The previous scenarios revolved around OEMs and data-based service providers as standard firms with a linear business model: buying inputs, producing and output and selling it to clients. In the last two scenarios we move to platform-based operators in data services markets. The word "platform" is used here in its economic meaning as a multi-sided market with two or more types of participants and coordinated by a platform operator. Platforms or multi-sided markets generate direct and/or indirect network effects: an increase in the number of users on one side of the market (for example OEMs) attracts more users on the other side (for example aftersales service providers). The magnitude of network effects varies widely across

[28] The underlying idea is that, at the stage of investing in car data infrastructure, the maximum amount that the OEM is willing to invest is the expected profit that can be generated from that investment.

platforms and is an empirical question. Some services may be subject to stronger network effects than others. For example, modern navigation services rely on a large population of users to crowd-source real-time information on traffic jams, road works, vacant parking spots etc. A large user base generates direct network effects because it improves the quality and reliability of the service. However, network effects in navigation services accumulate across OEMs, not within a single OEM services platform. Similar network effects may also occur in media & infotainment services. OEMs are not in a position to match the magnitude of these network effects.

When a service supplier enjoys stronger network effects than the OEM, this may tilt the balance of consumer choice in favour of the external provider. Alternatively, the OEM may enter into a joint venture with the external service provider and agree on the distribution of costs and benefits between the partners that mutually depend on each other to maximize their revenues. A good example is HERE[29], a navigation services supplier established as a joint venture by several European car manufacturers. Network effects increase the revenue from services and thus the value of the underlying data on which the service is built.

The classic multi-sided market model in economics[30] (Caillaud & Jullien, 2003; Rochet & Tirole, 2006) suggests that platforms can leverage network effects to maximize their revenue by offering lower market entry prices on the side of the market that is most price sensitive and impose higher prices on the side that is less price sensitive. For example for navigation platforms that rely heavily on direct network effects on the consumer side, subsidizing consumers by offering them a free or some form of freemium services but not charging the full monopolistic price, and charging a higher price to the supply side of the platform (hotels, restaurants, shops, gas stations, firms that want their location to appear on the map) solves the "chicken and egg" problems (Caillaud & Julien, 2003): it attracts more drivers who deliver data and thereby improves the quality of the system. It also attracts more data suppliers on the firm side because they have a larger audience that will be receptive to their information signals.

OEMs are confined to their brand-based car data silos and cannot realize the wider network effects of service providers who sell services across car brands. That makes them vulnerable to competition from platforms with stronger network effects. However, OEMs have strong price leverage over these data-based service providers as long as they remain the sole source of data. That strengthens the OEM's defense against larger platforms and enables them to charge higher access prices for the data and hardware and preserve some of its monopoly gatekeeper rents at the expense of consumers and service providers. The situation may vary across aftersales services (maintenance, navigation and infotainment). If various user segments have distinct preferences and no single platform can profitably satisfy all segments' needs, then the overall market is more likely to be served by multiple rival platforms. We do indeed observe that several platforms are operational in car aftersales markets for navigation, infotainment and maintenance services.

We explore two sub-scenarios here. Scenario 6a looks at pure data trade platforms and examines the economic benefits of "neutral servers" that turn into data marketplaces or platforms. Scenario 6b looks at aftersales service providers platforms that take data as an input.

[29] See https://here.navigation.com/europe/
[30] For a more detailed discussion of platforms see Martens (2016).

3.6a Data marketplaces

In the course of the technical debates on access to car data in C-ITS working group 6 the idea of a neutral third-party server was launched. The purpose of that neutral server was to reduce the privileged oversight that OEMs would have on data transactions. In practice, a number of these third-party neutral servers have emerged, such as Otonomo, Caruso[31], IBM BlueMix and others. These data marketplaces serve at least two types of clients: OEMs selling car data and aftersales service providers that want to access the data. A major disadvantage of the centralized OEM server (CDSP) business model is that it stores car data in OEM brand-based silos and cannot realize the value of aggregated datasets that provide a better market overview across brands. Silos reduce the value of the data. This creates an entrepreneurial opportunity for third-party B2B car data marketplaces that respond to the need for data aggregation across car brands.

First, data marketplaces reduce transaction costs. They collect data from different brands, invest in standardisation of datasets and transfer protocols[32], and sell packaged sets of data that can cover several OEM brands. Combining these costs in a single firm generates economies of scale in data production and reduces market entry costs for individual service providers who want to market their services across OEMs.

Second, B2B data marketplaces can benefit from economies of scope (Rosen, 1983) in data aggregation[33]. They potentially have a more complete data market overview than individual OEMs[34]. There is additional value in the insights that can be extracted from aggregated data that cannot be obtained from examining individual datasets separately. That boosts the welfare of car services suppliers.

Third, B2B car data marketplaces are platforms in their own right that benefit from network effects. They bring buyers and sellers of data together for transactions between the two sides of the market. Making more OEM datasets available in the marketplace attracts more service suppliers, and vice versa. These indirect network effects give them an additional advantage over individual OEM datasets, on top of the economies of scale and scope from data aggregation. It is not clear to what extent B2B marketplace users are overlapping with OEM platform users. Some OEMs, like BMW for example, make car data directly available to aftersales service providers through the AOS website. That short-circuits B2B marketplaces that distribute OEM data. However, marketplaces can offer additional services such as standardization and aggregation that are not available from individual OEMs.

At the same time, B2B car data marketplaces are in a precarious position because they are downstream data service providers that depend on a continuous supply of data from upstream OEMs that will apply monopolistic pricing. Otonomo and Caruso charge a percentage fee on sales while sales prices are determined by OEMs. This fee system avoids double marginalization problems in data pricing. It is not clear to what extent these data marketplaces charge premium fees for additional value-added services that build on the primary data obtained from OEMs. OEMs of course understand that these market places could generate

[31] Third-party data servers that store and process car data on behalf of several OEMs are also in a position to aggregate data across several car brands, through their market position is limited by the number of OEMs that they serve. For example, IBM BlueMix has exclusive data server and analytics agreements with several major OEMs, including GM and Toyota. Their exclusive position with OEMs would enable them to bring service providers together in real-time auctions for messaging slots in cars. Messaging services can be used to draw the driver's attention to needed repairs and maintenance services and steer them to service providers that made the highest bid in these auctions.

[32] Some European OEMs have proposed a standardized data transfer protocol "The Extended Vehicle Standard". See Section 1.2 on the CDSP above.

[33] Economies of scope occur when the benefits (B) of learning insights from two datasets (d1,d2) jointly are higher than the benefits of doing so separately: $B(d1,d2) > B1(d1) + B2(d2)$.

[34] This is very similar to the situation of e-commerce platforms for example. Amazon and eBay have a better market overview than individual sellers on these platforms. That makes their aggregated data more valuable than the separate datasets from each seller.

additional data value. Marketplaces can turn these cost savings into a price premium for selling bundled data from several OEMs. As long as OEMs remain the exclusive source of the data they can appropriate (part of) that surplus value through a monopolistic price premium. Only in the "by-pass server" scenario this assumption is no longer valid.

3.6b Media & infotainment service platforms

In this second platform scenario we look at media and infotainment services marketplaces such as Apple and Google that offer car versions of their popular operating systems (Apple iOS CarPlay and Android Auto). There is a strong overlap in users between cars and media platforms. Most drivers will use both. It creates consumer demand for seamless connectivity and media synchronization between their home media systems, mobile phone apps and in-car apps, possibly across several family cars or even rented cars. It could potentially generate significant economies of scope from data aggregation (a) between cars and media and (b) across car brands. The combination of consumer behaviour data inside and outside the car, including a better overview of locations, routes and means of transport, generates a more fine-grained picture on consumer behaviour and more insights and economic value compared to driver-only datasets that remain separated in OEM-based silos. These insights can improve the quality and variety of on-board and off-board services available to consumers. It would enable these media platforms to expand app-based services beyond infotainment and integrate not only navigation, driving assistance and car insurance services but also a wider variety of consumer services.

OEMs face a choice between making their cars more appealing to consumers by installing these media systems in their cars, and avoiding competitive pressures from alternative aftersales services being offered by these media platforms. Monopolistic pricing conditions for the installation of these media platforms, both on the consumer side and on the data supply side, allow them to manage this choice to their advantage and maximize their revenue. For example, BMW drivers can install Apple Carplay for 130 €/year as an add-on to BMW's own professional services app that costs 139 €/year. That double pricing scheme creates a steep price hurdle on the consumer side. On the services supply side, app developers who want to make aftersales services apps available in Carplay can access the BMW data store to feed the app with data but pay a flat rate of 0.29€ per data retrieval. BMW's own apps do not pay that rate to access the data. Moreover, app developers have to take into account that Apple and Google charge 30 percent on their revenue if it is channelled through the app store. This setting is not conducive to downstream services innovation and the production of a large variety of services apps. The combined costs on the consumer and developer side create high market entry barriers and are likely to reduce the size of the market for alternative service delivery channels.

For example, installing an alternative navigation services app to the one provided by the OEM becomes an expensive proposition in these conditions. Apple and Google provide free navigation apps through their app stores. The standard pricing strategy of these navigation services apps gives users free access in return for their location data. Revenue comes from charging service providers for advertising their services in navigation maps. OEMs turn around this business model and charge users for access to navigation services. Moreover, they benefit from collaboration with a preferred navigation services provider that has preferential access to car navigation data, possibly combined with deeper car data on weather, road, traffic and parking conditions, to feed its own system.

4. Some tentative conclusions

C-ITS Working Group 6 (European Commission, 2016; C-ITS, 2015) proposed some general car data governance principles:

- Data protection in line with the GDPR, with consent from the data subject.
- Data protection for firms, for competition and security reasons.
- Fair and undistorted competition and access to data.
- Tamper-proof access to avoid endangering the secure functioning of vehicles.
- Data economy: standardization of data access protocols and interfaces.

The working group could not get further than these general principles because of *"strong disagreements between vehicle OEM and independent operators/service providers remain on several important topics, in particular: different views on how data can be accessed, different strategies towards on-board application platform, different views on governance of the data server platform, different views regarding concrete implementation and possible legislation"* (European Commission, 2016, p 12). This conclusion is not surprising in the light of the economic analysis in this study. OEMs design the car in such a way as to retain exclusive access to the data. They face a competitive market for cars and aftersales service but they become monopolists in the market for data generated by the cars from their brand if they implement the Extended Vehicle concept where all car data are exclusively collected on a server operated by the OEM. They can use this monopoly to gain more leverage in aftersales services markets. Car data can be used to nudge service providers and consumers into decisions that benefit the OEM. Monopolistic pricing of data access maximises OEM revenue. However it reduces consumer welfare because they pay higher prices for less service choices, and affects the welfare of (independent) aftermarket service providers whose profits may be reduced by high data costs.

We identified some market forces that might reduce to some extent the monopolistic power of OEMs. First, competition between manufacturers for a larger share in the car market may motivate them to lower the price of data and increase the variety of aftersales service providers who can access the car. OEMs in the more price competitive segment of the car market will be more sensitive to this than those with less price sensitive consumers. Second, OEMs face competition from data marketplaces that collect data across a variety of car brands and benefit from economies of scale and scope in data aggregation to deliver higher quality and more variety of data to a wide range of aftersales service providers. Third, well-known media platforms may deliver services via alternative operating systems and services apps installed in the HMI. However, third-party marketplaces and platforms still depend on data supplies and access to the HMI that are controlled by the OEMs. That gives OEMs leverage over these parties and reduces their effectiveness as countervailing forces to increase competition in downstream aftersales services markets.

Policy makers could consider measures to promote more competition in these markets and reduce the OEMs monopolistic hold on car data and service delivery channels. Two types of measures could be considered: opening more car data access channels and opening more services delivery channels in the car.

A first option to widen the number of data access channels would be to keep the OBD plug open (for read access only) for the entire set of data points collected by the manufacturer (and not only for the minimum regulated environmental dataset), or the equivalent of all data transferred to the CDSP. This would enable the creation of an in-vehicle information platform under relatively secure conditions. Still, the OBD is an imperfect substitute for full data access because it is local, requires investment in an additional hardware device and a separate telecom channel. Moreover it excludes access to the HMI and creates switching costs for drivers between the HMI and an additional (smartphone) screen. It is therefore likely to have only a minor impact on competition between the OEM and aftermarket services providers.

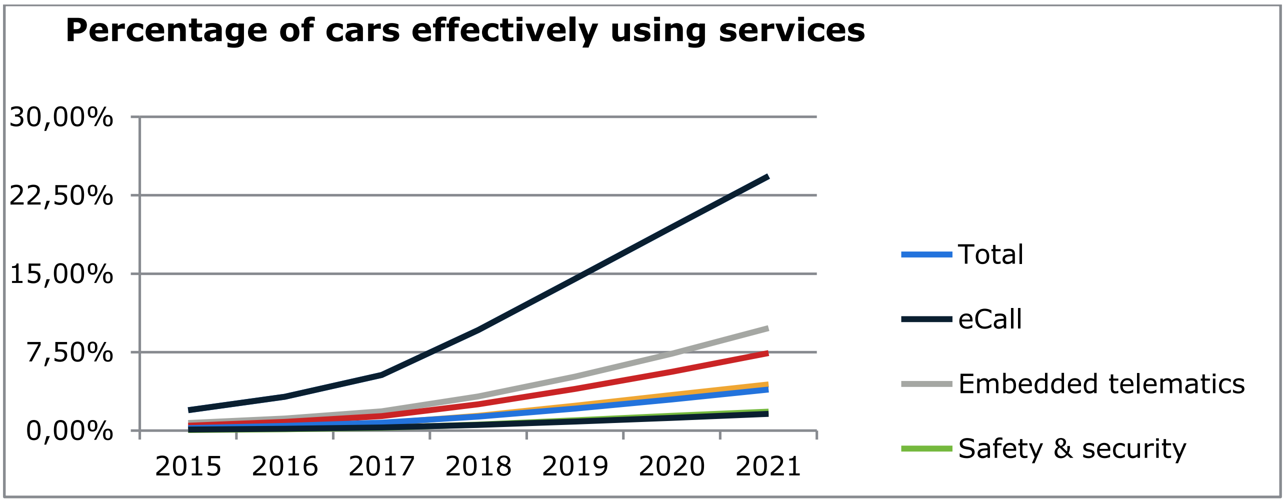
A second option would be to support full portability of personal car data in line with Art 20 of the GDPR. This is already an obligation under the GDPR but a lot will depend on the actual interpretation and implementation of this provision in the context of cars. The Extended Vehicle ISO technical standard will in fact facilitate full and secure portability of data in real time through the manufacturer's CDSP or via a third-party server. This would enable drivers to transfer their data to the service providers of their choice. This would be very similar to data portability under the second Payment Services Directive (PSD2) where consumers can instruct their banks to give a third-party payment services provider access to their bank account data and carry out transactions on their behalf. This measure was taken with a view to promote competition in financial services markets. It could have a similar effect on competition in aftersales services markets. Still competition would be imperfect because the OEMs control the in-car HMI that is an important channel for services delivery. A second screen would be required to deliver the services signals, possibly through the driver's smartphone.

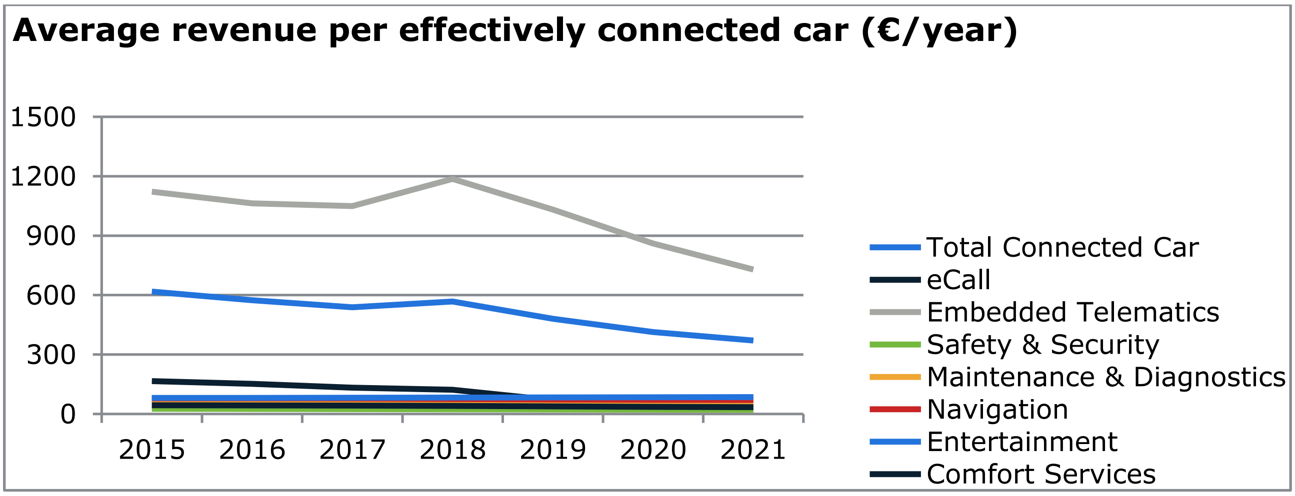
The main hurdle in the effectiveness of these options is the OEM's control over the services delivery channel through the in-car HMI. OEMs allow delivery through alternative operating systems and apps platforms but reduce the attractiveness of these channels through pricing strategies. They use price measures as a substitute for access restrictions. The only solution here would be to create a competitive level playing field between OEM and third-party services delivery platforms. That may require a regulatory intervention.

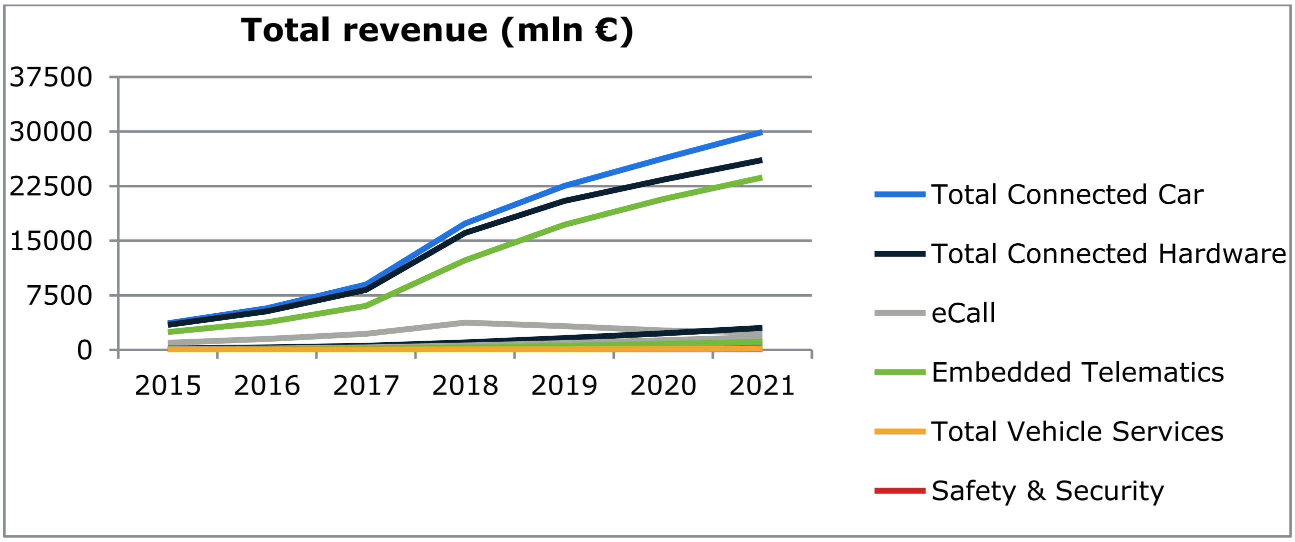
The Commission Communication (2018, p 13) on automated mobility concludes that it *"will continue monitoring the situation on access to in-vehicle data and resources and will consider further options for an enabling framework for vehicle data sharing to enable fair competition in the provision of services in the digital single market, while ensuring compliance with the legislation on the protection of personal data"*. The present study is an attempt to get a better understanding of the economic characteristics of these data markets and related services. We concluded that markets for car data have monopolistic characteristics. There is not enough empirical evidence available at present to go further than these general observations. It would be important however to get access to the relevant statistics in order to produce robust empirical estimates of the data market power of OEMs. That is work for future research.

Annex: Figures and Tables

Figures 1-2-3:







Source: Statista

Table 1: Data services pricing on the consumer side of the market

	Monthly Pricing	Yearly Pricing
GM OnStar US	\$19.99 to \$34.99	\$199.90 to \$349.90
GM OnStar Canada	Canadian \$24.99 to \$39.99	Canadian \$249.90 to \$399.90
Opel OnStar Germany	n/a	€ 99.50
Vauxhall OnStar UK	n/a	£89.50
Opel OnStar Switzerland	n/a	CHF 119.50
Opel OnStar Spain	€ 9.95	99.50 €
Open Onstar Belgium	€ 9.95	99.50 €
OnStar China	n/a	n/a
MercedesMe	n/a	n/a
myHyundai Blue Link Connected Care	\$9.90	\$99
myHyundai Blue Link Remote	\$9.90	\$99
myHyundai Blue Link Guidance	\$9.90	\$99
Nissan App Service Bundle	n/a	\$99

Source: compiled by the authors from OEM websites

Bibliography

ACEA (2016a), Strategy paper on car connectivity, European Automobile Manufacturers' Association, April 2016, Brussels.

ACEA (2016b) Position Paper Access to vehicle data for third-party services, European Automobile Manufacturers' Association, December 2016, Brussels.

Alonso-Raposo M., Ciuffo, B., Makridis, M. and Thiel, C et al (2017), Connected, coordinated and automated mobility to achieve a sustainable road transport, Joint Research Centre of the European Commission.

Bergemann, D. and A. Bonatti (2015), Selling cookies, American Economic Journal: Microeconomics, 7(3), 1–37.

Boston Consulting Group (2014), Returning to growth: A look at the European automotive services aftersales. Available at: https://www.bcg.com/publications/2014/sales-channel-returning-growth-european-automotive-aftermarket.aspx.

Brousseau E. and Penard Th. (2007), The economics of digital business models: a framework for analyzing the economics of platforms, Review of Network Economics, Vol 6(2), June 2007.

Caillaud, B. and B. Jullien (2003), Chicken and egg: Competition among intermediation service providers, RAND Journal of Economics 34(2), 521-552.

Determann, L. and B. Perens (2017), Open cars, Berkeley Technology Law Journal, issue 2 (2017)

Duch-Brown, N., Martens, B. and F. Mueller-Langer (2017), The economics of ownership, access and trade in digital data, JRC Digital Economy Working Paper 2017-01. Available at: https://ssrn.com/abstract=2914144.

Eisenmann, T., Parker, G. and M. Van Alstyne (2011), Platform envelopment, Strategic Management Journal 32, 1270-1285.

Fransson, L. and J. Larsson (2017), Developing an innovative business model for the connected car, Chalmers University of Technology, Department of Technology Management and Economics, Division of Innovation and R&D Management, Report Nr. 2017-30.

European Commission (2015), C-ITS platform access to in-vehicle resources and data, Report by Working Group 6, December 2015, European Commission: Brussels.

European Commission (2016), C-ITS Working Group 6 final report, European Commission: Brussels.

European Commission (2018), On the road to automated mobility: An EU strategy for mobility of the future, Communication COM(2018) 283 final, European Commission: Brussels.

Kerber, W. and J. Frank (2017), Data governance regimes in the digital economy: The example of connected cars. Working paper available at: https://ssrn.com/abstract=3064794.

Martens, B. (2016), An economic policy perspective on online platforms, Joint Research Centre Digital Economy Working Paper 2016-05, available at https://ideas.repec.org/p/ipt/decwpa/2016-05.html

McKinsey (2016), Car data: Paving the way to value-creating mobility – Perspectives on a new automotive business model, McKinsey & Company, Advanced Industries, March 2016.

McKinsey (2015), Competing for the connected customer: Perspectives on the opportunities created by car connectivity and automation, McKinsey & Company, Advanced Industries, September 2015.

McKinsey (2014), Connected car, automotive value chain unbound, McKinsey & Company, Advanced Industries, September 2014.

Parker, G. and M. Van Alstyne (2017), Innovation, openness, and platform control. Management Science, 64(7), 3015-3032.

Parker, G. G., & Alstyne, M. W. V. (2005). Two-Sided Network Effects: A Theory of Information Product Design. Management Science, 51(10), 1494-1504. doi: 10.2307/20110438.

Rochet, J. C. and J. Tirole (2003), Platform competition in two-sided markets, Journal of the European Economic Association, 1(4), 990-1029.

Rochet, J. C. and J. Tirole (2006), Two-sided markets: a progress report, Rand Journal of Economics, 37(3), 645-667.

Rosen, S. (1983), Specialization and human capital, Journal of Labor Economics, 1(1), 43-49.

TRL (2017), Access to In-vehicle Data and Resources, Report prepared by TRL for the European Commission DG MOVE, European Commission, Brussels. Authors: M McCarthy, M Seidl, S Mohan, J Hopkin, A Stevens, F Ognissanto.

West, J. (2003), How open is open enough? Melding proprietary and open source platform strategies, San Jose State University Management School Working Paper.

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.