Journal of Competition Law & Economics, 16(1), 116–141
doi: 10.1093/joclec/nhaa005
Advance Access publication 25 March 2020

ACCESS TO DIGITAL CAR DATA AND COMPETITION IN AFTERMARKET MAINTENANCE SERVICES

Bertin Martens & Frank Mueller-Langer***

ABSTRACT

Before the arrival of digital car data, car manufacturers had already partly foreclosed the maintenance market through franchising contracts with a network of exclusive official dealers. EU regulation endorsed this foreclosure but mandated access to maintenance data for independent service providers to keep competition in these markets. The arrival of digital car data upsets this balance because manufacturers can collect real-time maintenance data on their servers and send messages to drivers. These can be used to price discriminate and increase the market share of official dealers. There are at least four alternative technical gateways that could give independent service providers similar data access options. However, they suffer in various degrees from data portability issues, switching costs and weak network effects, and insufficient economies of scale and scope in data analytics. Multisided third-party consumer media platforms appear to be better placed to overcome these economic hurdles, provided that an operational real-time data portability regime could be established.

JEL: L11, L41, L43, L62

I. INTRODUCTION

A number of recent competition policy reports (Crémer *et al.*, 2019; Furman *et al.*, 2019; Scott-Morton *et al.*, 2019) have explored the challenges of countering anticompetitive behaviour of large digital platforms that thrive on network effects and economies of scale and scope in data to acquire a dominant

* European Commission, Joint Research Centre, Digital Economy Unit, Seville, Spain; E-mail: Bertin.Martens@ec.europa.eu. The views expressed are the authors' and may not in any circumstances be regarded as an official position of the Joint Research Centre or the European Commission.

** European Commission, Joint Research Centre, Digital Economy Unit, Seville, Spain; Department of Business Administration, Bundeswehr University Munich, Germany; Max Planck Institute for Innovation and Competition, Munich, Germany; E-mail: Frank.Mueller-Langer@unibw.de.

position in a market. They converge on the role of data portability as a means to stimulate competition. According to (Federico *et al.*, 2019), innovation is best promoted when market leaders are allowed to exploit their competitive advantages while also facing pressure from rivals and disruptive new entrants in the same and in adjacent markets. The role of competition policy is to prevent market leaders from using anticompetitive tactics to disable disruptive threats.

This paper focuses on digitally connected cars as a case study of pro- and anticompetitive forces in an Internet of Things setting where digital service platforms piggy-bag on connected hardware devices. In the predigital age, cars used to be essentially mechanical devices. Whatever electronic data they generated was mostly used inside the car and hard to access from the outside. Once the car left the showroom, contact was lost until it would show up periodically for maintenance at a workshop. By contrast, modern cars are loaded with sensors that collect large amounts of data on the mechanical functioning and location of the car. These data can be communicated in real time to manufacturers and service providers. They can be used to improve the quality and reduce the cost of maintenance and to influence consumer (driver) decisions to purchase aftermarket services. Access to the data and access conditions will therefore be crucial for competition in these markets. In this paper we concentrate on car maintenance services. The EU car maintenance market exceeds a hundred billion € per year (Boston Consulting Group, 2014).

Before the digital era, maintenance data were accessible inside the car but not portable. Manufacturers could sign exclusive franchise contracts with official dealers, endorsed by the Block Exemption Regulation (BER, EU 461/2010). Combined with the Type Approval Regulation (TAR, EU 858/2018), they created a level playing field between official dealers and independent service providers for access to these data. The on-board diagnostics (OBD) socket established a quasi-open technical standard for access and data interoperability. The arrival of digital telematics made it possible to communicate data from the car to a central server controlled exclusively by the car manufacturer. Moreover, messages can be sent from the server to the driver. The manufacturer seeks to maximize profits from these nonrival data and will sell them for use in various downstream service markets provided they do not compete with his official dealers[1] because that would reduce his net revenue. Our analysis suggests that selling read access only, even to competitors, is not likely to affect market shares. Selling write access however is likely to affect market shares because it can be used to apply price discrimination strategies and nudge drivers towards official dealers. We argue that the manufacturer's exclusive read and write access distorts the level playing field mandated by the BER and TAR and increases the market share

[1] We distinguish between official dealers who have a franchise contract with the manufacturer and independent workshops or service providers that are authorized by the manufacturer to carry out repairs but are not subject to a franchise contract (Boston Consulting Group, 2014).

of official dealers. Notably, existing regulations do not cover write access. We then examine how four alternative data access gateways can make data more widely available to independent service providers: telematics platforms on top of the existing OBD, on-board platforms, opening access to the central server, and bringing consumer media platforms inside cars. We assess to what extent they improve data portability and interoperability and affect competition between official dealers and independent service providers in maintenance markets, using a simple Hotelling model of price competition. The underlying assumption is that more competition reduces prices and improves consumer welfare (Furman *et al*., 2019, pp. 86–87).

Beyond competition, we also look at the possible welfare gains for society from sharing nonrival car data through (a) cost savings from economies of scale and scope in data aggregation across car brands (Scott-Morton *et al*., 2019, pp. 26–27) that enable them to overcome the fixed costs of interoperability obstacles and (b) enhanced market efficiency through network effects. We argue that these aggregation benefits cannot be matched by manufacturers' brand-based data silos. Data accumulation and aggregation can be used for pro- and anticompetitive purposes (Scott-Morton *et al*., 2019). Wider access and availability can diminish the market value of the data and the incentives to invest in data collection (de Cornière and Taylor, 2019; Montes *et al*., 2018). In the longer run, it may reduce data-driven innovation (Scott-Morton *et al*., 2019, pp. 53–56). The tension between the manufacturer's incentive to restrict data access and potential social welfare gains from wider access may lead to market failures and require regulation on access rights Jones and Tonetti (2019). Data access and portability at the request of the driver exist under the GDPR, but the lack of operational real-time data portability and write access provisions remains an obstacle. Replacing the manufacturer's exclusive data monopoly with large third-party platforms that can tip the market with strong network effects may herald the arrival of new anticompetitive forces in car service markets. This will require close monitoring by competition authorities.

Competition case studies often start by asking what the relevant market is. In the case of data, one could ask if it is the upstream data market or the downstream service market. (Crémer *et al*., 2019, pp. 3–4) suggest that it is better to shift emphasis from market definition to identification of anticompetitive behaviours. Looking at data or service markets separately omits the interaction between the two. When manufacturers have a monopoly on read and write access in data markets, they can use this to leverage their position in competitive downstream maintenance services markets. We therefore focus on anticompetitive interactions between these two markets.

We find that the arrival of digital telematics introduced real-time access to car data and the possibility to send messages to drivers. Read access can only be used to improve the productivity of maintenance services. Write access can be used for price discrimination and 'nudging' to influence the driver's selection of service providers. Manufacturers can use their exclusive read and write access through the central data server to expand the maintenance market share of their official dealers. The manufacturer's exclusive position can be circumvented through alternative data gateways. OBD-based access suffers from high market entry costs and remains very fragmented. A more neutral third-party server can potentially generate important efficiency gains from economies of scale and scope in data collection across car brands. However, third-party servers remain very dependent on data access conditions set by manufacturers. The same applies to on-board platforms installed by the manufacturer. Only third-party on-board platforms, such as popular consumer media operating systems, can bypass the manufacturer with direct write access to drivers, provided that real-time portability is ensured. However, they may also introduce new forms of anticompetitive behaviour in aftermarket services. We conclude that introducing more operational forms of personal data portability, beyond the general provisions in the EU GDPR, either through sectoral or horizontal regulations, could restore the competitive level playing field in maintenance markets.

The rest of the paper is structured as follows. Section II discusses vertical integration in automotive markets before the arrival of digital data. It uses a simple economic Hotelling model to explain that market structure. Section III explains the impact of the manufacturer's exclusive real-time read access to car data and write access to the driver on this market structure. Section IV explores alternative data access gateways where portability erodes the manufacturer's exclusive control over read and write access. Section V concludes.

II. CAR MAINTENANCE MARKETS IN THE PREDIGITAL ERA

To understand how the arrival of digital data affects car maintenance markets, we should first examine the market structure and regulatory characteristics of the automotive industry before digital data. A defining feature of the automotive industry is the existence of a network of franchised or official dealers who hold exclusive rights to sell cars and produce aftersales maintenance services in a geographic area (Rey, 1991; Bauer, 2007; Brenkers and Verboven, 2006). Limiting the number of dealers, or foreclosing on downstream distributors (Rey and Tirole, 2007; Bauer, 2007; Borenstein *et al*., 1995), reduces intra-brand competition and enables manufacturers and dealers to charge monopolistic prices for sales and maintenance (Beard *et al*., 2015). The franchise imposes investment and quality conditions that increase production costs for official dealers[2]. In return, official dealers capture nearly

[2] Dealers commit to invest in infrastructure, show rooms, skilled workers, and spare parts to ensure the quality of maintenance services, client relations, financial and marketing management, and restrictions on the markets in which dealers can compete (Arruñada *et al*., 2005; Lafontaine and Scott Morton, 2010). Dealers have to achieve sales targets and receive discounts on car prices in function of the volume of sales. They have a large degree of autonomy in negotiating prices with customers to maximize their sales volume and revenue.

the entire maintenance market for cars up to 2 years, as long as they are under guarantee provisions (McKinsey, 2014). Their market share declines to about a third for cars aged 3–5 years. The market share of official dealers varies considerably across EU Member States, from less than 30 percent in the UK to over 50 percent in Germany (Autorité de la Concurrence, 2012, p. 24). Captive market shares force independent maintenance providers to lower prices to compete with official dealers. Independent repairers' prices can be 16–30 percent lower than official dealers (Autorité de la Concurrence, 2012, p. 21). (Gibson *et al.*, 2014, p. 128) find even higher price gaps.

Exclusive franchise contracts deter market entry of independent service providers and distort competition in car maintenance markets (Verboven, 1996; Brenkers and Verboven, 2006). While they violate Article 101 of the EU Treaty, the EU Block Exemption Regulation (BER, EU 461/2010) on vertical restraints for motor vehicles endorses this exclusive vertical relationship for the purpose of sales of motor vehicles, spare parts, and maintenance services. It argues that the efficiency-enhancing effects outweigh the anticompetitive effect (EU Regulation 461/2010, Whereas 6, 7 and 8). At the same time, the BER underlines the importance of maintaining effective competition in downstream maintenance markets. Art 5 of the BER clarifies that the block exemption does not apply to agreements that restrict access to spare parts and diagnostic tools and information for independent providers. Whereas 13 is explicit about the need to maintain 'effective competition on the markets for the purchase and sale of spare parts, as well as for the provision of repair and maintenance services for motor vehicles' stressing that the independent parts suppliers' and repairers' 'ability to compete depends on unrestricted access to essential inputs such as spare parts and technical information'.

An important element in competition is open access to car maintenance data. Even in the predigital era, cars already contained a substantial amount of electronic data that could be accessed through a standardized OBD socket[3] that has been available in all cars since the 1990s. It serves the dual purpose of checking emissions and enabling repair and maintenance providers to access a wide range of diagnostic codes that have been added by manufacturers. That reduces maintenance costs and increases the productivity of maintenance work, for example, by enabling faster and more accurate detection of mechanical problems.

OBD data are not standardized beyond the regulated emissions data. To read nonstandard OBD codes that vary widely across manufacturers,

[3] Volkswagen introduced the first OBD-type diagnostic system in 1968 to facilitate maintenance and repair work. It became a mandatory standard in the state of California in 1991, with a standard socket design and set of codes that included emission diagnostics for environmental purposes. It became an EU regulatory standard with a mandatory dataset for emission measurement in 1998 (Directive 98/69/EC).

maintenance providers require access to software programmes that can interpret the OBD signals. The Type Approval Regulation (TAR, EU 858/2018, Art 61) makes open access to OBD maintenance data mandatory: 'Manufacturers shall provide to independent operators unrestricted, standardised and non-discriminatory access to vehicle OBD information, diagnostic and other equipment, tools including the complete references, and available downloads, of the applicable software and vehicle repair and maintenance information. (...) Independent operators shall have access to the remote diagnosis services used by manufacturers and authorised dealers and repairers'. TAR Annex X, para 2.9, adds that 'For the purpose of vehicle OBD diagnostics, repair and maintenance, the direct vehicle data stream shall be made available'. Art 63(1) allows manufacturers to charge a 'reasonable and proportionate fee for access to vehicle repair and maintenance information'. While access to OBD socket is open, discrimination occurs in the pricing of the computer programmes and access codes to read and interpret the OBD data. (Gibson *et al.*, 2014) found a large number of obstacles for independent repairers to access the necessary information and wide variations in access prices. These additional costs restrict the ability of independent repairers to price compete with official dealers whose access to the data is usually part of their franchise contract with the manufacturer. That has a dampening effect on competition in maintenance markets.

We use a simple Hotelling model with location-based price competition between official dealers and independent maintenance providers (see Figure 1) to describe the predigital situation in maintenance markets[4]. We assume that cars and maintenance services are perfect complements: consumers who buy a car also need to buy a fixed amount of maintenance to keep it running. Their only choice consists of having the car serviced by an official dealer S1 or an independent service provider S2. In Figure 1 we rank all consumers according to the strength of their preferences for S1 and S2, depending, for example, on the age of the car. S1 and S2 are located at the extremes of this interval. Consumers with a stronger preference for S1 will be located more to the left on the interval; consumers with a preference for S2 will be located more to the right. S1 and S2 sell maintenance services at list prices P1 and P2 and produce these services at costs C1 and C2. A consumer located on the extreme left has a strong preference for official dealer S1 and pays a price P1, leaving him with the highest consumer surplus equal to his willingness to pay (WTP) minus P1. Consumers incur a reduction in consumer surplus when their preference is further removed from either S1 or S2. Because of his franchise contract with the manufacturer, S1 has a monopolistic market position and can charge a higher markup on top of his

[4] See (Hotelling 1929). For a detailed and mathematical explanation of Hotelling competition models, including the extensions with endogenous location of competitors in Figure 2, see, for example, (Machado 2018).

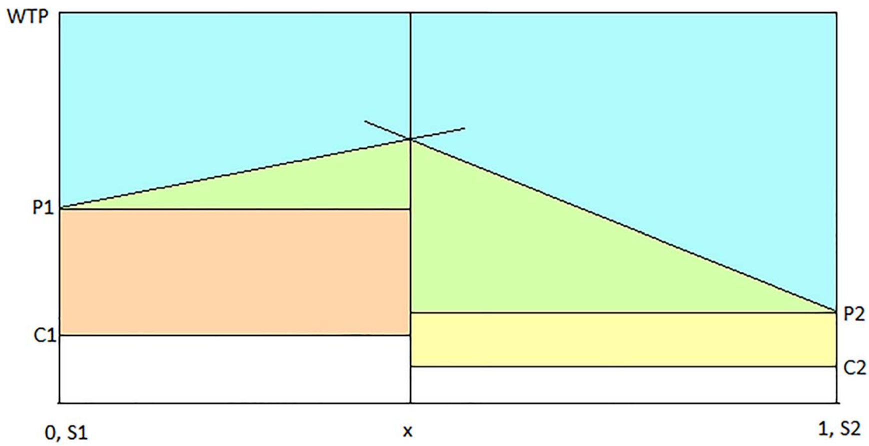

Figure 1. Competition in maintenance markets.

production cost: P1/C1 > P2/C2. At the same time, C1 > C2 because the franchise contract forces him to invest in a brand-specialized trained workforce and workshop equipment and to use more expensive original spare parts. S2 is less specialized and uses cheaper equivalent spare parts. On the other hand, he has to pay for access to the OBD codes to read the data. S2 has no monopolistic market position and competes with other independent service providers. That lowers his cost markup pricing P2/C2. S1 and S2 have market shares of x and (1 − x) that are a function of prices P1 and P2 and consumer preferences for each service provider. At some point, consumers will switch from S1 to S2. Consumers closer to x have the lowest surplus and are therefore more susceptible to switch, depending on prices. In Figure 1 the orange rectangle, (P1 − C1)x, represents the profit of S1, and the yellow rectangle, (P2 − C2) (1 − x), represents the profit of S2, respectively. The blue areas indicate the consumer surplus for clients of S1 and S2, respectively. The green triangles are deadweight social welfare losses because consumers get further removed from their preferred choice. Total social welfare is given by the sum of the orange, yellow, and blue areas.

We use this model as a benchmark to examine the effects of the different data access options on service providers and consumers below.

III. THE CENTRAL SERVER

Telematics technology emerged in the wake of mobile telephone networks. In the EU, the mandatory eCall emergency road assistance system for drivers (Regulation EU 758/2015) accelerated the introduction of telematics capabilities in cars from 2018 onwards. To protect drivers' privacy, data transfers in eCall are strictly limited to emergency services and location needs. The same telematics infrastructure can be used for transmitting other data, subject to the consent of the driver. Manufacturers have designed the telematics system to collect the data from all cars belonging to their brand on a central server to which they have exclusive access. They collaborate with telecom operators to manage the huge numbers of SIM cards that transmit the data through mobile phone networks and with cloud service providers such as Microsoft Azure and IBM Bluemix to handle data storage and processing.

The arrival of digital telematics introduces two distinguishing features in automotive aftermarkets (Kelchtermans *et al*, 2015). First, it enables real-time read access to car data[5] long before the car arrives in a workshop and before the driver has taken a decision on a service transaction. That permits faster and more accurate diagnostics and preventive maintenance that may increase the quality and productivity of maintenance services. Second, messages can also be sent to the car and the driver. The combination of read and write access[6] opens the door to price discrimination in maintenance services and the ability to nudge drivers towards preferred service providers. However, read access on its own can only be used after the driver has selected a workshop and the car arrives in the workshop. At that moment, market shares of official and independent service providers are settled. With write access, a maintenance service provider can reach the driver with competitive service proposals before the driver's decision on a service transaction. It is the combination of read and write access that makes digital telematics a powerful tool for increasing competition in maintenance markets.

Exclusive access to the data gives the manufacturer and his official dealer network an information advantage over independent dealers (Kerber, 2019). It also gives the manufacturer a privileged overview of the maintenance market because the data include information on all kinds of service interventions, from replacing parts to filling the tank. While the BER and TAR mandate a level playing field for access to OBD data, they do not mention real-time read access or write access. The TAR (Whereas 51) warns that 'Technical progress introducing new methods or techniques for vehicle diagnostics and repair, such as remote access to vehicle information and software, should not weaken the objective of this Regulation with respect to access to vehicle repair and maintenance information for independent operators'.

Access to the central server requires portability and interoperability. Most manufacturers are developing their own central server operating systems and data formats. Some European manufacturers (BMW, Mercedes, PSA) have created a consortium that promotes the 'Extended Vehicle' ISO standard for

[5] 'Real-time' does not necessarily imply continuous real-time access. Most manufacturers download car data in packages at regular time intervals, often at night to reduce telecommunication costs.

[6] We do not consider write access to the car, for instance, to install software updates or reset error codes, because it has no impact on aftermarket competition. These are complements to prior purchase decisions.

the car dataset and transmission protocol, that is, ISO 20078[7] (ACEA, 2016a, b). While this standard could in principle cover all car data, in practice the number of data points available is very limited (Knobloch, 2018). There is no real-time read access; the sampling rate or frequency of updates is not clear. To date applications of the Extended Vehicle standard by car manufacturers do not allow independent service providers write access to drivers (Knobloch, 2018).

The economic impact of real-time read and write access can be illustrated in a simple extension of the price competition model from Figure 1 (see Figure 2). Before real-time data, official dealers could only announce list prices P1 that were the same for all clients. With real-time digital data, manufacturers and official dealers can distinguish between clients with a strong preference for official dealer services, for example, in function of car age and mileage and clients that are more likely to switch to independent service providers. They can use this information in several ways. First, S1 can send service proposals at a discounted price (P1 − d) to clients that are more susceptible to switch to a cheaper service provider S2. These discounts expand the market share of S1 from x to x_d. Second, S1 can also target clients in the market segment [0, x_r] who have a strong preference and high WTP for his services, for instance, by offering them 'premium' service packages at higher prices (P1 + r). That does not expand market shares but increases profits for S1 in the 'safe' part of the market where clients are unlikely to switch to S2. Third, apart from price competition, S1 may also send purely behavioural messages to 'nudge' drivers to official dealers and expand his market share to x_n.[8] Nudging relies on bounded rationality in consumer responses. It is not in the consumer's interest to accept these proposals because they reduce consumer surplus and only increase revenue for S1. As a result of these three strategies, S1's market share increases from x to x_n. With this pricing strategy, S1 moves from the extreme left position (0) to a new position S1' on the [0, 1] interval that maximizes his profits by offering discounts to consumers located to the right and premium prices to consumers located to the left. Importantly, S2 is unable to respond to these strategies because he does not have any information to target susceptible drivers. He can only reduce his list price P2 for all his customers. However, this is a costly undifferentiated strategy that may reduce his overall profits. As compared to the benchmark case illustrated in Figure 1, the market share of S2 is reduced from $(1 - x)$ to $(1 - x_n)$. The net impact of these strategies on consumer welfare and overall social welfare is an empirical question since there are positive and negative welfare components in these market shifts.

[7] See https://www.iso.org/standard/66978.html. Several competing data transmission standards are being developed by the W3C Consortium and the US Society of Automotive Engineering (SAE), for example.

[8] For simplicity, we assume that nudging occurs under the discounted price (P1 − d).

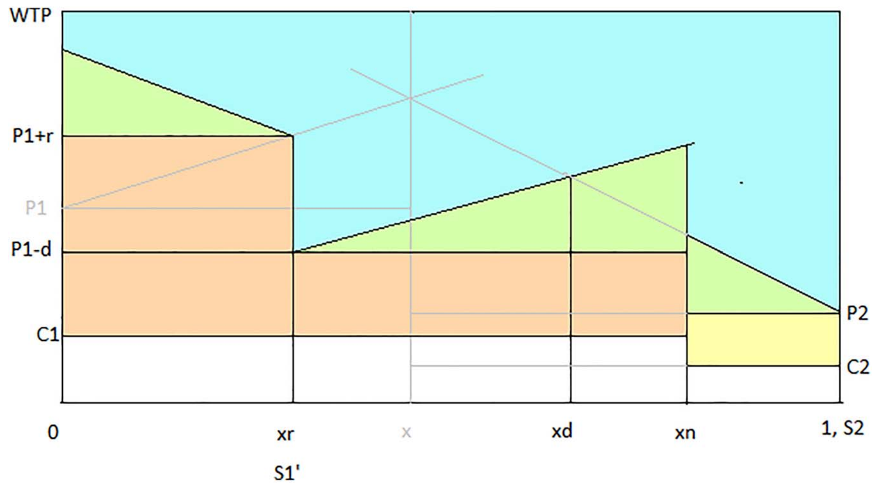

Figure 2. Competition with the central server as exclusive data source.

Evidence suggests that some manufacturers in the Extended Vehicle consortium (BMW, Mercedes, PSA) are already effectively using the messaging system to nudge drivers towards official dealers when they need maintenance, even when an independent service provider is much closer to the car (Knobloch, 2018). Mercedes has also started sending maintenance messages with price offers. There are no known examples to date of write access made available to independent maintenance service providers.

These data-driven strategies increase the value of the franchise contract between manufacturers and their official dealers because they increase the market share and revenue of the dealers. They enable the manufacturer to monetize the value of his data across a large part of the maintenance market. He will only stop monetizing access to his exclusive data when it risks undermining the value of his franchising agreement with official dealers. He may still allow read-only access to maintenance data for independent service providers because that can only affect maintenance production costs. It does not reduce his market share and may even increase his data revenue. The BER and TAR do not permit blocking access to read data and allow charging a price for that access. By contrast, the manufacturer has an incentive to restrict write access to drivers to disable price discrimination strategies by independent service providers. Selling write access to all service providers would increase price competition and lower the value of the manufacturer's data because they are no longer scarce. Rationing access to data is a common theme in spatial models of price discrimination (Thisse and Vives, 1988; Bouie *et al.*, 2018; Montes *et al.*, 2018; de Cornière and Taylor, 2019). Our analysis also provides possible explanations why past attempts at industry self-regulation of car data access and governance rules failed (European Commission, 2016).

Manufacturers were willing to offer access to read data but wanted to preserve their privileged market overview and write access.

IV. DATA PORTABILITY

Several data competition policy reports (Crémer *et al.*, 2019; Furman *et al.*, 2019; Scott-Morton *et al.*, 2019) and academic studies (Graef *et al.*, 2018; Drexl, 2019) have emphasized the importance of access to data. Portability and interoperability facilitate switching between service providers, bring more competition in data-driven services markets, and stimulate innovation in services[9]. There are a number of technical options available to open up read and write access to downstream service providers. We explore these options below.

A key question is whether these technologies put sufficient pressure on manufacturers to evolve in a more open and competitive direction or whether additional intervention by competition and regulatory authorities is required to make this happen. According to the 'Chicago critique' (Posner, 1976), there is no need for policy intervention to stimulate competition in downstream markets. Rational nonmyopic consumers will consider prices and qualities of the car and aftermarket services as a single bundle at the time of purchase of the car. Lack of price and quality competition in aftermarkets will steer consumers towards other car brands in a competitive car market. Manufacturers thus have an interest in ensuring competition in their aftermarket services. The available empirical evidence on consumer myopia in car markets relates to fuel consumption, a variable that does not change over the lifetime of a car. Earlier empirical work suggested only slight consumer myopia[10] and lent support to the Chicago critique. Recent research using behavioural experiments provides evidence for much stronger myopia (Leard *et al.*, 2018; Gillingham *et al.*, 2019)[11]. A counter argument is that rapidly evolving digital service technologies make it difficult for the driver to know service sales conditions at the time of purchase. The lifetime of modern cars can easily reach

[9] An important precedent for portability as a tool to stimulate competition is the second EU Payment Services Directive (Directive (EU) 2015/2366) that 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 purpose is precisely to increase downstream services competition in the payment industry, lower service prices, and increase the variety of offers.

[10] Allcott and Wozny (2014) find consumer responses to fuel price changes in the order of 0.42–1.01 with an average of 0.72. Grigolon *et al.* (2018) use temporal variations in fuel prices to find a central-case valuation parameter of 0.91 in Europe.

[11] Recent evidence shows much stronger myopia when using a different identification strategy that departs from time series and cross-section models and uses natural experiments with an exogenous shock. In 2012 the U.S. Environmental Protection Agency discovered that Kia and Hyundai had overstated the fuel economy of a number of their models and forced these brands to correct fuel information and compensate previous buyers. Gillingham *et al.* (2019) examine the impact of this correction on vehicle sales prices.

15 years, while technologies will evolve very substantially over that lifetime. Consumers may of course switch to another car, but rapid technological change will put downward pressure on the second-hand value of cars that cannot accommodate new technologies. Having a more open data system in a digitally connected car reduces that risk.

In the next sections, we discuss four alternative data access pathways that imply a degree of portability: through the OBD socket, the central server, an On-Board platform, and a multibrand platform. For each of these, we assess to what extent portability is supported by interoperability and their capacity to effectively compete with the manufacturer's central server in terms of the value they add to car data through cost savings, economies of scope in data aggregation, and network effects. If that value added exceeds the manufacturer's capacity to extract value from the data, market pressure will sooner or later force manufacturers to cede exclusive control of the data to other gatekeepers.

A. Real-Time Portability Through the OBD

The most obvious solution to weaken the manufacturer's exclusive access to the data is to keep the existing OBD gateway open, in parallel to the central server. Still, to compete with the manufacturer's real-time diagnostics and ability to send write messages to the driver, a parallel telematics system is required on top of the OBD socket to communicate data to an independent service platform. This is technically feasible. Drivers can plug a telematics-equipped dongle into the OBD socket that can communicate to the driver's smartphone or directly to an external service provider through an embedded SIM card. Many OBD dongle hardware and service providers have emerged in recent years (Roland Berger, 2016; Fransson and Larsson, 2017).

If this channel would be successful, it could reverse the logic of Figure 2. Service providers could use the data to make discounted price offers to drivers to reclaim some of the market share lost to official dealers from write messages send through the central server. Despite initial optimistic forecast for growth in the market for OBD dongles and services (McKinsey, 2014), the economics of OBD service markets does not seem to work in favour of this portability channel. It remains fragmented and scaling-up is difficult for several reasons. First, drivers incur additional costs including the purchase of a dongle, subscription to a service platform, and possibly a separate data transmission plan unless data are transmitted through the driver's smartphone. Second, the OBD channel does not offer write access to the in-car screen, only to the driver's smartphone[12]. Drivers have to switch attention between their (small) mobile phone and (larger) dashboard screens in the car. These monetary and

[12] Unless MirrorLink communication technology between smartphone and car is available in the car.

nonmonetary switching costs make OBD dongles an imperfect substitute for the services offered by the manufacturer inside the car. Third and perhaps more importantly, dongle-based platforms do not seem to scale in the absence of strong network effects. The market remains very fragmented and there are no large platforms. Switching cost increases market entry costs for drivers and reduces consumer demand for dongle-based services. That, in turn, reduces the variety of service providers who are willing to invest in this alternative aftermarket service channel. In the absence of strong network effects, neither drivers nor service providers have strong incentives to invest in these platforms. Single-purpose dongles have been more successful. They are used by firms for specific purposes such as Pay-As-You-Drive car insurance and proprietary fleet management. These business models are driven by service cost savings and do not depend on network effects.

Moreover, manufacturers have an incentive to close the OBD channel, at least to the extent allowed by regulatory constraints. Manufacturers argue that there are security concerns with OBD dongles that are not tested and added at the discretion of the driver. Since dongles have write access to the car data network, they can be used to introduce malware or hack the car[13]. This argument is used by some manufacturers to gradually reduce OBD data access to the minimum mandatory emission dataset[14]. That effectively closes the OBD as a substitute channel for maintenance car data and consolidates the position of the manufacturer's central server as the exclusive source of data.

B. Portability Through the Central Server

Once manufacturers have collected the data, they will want to maximize revenue from these data. They have two options for doing so. They can use the data to leverage sales of their own products and services, including maintenance services from official dealers. They can also sell data in service markets that do not compete with their own services, for instance, car insurance and refuelling services or read access for maintenance purposes after the driver has decided on a transaction with a competing provider. All these data monetization opportunities require opening access to the central server, either through a standard access protocol such as the extended server or through a manufacturer-specific access protocol.

Ways to achieve this were discussed in 2016 in an automotive industry stakeholder working group that proposed basic car data governance principles (European Commission, 2016) including fair and undistorted competition in aftermarkets and access to data, standardization of access protocols, and data protection for drivers and firms. However, 'strong disagreements between

[13] In fact, modern cars have many vulnerabilities to hacking, independently of OBD add-ons. For an overview see, for example, https://www.carhackingvillage.com/.

[14] See, for example, https://www.smart2zero.com/news/german-car-industry-plans-close-obd-interface.

vehicle manufacturers and the independent operators/service providers remained on several important topics, in particular: different views on how data can be accessed, different strategies towards on-board application platform, different governance of the data server platform, different views regarding concrete implementation and possible legislation' (European Commission, 2016, p. 12)[15]. In the light of the analysis above, it is straightforward to see the source of disagreements.

Nevertheless, some manufacturers have recently opened direct read access to their server for maintenance data. For example, the BMW Aftersales Online System (AOS[16]) sells maintenance data directly, including to independent service providers. The system does not permit write access to the driver. While independent providers pay for access, authorized dealers may receive free access to the data under the terms and conditions of their franchise contract. So far, very few manufacturers have made data prices publicly available. (Hoegaerts and Schönenberger, 2019) cite prices of 5–6€ per maintenance dataset for Daimler and BMW. They claim that the number of data points available in these sets is smaller than what is actually required for proper maintenance and much smaller than the number of points available through the OBD. A full OBD-sized set of data points could amount to several thousand euros[17]. That opens new possibilities for manufacturers for price discrimination to distort the level playing field between official and independent maintenance service providers. Moreover, the central server gives manufacturers a privileged market overview for all maintenance transactions: who carried out the operation, when, and which parts were replaced. That information may be used to design commercial strategies to increase their market share in maintenance.

Service providers have been very reluctant to accept this situation. This led to discussions on a 'neutral server' architecture whereby data storage, processing, and customer relations with service providers are handled by a third party[18]. Several manufacturers are already collaborating with third parties such as Otonomo[19] and Caruso[20], thereby signalling their willingness to provide open access to the central server and to keep at least some distance from supervising data traffic to strengthen commercial confidentiality and trust. However, neutral servers still allow manufacturers to block write access

[15] The manufacturers' main argument in favour of an external server is security. It would prevent unauthorized third-party access to the vehicle data and vital mechanical functions and ensure the technical integrity of the vehicle (ACEA, 2016a, b).

[16] See https://aos.bmwgroup.com/web/oss/start.

[17] Charging per dataset per car creates an additional marginal cost for maintenance. The pre-digital OBD charging system for software and data codes constituted a fixed cost, irrespective of the number of cars.

[18] Another option is the 'by-pass server' that would cut the manufacturer entirely off from the data stream.

[19] See https://otonomo.io/.

[20] See https://www.caruso-dataplace.com/.

to drivers for competing service providers. They do not significantly change the maintenance market situation described in Figure 2 where pure pricing strategies of car manufacturers result in welfare transfers.

An important economic feature of these third-party intermediaries is that they can generate real economic efficiency gains compared to the manufacturer's central server. First, they may generate economies of scale by incurring the high fixed cost of setting up a data platform, standardization of datasets into a common format, developing data transfer protocols across car brands and service providers, and so forth. Working across many brands facilitates amortization of fixed costs. This lowers market entry cost for independent service providers who want to reach clients across many car brands and for drivers who can share their data with a single platform to reach many service providers. Fleet managers who operate a diversified car fleet can benefit from these cross-brand platforms. Second, third-party intermediaries can generate economies of scope by collecting and aggregating data across manufacturers' brand-based data silos. The value of the insights delivered by the analysis of a joined dataset is higher than the sum of values obtained from analysing the constituent datasets separately (Rosen, 1983). For example, an analysis of maintenance needs of a large sample of cars across brands is more valuable for independent service providers who cater to the needs of many brands than a brand-by-brand analysis. The combination of economies of scale and scope lowers market entry costs for service providers and increases the variety of services available to drivers. It also lowers access costs to service providers for drivers. In theory this opens the door to indirect network effects across both sides of the car service market.

In practice however the position of these third-party platforms remains fragile because they depend on a continuous data supply from manufacturers. This reduces their commercial autonomy and allows manufacturers to maintain tight control over service providers who enter the market, data access conditions, and pricing. Manufacturers have incentives to collaborate with third-party platforms to reap some of the benefits of additional data sales but only to the extent that it does not affect market shares of their official dealer network or undermine the value of the franchise contract. They will not allow write access that competes with their network of official dealers. They can rigorously enforce such policies because write access still passes through the manufacturer's server. For these reasons, the impact of third-party servers on competition between service providers remains limited. Drivers can preselect service providers, based on their own information sources, provided they do not compete with the manufacturer. There is no two-sided market place where service providers and drivers can freely interact directly in a competitive market. There is no search engine where drivers can compare service providers or an advertising service for service providers to reach drivers. That reduces the magnitude of indirect network effects and limits the scaling potential of third-party servers.

Transferring data from the central server to a third-party server requires consent from the driver. Car data are linked to the behaviour of drivers as natural persons and are therefore personal data that fall under the EU GDPR. The GDPR created a legal basis for data portability or transferring data between parties. Article 20 GDPR makes portability of personal data mandatory. Drivers can ask manufacturers to securely transfer their car data from the central server (or from inside the car) to a third-party service provider of their choice. Article 20 says little about the modalities other than that the data should be provided 'in a structured, commonly used and machine-readable format' and that 'the data subject shall have the right to have the personal data transmitted directly from one controller to another'. An opinion from the (Article 29 Working Party, 2017) suggests that portability covers data provided by the data subject by virtue of the use of a service or a device, such as a car. Inferred and derived data are not within the scope of portability. GDPR Recital 68 indicates that portability 'should not create an obligation for the controllers to adopt or maintain processing systems which are technically compatible'. Still, the opinion states that it 'strongly encourages cooperation between industry stakeholders and trade associations to work together on a common set of interoperable standards and formats to deliver the requirements of the right to data portability'. It also notes that digital service providers are likely to be better equipped to be able to comply with requests much faster than the 1 month time limit imposed by Art 12(3) GDPR, notably through the use of APIs. The GDPR does not allow the data provider to charge a fee for the portability service. While APIs can offer a more sophisticated access system that enables subsequent requests without these additional requests being onerous on the data controller, Art 20 was not written with real-time continuous data portability through streaming in mind. As mentioned above, portability also suffers from the lack of interoperability between manufacturers. Few manufacturers adhere to the Extended Vehicle ISO standard, and the number of data points available in that standard is very limited for the time being (Knobloch, 2018). (Kerber, 2018) concludes that there is still some way to go to make car data portability operational.

C. Portability Through an On-Board Platform

The on-board platform is a fully fledged in-car operating system on which, at the driver's request, service providers can install their own application software to extract data and run services for the driver, comparable to an operating system that runs on a smartphone or PC[21]. Physically, it consists of a box in a car that contains the hardware and software of the operating system. It is

[21] (ACEA, 2016a, b), the car manufacturers' association, argues that cars are not to be put on the same footing as smartphones or laptops. Cars cannot be rebooted while driving and security concerns are vastly more important.

linked to internal car data, to the human–machine interface in the car, that is, the screen and buttons, and has a telecom link to the outside world. It enables real-time data portability when the driver authorizes direct access to his car, just as he gives apps access to his emails or pictures on his phone. This is important for enabling time-critical services and the emergence of innovative applications for data that were so far inaccessible[22]. The data go directly from the car to service providers and do not transit through the manufacturer's server. For these reasons, this is the preferred option of many aftermarket service providers (CECRA, 2018; FIA, 2016; European Commission, 2016; McCarthy *et al*., 2017). The manufacturer retains a role as architect, operator, and gatekeeper of the on-board platform to ensure the technical integrity and security of the car and continues to have parallel read and write access to the driver. Like in-app stores for smartphones, manufacturers keep some control over the available apps, for security and/or economic reasons[23].

Standardization and interoperability remain an issue because manufacturers are developing their own operating systems (Knobloch, 2018). This reduces the capacity to generate cost savings and economies of scale from market-driven standardization. Network effects will be weak and fail to attract many users on both sides of the market. (Knobloch, 2018) classifies the in-car entertainment systems of GM, Ford, Volkswagen, Toyota, and a number of other Japanese manufacturers as on-board platforms because they offer the possibility of read access to at least a few in-car data points. Write access remains very limited and nonexistent so far for independent service providers. He also classifies Google and Apple operating systems in this category. In this paper we classify them separately as multibrand platforms (see next section).

How access permissions are configured in the on-board platform may have implications for competition in maintenance markets. If drivers can only download apps from specific service providers, based on their prior information and preferences, competition may increase a bit but may still remain somewhat limited. There is no multisided market where many service providers can compete for access to many drivers to make their service offers. Using the write access function to the driver in an efficient way requires a

[22] Since mobile data transmission is costly, manufacturers make a selection out of the thousands of data points collected by modern cars and transmit only between 80 (BMW) and 400 (GM) data points to their central servers, usually the data for which there may conceivably be a business model. In the on-board platform, telecom costs will have to be shared between drivers and the service providers.

[23] Some technical security solutions are emerging. For example, the Towersec–Harman (a Samsung company) 'Ecushield' technology (https://www.harman.com/security) provides multilayered protection with hypervisor for access to internal car data. It separates infotainment data from car data and allows for real-time updates to protect against new viruses. 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. The U.S. Department of Transport has asked the Society of Automotive Engineers (SAE) to develop a secure car data access standard.

platform operator who matches service providers with drivers and selects the offers that are made visible to the driver. This matching function could well be exercised by an app, or several apps, within the operating system. This implies that the on-board platform itself would have weak network effects. Network effects would be stronger at the app level than at the platform level. The on-board platform operator thereby risks being 'enveloped' by a successful app on that platform (Eisenmann *et al*., 2011).

Manufacturer-installed on-board platforms should be distinguished from third-party on-board platforms that pose more risks for manufacturers. The manufacturer has no incentive to permit a third-party on-board platform because he may lose his privileged data read and write access position. The third-party operating systems may drive an economic wedge between manufacturers and their cars. Unless it is an open-source software, the operating system would set a proprietary technology standard not owned by the manufacturer. This could be exploited to extract rents from the manufacturer. Whoever becomes the on-board platform gatekeeper will also be liable for the technical integrity and security of the car. This is a heavy responsibility that third-party platform operators may not want to face.

D. Portability Through Consumer Media Platforms

Despite all the risks of third-party platforms, some manufacturers have started to allow car versions of popular media operating systems such as Apple iOS (Car Play) and Google Android (Android Auto) into the car, under pressure from consumer demand. The strength of these platforms is first and foremost on the consumer side. Consumers are attracted by the possibility to seamlessly integrate their preferred media systems across cars, smartphones, and home devices. This ensures interoperability at the application level. However, direct access from these platforms to car data still appears to be restricted. Manufacturers fear that large US-based media platforms like Google and Apple become Trojan horses inside the car and could eventually dominate the car data and downstream service market. In-car applications remain mostly confined to popular music, video, games, Internet, and social media apps that are already present on smartphones and home devices and do not compete with services offered by the manufacturer. Still, some manufacturers though (Toyota, Volvo, Nissan-Renault, Seat) have started to allow access to some mechanical car data (Knobloch, 2018). They are motivated to do so because it makes their cars more attractive to consumers. It could potentially turn these operating systems into a comprehensive on-board car data platform and offer scope for innovative app-based services for drivers. This suggests that manufacturers are responsive to service quality in aftermarkets and that the Chicago critique should perhaps not be dismissed too fast. On the other hand, manufacturers remain very protective about their authorised dealer networks. There are as yet no apps from independent service providers or maintenance price comparison apps in these app stores. The two-sidedness of these platforms remains limited.

Manufacturers can resist pressure from media platforms to provide open access to data because personal (car) data portability provisions in the GDPR (Art 20) are not sufficiently operational yet for the purpose of real-time read portability and write access. If they would be, drivers could request manufacturers to transfer the data to their preferred media platform, and manufacturers would be legally obliged to comply. This may require additional regulation, that is, either general provisions to operationalize portability in the GDPR or sectoral regulation similar to, for example, the Second Payment Services Directive (EU 2366/2015) in financial retail services and the technical standards regulation that complements it (EU 389/2018).

Consumer media platforms bring several additional economic benefits compared to other data access options:

First, they are on-board platforms that can escape the manufacturer's control once portability at the initiative of, and with the consent of, the driver gives them read access to the car data and write access to the driver. That would allow them to reverse the logic of Figure 2 and start competing with car manufacturers in terms of write access to the driver. Independent service providers can get write access to drivers. That increases competition in maintenance services markets. Car manufacturers cannot deliver these economic benefits because they are locked into their own data silo and their preferential franchise agreement with official dealers.

Second, consumer media platforms can deliver additional economic efficiency gains, over and above the economies of scale and scope of neutral server platforms that are still very dependent on data supply and access conditions set by car manufacturers, and cannot deliver write access to independent maintenance service providers. They can generate additional economies of scope for users on the supply and demand sides of the market. Drivers save learning costs because they are already familiar with the operating system and benefit from seamless integration across consumer devices. Service providers and app developers can use the same app across many car brands. The platform operator can aggregate data from millions of cars with existing datasets from media and consumer platforms and thereby increase the value of the combined dataset (McNamee, 2019).

Third, besides maintenance services, third-party consumer media platforms open the door to a wide range of aftermarket service providers that would like to access car data. They are truly multisided markets that enable buyers and sellers to interact directly. Making datasets from more manufacturers available in the marketplace attracts more service providers, more drivers, and vice versa. They may strategically redistribute entry costs between different types of users to leverage network effects (Caillaud and Jullien, 2003; Parker and Van Alstyne, 2005; Rochet and Tirole, 2006).

Fourth, platforms can compete more effectively with car manufacturers by adopting a bundling strategy to penetrate deeper into car service markets (Eisenmann *et al.*, 2011). For example, an in-car media platform can offer car navigation and maintenance and diagnostic services bundled in a package. Bundling is profitable when revenue from selling the two services jointly is higher than selling them separately. It is beneficial for consumers when the bundle is cheaper and/or offers stronger network effects than the two services sold separately. That condition is likely to be satisfied when (1) users overlap significantly—car drivers and smartphone users—or (2) the multibrand platform can harness price discrimination benefits or (3) economies of scope are strong (Eisenmann *et al.*, 2011). Manufacturers can retaliate against these strategies by blocking access to car data and the in-car screen. They can find ways to get their share of the data value increase generated by consumer media platforms, either directly through monetisation of the data or indirectly through higher sales prices and volumes for their cars that are more attractive to consumers when they are equipped with these media platforms. This brings the 'Chicago critique' back into play, not so much through the pricing channel but rather through the service quality channel: manufacturers are sensitive to aftermarket service quality preferences of their consumers.

The economic impact of consumer media platforms is illustrated in Figure 3. They give independent service providers S2 read access to car data and write access to the driver and thereby create a level playing field between official dealers and independent service providers. In particular, this enables S2 service providers to price discriminate between drivers. Copying the strategies of official dealers S1, as illustrated in Figure 2, they relocate from the extreme right position S2 to a place S2' somewhere in the interval that maximizes their profits from price discrimination. They replace list prices P2 with targeted price discounts (P2 $-$ d) and by offering premium services at (P2 $+$ r). That pushes back market shares of S1 from x to x_d and increases the profits of S2 over the market interval [x_r, *1*], as illustrated by the yellow areas. S2 may also apply behavioural nudging strategies to acquire an even larger market share [x_n, *1*]. This results in substantial welfare shifts between S1 and S2 and between producers and consumers. The net social welfare effect is an empirical question that cannot be determined a priori in a theoretical model. In addition, Figure 3 presents only the static price competition picture. There may be dynamic effects as price competition is likely to put downward pressure on prices and costs, forcing official dealers to respond with lowering P1 and C1. That, in turn, may erode the monopolistic value of the franchise contract between manufacturers and official dealers and weaken the extent of vertical integration between the two. Official dealers may be able to resist being drawn into pure price competition and strengthen the loyalty of drivers with brand recognition strategies that increase their WTP for branded maintenance services.

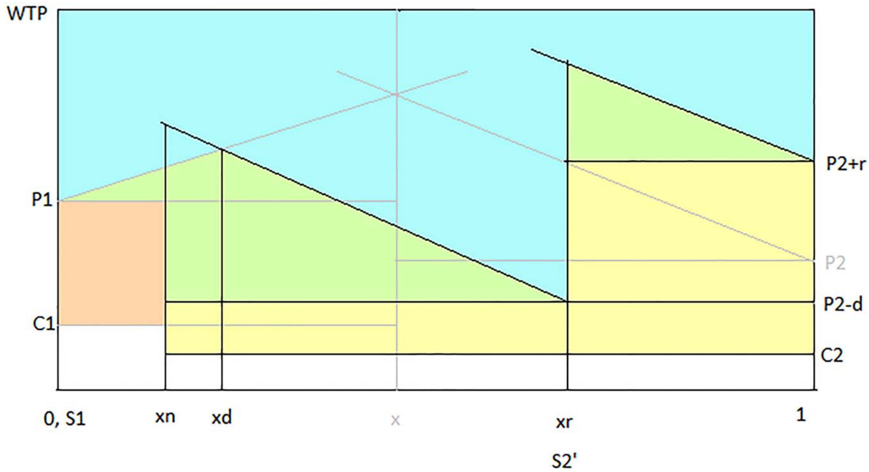

Figure 3. Competition push-back from independent service providers with access to data.

Multisided consumer media platforms with strong network effects may displace manufacturers as gatekeepers to car data. While they bring economic advantages, the risk that large consumer platforms exploit their market dominance to implement anticompetitive strategies has become obvious in recent years (Crémer *et al.*, 2019; Scott-Morton *et al.*, 2019; Furman *et al.*, 2019). The platform economics literature (Caillaud and Julien, 2003; Rochet and Tirole, 2006) shows that gatekeepers have an incentive to drive a wedge between users on different sides of the market to maximize their own profits. They can leverage their strong market positions to reduce competition and promote their own services, as the on-going Google Search and Amazon EU competition cases demonstrate. A first case of alleged anticompetitive behaviour in car aftermarket services by a large consumer platforms occurred in 2019. The Italian competition authority (AGCM, 2019) launched an investigation against Alphabet and Google because Android Auto refused to allow an app for recharging electric car batteries, designed by Enel, the Italian energy company, into its Android Auto app store because it competes with Google Maps. There would be a role for competition policy authorities to carefully monitor the behaviour of these platforms.

V. CONCLUSIONS

This paper compared competition between official dealers and independent service providers in car maintenance markets before and after the arrival of digital car data, taking the regulatory setting on foreclosure and franchising agreements in the BER and TAR as exogenously given. The arrival of digital telematics introduced real-time access to the data and the possibility to send messages to the driver. Without write access to drivers, read access can only be used after the driver has selected a service provider to improve the productivity of maintenance services. Combined with write access, however, it can be used for price discrimination and 'nudging' to influence the driver's selection of service providers. Manufacturers have designed the data architecture so that they have exclusive read and write access. They can use this to expand the market share of their official dealers and therefore increase the value of their franchise contracts. Notably, the current BER and TAR say nothing about write access to the driver.

We then explored the impact of alternative data access gateways. Telematics technology can create read and write access through the open OBD socket. But platforms that exploit this gateway have suffered from high market entry costs for drivers and consequently poor network effects. They do not scale and remain very fragmented. Opening access to the manufacturer's data server through a more neutral third-party server can potentially generate important economic efficiency gains because of economies of scale in amortizing the fixed costs of data format and protocol harmonization and economies of scope in data aggregation across brands. This lowers market entry costs for service providers and increases the variety of services available to drivers. However, third-party servers remain very dependent on data access conditions set by manufacturers who will be careful not to allow any service providers that compete with their official dealer network. It is unlikely to affect competition in maintenance markets. If the manufacturer installs an on-board platform, he will remain in control of the selection of service providers that can install their applications on this platform. Only consumer media operating systems that come on-board as third-party platforms can bypass the manufacturer. Manufacturers are gradually opening up to these media platforms under pressure from consumer demand. They can offer unrestricted direct read access inside the car and write access to the driver through the in-car screen, at the request of the driver, provided portability provisions allow for real-time access—which does not seem to be the case at the moment. This could potentially restore the level playing field between official dealers and independent service providers. Consumer media platforms could bring in additional efficiency gains in terms of economies of scope in data aggregation. However, they may also introduce new forms of anticompetitive behaviour in a wider range of services aftermarkets. This would require careful monitoring by competition authorities.

Regulators are considering the possibility to intervene in-car data markets. An abortive attempt at industry self-regulation in 2016 demonstrated that conflicting interests between manufacturers and independent service providers undermined voluntary joint action (European Commission, 2016). The (European Commission, 2018, pp. 13–14) announced that it 'will consider further options for an enabling framework for vehicle data sharing to enable fair competition in the provision of services' and 'issue (...) a Recommendation (...) on a data governance framework that enables data sharing'. One can question if intervention is needed. The Chicago critique against intervention to prevent foreclosure argues that consumers will force manufacturers to offer competitive services. Our analysis suggests that sufficient consumer pressure is only likely to occur when popular consumer media platforms are installed on-board in the car. Their successful introduction in cars is also subject to operational real-time data portability solutions.

One option would be to introduce mandatory portability solutions in the existing automotive sector regulation, for instance, by specifying data interoperability standards (Crémer *et al*., 2019, pp. 83–85) in the BER and TAR. (Kerber and Möller, 2019) suggest that the TAR could be amended to include such provisions. Others have advocated a more horizontal approach with a block exemption regulation for pro-competitive data sharing and access (Crémer *et al*., 2019, p. 9). The use of automotive data goes far beyond maintenance and covers a wide range of services, including refuelling and battery recharging, car insurance, navigation and multimodal mobility services, and related services such as accommodation, catering, and in-car media and entertainment. Sector regulation may not be an appropriate setting to include provisions that affect a wide range of services far beyond the automotive industry.

Our analysis focused on car maintenance services. It can be extended and applied in many other data-driven automotive aftermarket services where exclusive data access increases the risk of foreclosure. For example, car data are increasingly being used for Pay-As-You-Drive insurance services whereby drivers are billed according to their mileage and driving style. Exclusive access to the relevant data gives manufacturers an advantage in that market and increases the risk of foreclosure. Competing insurance companies face a cost disadvantage: they can buy the data from the manufacturer or install their own tracking device in the car. Another example is the navigation services. There are many competing navigation service providers, but competition to get into a car is hampered because manufacturers have their own preferred navigation service provider and do not give drivers a choice—other than using their smartphone-based navigation app. Switching costs make smartphones only a partial substitute for in-car screens and reduce competition. Data portability is not the issue here; the GPS navigation signal is in the public domain. The obstacle is access to the in-car screen and human–machine interface. These examples show that every aftermarket service presents different challenges and risks of foreclosure. This will require further research.

REFERENCES

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

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

AGCM. 2019. Investigation launched against Google for alleged abuse of a dominant position, press release, Rome, 17 May 2019. Available at: https://en.agcm.it/en/media/press-releases/2019/5/ICA-investigation-launched-against-Google-for-alleged-abuse-of-a-dominant-position

Allcott, H., Wozny, N. 2014. Gasoline prices, fuel economy, and the energy paradox, *Review of Economics and Statistics*, **96**(5): 779–95.

Article 29 Working Party 2017. *Guidelines on the Right to "Data Portability"*. Brussels. WP 242 Rev 1, April 2017.

Arruñada, B., Garicano, L., Vazquez, L. 2005. Completing contracts ex post: how car manufacturers manage car dealers, *Review of Law and Economics*, **1**(1): 149–73.

Autorité de la Concurrence. 2012. *Competition in the vehicle repair and maintenance sector and the spare parts manufacturing and distribution sector, Opinion no 12-A-21 of 8 Oct 2012*.

Bauer, J. 2007. Antitrust implications of aftermarkets, *The Antitrust Bulletin*, **52**(1): 31–51.

Beard, T., Ford, G., Spiwak, L. 2015. The price effects of intra-brand competition in the automobile industry: an econometric analysis. Phoenix Center Policy Paper Number, 48

Bounie, D., Dubus, A. and Waelbroeck, P. 2018. Selling strategic information in digital competitive markets. SSRN: 10.2139/ssrn.3180277.

Borenstein, S., MacKie-Mason, J., Netz, J. 1995. Antitrust policy in aftermarkets, *Antitrust Law Journal*, **63**: 455–82.

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.

Brenkers, R., Verboven, F. 2006. Liberalizing a distribution system: the European car market, *Journal of the European Economic Association*, **4**(1): 216–51.

Caillaud, B., Jullien, B. 2003. Chicken and egg: competition among intermediation service providers, *RAND Journal of Economics*, **34**(2): 521–52.

Crémer, J., de Montjoye, Y.-A., Schweitzer, H. 2019. *Competition Policy for the Digital Era, Report for Commissioner Vestager*, Brussels: European Commission.

CECRA. 2018. *Position Paper on Connectivity, European Council for Motor Trades and Repairs, February 2018*.

Drexl, J. 2019. *Data Access and Control in the Era of Connected Devices*. Study on Behalf of the European Consumer Organisation BEUC.

De Corniere, A., Taylor, G. 2019. Data-Driven Mergers, mimeo, February 21, 2019.

Eisenmann, T., Parker, G., Van Alstyne, M. 2011. Platform envelopment, *Strategic Management Journal*, **32**(12): 1270–85.

European Commission 2016. *C-ITS Working Group 6 Access to In-vehicle Resources and Data, final report* Brussels, European Commission.

European Commission 2018. *On the Road to Automated Mobility: An EU Strategy for Mobility of the Future, Communication COM(2018) 283 Final*. Brussels: European Commission.

FIA. 2016. *Position paper on car connectivity, Federation International de l'Automobile*. FIA Region 1 Europe.

Federico, G., Scott-Morton, F., Shapiro, C. 2019. Antitrust and Innovation: Welcoming and Protecting Disruption. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3393911

Fransson, L., Larsson, J. 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 No. 2017-30.

Furman, J., Coyle, D., Fletcher, A., McAuley, D., Marsden, P. 2019. Unlocking digital competition, report of the digital competition expert panel, UK government publication, HM Treasury, March 2019.

Gibson, G., Brannigan, C., Kaar, A., Kirsch, F., Twisse, F., Bonifazi, E., Lorton, C., Troncoso-Ferrer, M., Ruixo, C., Moya-Izquierdo, S. and Verbeek, M. 2014. *Study on the Operation of the System of Access to Vehicle Repair and Maintenance Information, October 2014, Study by Ricardo-AEA for the European Commission (DG GROW)*.

Gillingham, K., Houde, S., van Benthem, A. 2019. Consumer myopia in vehicle purchases: evidence from a natural experiment. NBER Working Paper No. 25845.

Graef, I., Husovec, M., Purtova, N. 2018. Data portability and data control: lessons for an emerging concept in EU law, *German Law Journal*, **19**(6): 1359–98.

Grigolon, L., Reynaert, M., Verboven, F. 2018. Consumer valuation of fuel costs and tax policy: evidence from the European car market, *American Economic Journal: Economic Policy*, **10**(3): 193–225.

Hoegaerts, L., Schönenberger, B. 2019. *The automotive digital transformation and the economic impacts of existing data access models, report produced for the FIA*, available at: https://www.fiaregion1.com/wp-content/uploads/2019/03/The-Automotive-Digital-Transformation_Full-study.pdf

Hotelling, H. 1929. Stability in competition, *The Economic Journal*, **39**(153): 41–57.

Jones, C., Tonetti, C. 2019. *Non-rivalry and the Economics of Data*, National Bureau of Economic Research, Working Paper 26260, September 2019.

Kelchtermans, S., Vanormelingen, S., Schaumans, C. 2015. *Economic analysis of the introduction of a telematics platform in the motor vehicle industry*. Report prepared for ALD, Arval, Athlon and Leaseplan.

Kerber, W. 2018. Data governance in connected cars: the problem of access to in-vehicle data, *Journal of Intellectual Property, Information Technology and Electronic Commerce Law*, JIPITEC **9**(3).

Kerber, W., Frank, J. 2019. Data sharing in IoT ecosystems and competition law: the example of connected cars, *Journal of Competition Law and Economics*, December 2019.

Kerber, W., Gill, D. 2019. Access to Data in Connected Cars and the Recent Reform of the Motor Vehicle Type Approval Regulation. *Journal of Intellectual Property, Information Technology and Electronic Commerce Law*, **10**(2).

Knobloch, C. 2018. *The Connected Car Study: Telematics Systems Available to Third Parties in Comparison to Telematics for OEMs, Slides*, Knobloch and Gröhn, Gbr. Available at: https://www.figiefa.eu/wp-content/uploads/Presentation.pdf.

Lafontaine, F., Scott-Morton, F. 2010. State franchise laws, dealer terminations, and the auto crisis, *Journal of Economic Perspectives*, **24**(3): 233–50.

Leard, B., Linn, J. and Zhou, Y. 2018. How much do consumers value fuel economy and performance? Evidence from technology adoption. Resources for the Future report, Washington DC.

McCarthy, M., Seidl, M., Mohan, S., Hopkin, J., Stevens, A., Ognissanto, F. 2017. *Access to in-vehicle data and resources*. Report prepared by TRL for the European Commission DG MOVE. Brussels: European Commission.

Machado, M. 2018. The Hotelling model, course slides. Available at: http://www.eco.uc3m.es/~mmachado/Teaching/OI-I-MEI/slides/4.2.Hotelling%20Model.pdf.

McKinsey. 2014. *Connected Car, Automotive Value Chain Unbound*, McKinsey & Company, Advanced Industries, *September 2014*.

McNamee, R. 2019. *Zucked*. Waking up to the Facebook catastrophe: Penguin Press.

Montes, R., Sand-Zantman, W., Valletti, T. 2018. The value of personal information in online markets with endogenous privacy, *Management Science*, **65**(3): 1342–62.

Parker, G., Van Alstyne, M. 2005. Two-sided network effects: a theory of information product design, *Management Science*, **51**(10): 1494–504.

Posner, R. 1976. *Antitrust Law*. Chicago: University of Chicago Press.

Rey, P. 1991. *The Economics of Franchising*. Institut des Mathématiques Èconomiques.

Rey, P., Tirole, J. 2007. A primer on foreclosure. In *Handbook of Industrial Organisation*, Armstrong M., Porter, R. (eds), North Holland. Vol. **3**, pp. 2145–220.

Rochet, J.C., Tirole, J. 2006. Two-sided markets: a progress report, *Rand Journal of Economics*, **37**(3): 645–67.

Roland Berger. 2016. Connected car: App based dongle solution as shortcut to connectivity. Available at: https://www.rolandberger.com/de/Publications/Connected-Car.html.

Rosen, S. 1983. Specialization and human capital, *Journal of Labor Economics*, **1**(1): 43–9.

Scott-Morton, F., Bouvier, P., Ezrachi, A., Julien, B., Katz, R., Kimmelman, G., Melamed, A.D., Morgenstern, J. 2019. *Report of the Committee for the Study of Digital Platforms, Market Structure and Antitrust Subcommittee, George Stigler Center for the Study of the Economy and the State*. University of Chicago Booth School of Business, May 2019.

Thisse, J.-F., Vives, X. 1988. On the strategic choice of spatial price policy, *American Economic Review*, **78**(1): 122–37.

Verboven, F. 1996. International price discrimination in the European car market, *RAND Journal of Economics*, **27**(2): 240–68.