Barriers for the Advancement of an API Economy in the German Automotive Industry and Potential Measures to Overcome these Barriers

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Abstract: The API Economy is a type of service ecosystem that emerged due to organizations using Web APIs to provide third parties with access to their resources, i.e., functionality or data. It is argued that participation in the API economy creates value and offers strategic advantages to API providers. However, there are sectoral differences within the API Economy, with specific sectors being more advanced than others. Since there are currently no explanations for these differences between sectors, this research aims at providing insights into barriers inhibiting the advancement of the API Economy as well as potential measures to overcome these barriers for a specific sector, the automotive industry. We apply a Grounded Theory Methodology approach based on interviews with 21 experts from OEMs, automotive suppliers, consultants, mobility start-ups, and insurance firms. As a result, we present 14 legal, economic, social, technological, and organizational barriers. Furthermore, we derive five measures to overcome these barriers.

1 INTRODUCTION

An ecosystem perspective is increasingly applied in research and literature, enabling organizations to analyze the progressively more complex and dynamically changing environment they operate in (Basole, 2019; Adner, 2016). The ecosystem metaphor has been introduced by (Moore, 1996), who defined a business ecosystem as *"An economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world."* Within a business ecosystem, organizations create value symbiotically (Basole, 2019).

A type of service ecosystem that is currently drawing attention is the API Economy (Basole, 2019; Basole, 2016; Evans and Basole, 2016). At the heart of the API Economy are Web Application Programming Interfaces (Web APIs), which are machine-readable interfaces that make resources, i.e., functionality or data, accessible via the public internet. The providers of Web APIs aim at directly or indirectly monetizing the exposed resources. At the same time, Web API consumers use the newly available resources as a foundation to develop new applications or services. The resulting new resource constellations enable the realization of new business models.

From a provider perspective, the provision of APIs creates value, increases productivity, and offers strategic advantages (Evans and Basole, 2016). Nevertheless, previous research shows that Web APIs are distributed unevenly across organization types and industry sectors (Basole, 2019). However, to the best of the authors' knowledge, there are currently no explanations why these differences in the advancement of the API Economy in different sectors exist. Therefore, the goal of this research paper is to provide insights into barriers hampering the advancement of the API Economy as well as potential measures to overcome these barriers.

We investigate the automotive sector with a focus on vehicle-generated data, which is data generated by sensors mounted in- and outside of vehicles (Abdelhamid et al., 2015). Vehicle-generated data is a valuable resource since it provides the basis for new services that improve the security and comfort of a driver (Bertoncello et al., 2016) and is highly requested by third parties (EC, 2016). Also, a recently published ISO standards series defines specifications for Web APIs providing access to vehicle-generated data (Smethurst, 2017; McCarthy et al., 2017). Therefore, prerequisites for providing vehicle-generated data using Web APIs to enable a flourishing service ecosystem seem to be met. Nevertheless, the API Economy is only slowly emerging in the automo-

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tive sector.

Therefore, we aim at providing insights into the reasons for sectoral differences in the API Economy by addressing the following two research questions:

RQ1: What are barriers to the provision of vehicle-generated data using Web APIs in the German automotive sector?

RQ2: What are potential measures to overcome barriers for the provision of vehicle-generated data using Web APIs in the German automotive sector?

To address these research questions, we conducted 19 interviews with 21 interviewees from Original Equipment Suppliers (OEMs), automotive suppliers, automotive associations, consulting firms, mobility start-ups, and insurance firms. We analyzed the collected data using a Grounded Theory Methodology. Based on this data, we identify 14 barriers hampering the advancement of the API Economy in the automotive sector clustered into the categories legal, economic, social, technological, and organizational. Additionally, five potential measures to overcome these barriers are derived. With these findings, we contribute to a better understanding of challenges in the advancement of the API Economy in the automotive industry. Future work will investigate barriers in other sectors to allow for cross-case conclusions.

In the following, we describe relevant concepts, present our research approach, present, and discuss the findings.

2 FOUNDATIONS

2.1 Web APIs and API Economy

Application Programming Interfaces (APIs) are machine-readable interfaces that enable applications and databases to share assets like functionalities and data while encapsulating implementation details (Jacobson et al., 2011). Different technologies and protocols can be used to implement APIs, but we focus on Web APIs, which expose their resources over the public internet and are accessed using the HTTP protocol (Bermbach and Wittern, 2016).

From a provider perspective, APIs can be categorized into different types depending on their intended user group and goals. In general, APIs are either private or public. An API is private if it is only accessible for a predefined group of developers, which can be internal (internal API) or external (partner API) to the API providers organization. Internal APIs are usually used to foster interoperability and reuse, while partner APIs regularly aim at facilitating integration with external partners, generally in the context of specific business processes. Public APIs, on the other hand, can be accessed by everyone interested in the resources offered. The goal of providing open APIs is usually to generate additional profits through direct or indirect monetization of the API (Jacobson et al., 2011).

In the past, the research focus has been primarily on private APIs, with the goal of enabling integration and reuse. However, recent developments in mobile devices, decreasing data storage costs, and increasing economic value of data, lead to a dramatic growth in the number of public Web APIs in the last couple of years (Basole, 2019), with currently over 23,000 public APIs across different industry sectors registered in the most extensive public API registry, ProgrammableWeb[1]. Furthermore, organizations like Salesforce and eBay generate more than half of their revenue via APIs (Iyer and Subramaniam, 2015). This abundance of APIs allows third parties to access newly available resources, enabling the creation of new applications or services (Evans and Basole, 2016).

Web APIs enable the realization of new business models for API providers as well as consumers, enabling a type of service ecosystem, the so-called API Economy (Basole, 2019). A service ecosystem is defined as: *"A relatively self-contained, self-adjusting system of mostly loosely coupled social and economic (resource-integrating) actors connected by shared institutional logics and mutual value creation through service exchange."* (Lusch and Nambisan, 2015). Thus value is created by organizations forming relationships (Basole, 2019; Rouse and Basole, 2010) using digital connectors, e.g., Web APIs. In the context of digital platforms for third party development, these digital connectors are sometimes also referred to as boundary resources (Eaton et al., 2015; Ghazawneh and Henfridsson, 2013; Ghazawneh and Henfridsson, 2010).

Even though the provision of public Web APIs supposedly creates value, increases productivity, and offers strategic advantages, APIs are distributed unevenly across organization types and industry sectors (Evans and Basole, 2016; Basole, 2016; Basole, 2019). First of all, ecosystem analysis revealed that mainly young, digital organizations actively provide public Web APIs, e.g., Amazon and Google, compared to more traditional, established organizations

[1] https://www.programmableweb.com/, accessed on 12/09/2019.

(Evans and Basole, 2016). Additionally, there are differences across sectors, with mapping, e-Commerce, and social APIs being most relevant in the API Economy ecosystem (Basole, 2019). Thus, organizations choose different API strategies to influence their position within the ecosystem as well as the health of the ecosystem as a whole (Basole, 2019). However, the best of the authors' knowledge, currently no explanations for the differences between sectors within the API Economy exist.

2.2 Status Quo of the API Economy in the Automotive Sector

The automotive sector provides an appealing industry for analyzing barriers for the advancement of the API Economy since it is a sector characterized by traditional organizations. Additionally, prerequisites for providing access to data seem to be met, but the API Economy nevertheless advances only slowly.

Data generated by sensors mounted inside and outside of a vehicle, e.g., odometer or ambient temperature, is called vehicle-generated data (Abdelhamid et al., 2015). Vehicle-generated data is a valuable resource since it provides the basis for digital connectivity between vehicles, between vehicles and the transportation infrastructure (EC, 2016), and between cars and third-party service providers. Connectivity is the foundation for new services improving road safety, traffic efficiency, and driving comfort (EC, 2016). An analysis conducted in 2016 revealed that in general, customers are interested in services based on vehicle-generated data, which increases the safety and convenience of mobility (Bertoncello et al., 2016). The same study estimated the overall revenue pool for monetization of vehicle-generated data to reach 450 – 750 billion USD by 2030. Also, for almost a decade, there have been calls from various stakeholders within and outside of the automotive industry requesting to make vehicle-generated data available (McCarthy et al., 2017). Finally, (Evans and Basole, 2016) observed a rapid increase of transportation-related APIs, which goes beyond vehicle-generated data, including, e.g., public transportation APIs. This leads to the assumption that an API Economy in the automotive sector should flourish.

However, the implementation of vehicle-generated data using public APIs progresses only slowly, since the growth and shape of a new market for these services depends on the question who can access the data, and under which condition it can be accessed (McCarthy et al., 2017). Currently, data generated by sensors of a vehicle is transferred to a backend server of an OEM via a mobile network. Thus, the OEMs are in a powerful position since they decide which parties get access to the data and which approach for data access they provide. However, reacting to the market pressure, OEMs have committed themselves to provide a data server platform to grant access to vehicle-generated data to third parties per the standardization project Extended Vehicle (ExVe) which resulted in the ISO 20077, ISO 20078 and ISO 20080 standards and the Neutral Extended Vehicle for Advanced Data Access (NEVADA) approach. The goal of these standardization projects is to provide third-parties with standardized and non-discriminatory access to vehicle-generated data by granting them access to the backend server of the OEM, where vehicle-generated data is stored. In this research paper, we will focus on the provision of access to vehicle-generated data via data server platforms following the ExVe and the NEVADA concepts.

As of November 2019, German OEMs that have implemented the ExVe and NEVADA approaches are BMW[2] for specific BMW and Mini cars and Daimler[3] for certain Mercedes Benz cars. Each implementation consists of an API platform enabling third parties to access vehicle-generated data of a customer as well as a customer-facing portal providing vehicle owners with the possibility of releasing or withdrawing data access rights for respective third parties. Also, both APIs can be accessed via neutral car data platforms like Otonomo[4] and HIGH MOBILITY[5].

However, the number of services realized based on vehicle-generated data provided via the Web APIs is currently still minimal. Existing use cases, e.g., pay-as-you-drive insurances or driver logbooks, are predominantly realized using data collected via mobile apps or the in-vehicle on-board diagnosis (OBD) connector. An OBD interface is a mandatory and precisely specified physical connector in a vehicle that provides access to specific data, e.g., error messages for diagnosis purposes. However, data access via mobile apps or the OBD connector is very limited.

Summarizing, while there is high potential to create value through new services based on vehicle-generated data as well as high pressure to release the data, which even culminated in corresponding standards, the API Economy is only slowly advancing in the automotive sector. Therefore, the automotive industry provides an interesting case study for analyz-

[2]https://www.bmwgroup.com/de/innovation/technologie-und-mobilitaet/cardata.html
[3]https://developer.mercedes-benz.com/
[4]https://otonomo.io/
[5]https://about.high-mobility.com/

ing barriers for the advancement of an API Economy and measures to overcome these barriers.

3 RESEARCH APPROACH

This research paper aims at identifying barriers and measures to overcome these barriers for the API Economy in the automotive sector. To achieve these goals, we apply a Grounded Theory Methodology, which is suitable for research on technological change and socio-technical behavior for which limited prior research exists (Wiesche et al., 2017). The Grounded Theory Methodology approach that we applied comprises data collection, open coding, and selective coding.

We conducted a total of 19 semi-structured interviews with 21 experts in the time between October 2018 and February 2019. We targeted experts from the automotive industry, using existing contacts of our chair. We deliberately chose experts with different perspectives, including OEMs, automotive suppliers, automotive associations, mobility startups, consulting firms, and insurances. Tab. 1 provides an overview of all interview partners. The semi-structured interviews comprised seven open-ended questions and took 34 minutes on average. We recorded and transcribed each interview.

To analyze the collected data, we applied open coding to the interview transcripts resulting in 641 codes across 286 categories. This first analysis step was conducted to gain a better understanding of the use case domain and provided a basis for selective coding. During selective coding, we focused on barriers and measures to overcome these barriers. Overall, we identified 14 barriers categorized into legal, economic, social, technological, and organizational barriers. Furthermore, we derived five potential measures to overcome these barriers. We used the tool MAXQDA to support the coding process.

4 IDENTIFIED BARRIERS

This chapter presents 14 identified barriers for open vehicle-generated data clustered into the categories legal, economic, social, technological, and organizational. Figure 1 provides an overview of the barriers. In the following, we will describe each of the identified barriers in more detail.

4.1 Legal Barriers

The category legal barriers comprises three barriers that are related to German or international legislation.
Strict Regulations. Strict privacy regulations, especially the GDPR, can hamper the implementation of open vehicle-generated data projects. While the interviewees deem the need to get the explicit consent of the consumer as solvable, purpose limitation and the right to delete personal data are obstacles. However, the right to delete personal data is only applicable to data that has is not anonymized.
Uncertain Data Ownership. Some interviewees stated that it is currently not clear who owns vehicle-generated data. Data protectionists argue that the data belongs to the drivers of a car and their passengers since they produce the data. Here, a clear distinction has to be made between the driver of a vehicle and the owner of a car, especially since shared mobility concepts like car sharing lead to the fact that the ownership and use of cars often no longer coincide. Even though no interviewee argued that the data should belong to the owner of a car, a court decision exists, where the course of a car accident was reconstructed based on data collected by the car-sharing provider (Breitinger, 2016). Furthermore, some OEMs argue that specific data should belong to them since they carry the cost of data collection and storage. Finally, one could also argue that governmental institutions should have the right to specific data concerning the well-being and safety of society, i.e., the information on the condition of the infrastructure.
Uncertain Data Handling Requirements. Another barrier is concerned with uncertainty regarding how data should be stored and processed by the data collectors. There are currently no guidelines or precedents regarding the classification of data into different data categories (e.g., personal/non-personal), the privacy requirements for each data category, and the definition of access rights for various parties (e.g., private organizations/the government). Furthermore, the liability of organizations storing data providing safety-relevant information is not clear. As one interviewee reported, an entity collecting data could be liable for not forwarding safety-relevant information that this entity could theoretically derive from stored data.

4.2 Economic Barriers

Business considerations cause economic barriers, of which we identified a total of five.
Unknown Business Models. The collection and provision of vehicle-generated data requires considerable financial effort, as the OEM must create and main-

Table 1: Overview of interview partners.

ID	Organisation Classification	Role
1	Consulting	Technical Architect
2	Mobility Startup	CTO
3	Consulting	Head of Department Automotive
4	Consulting	Digital Innovation Officer
5	Mobility Startup	Senior Partner Manger
6	Insurance	Technical Architect
7	Automotive supplier	Business Development
8	Automotive supplier	Business Development
9	Automotive Association	Head of Department IT
10	Consulting	Head of Department IT
11	Automotive supplier	Head of Department IT
12	OEM	Technical Architect
13	Mobility Startup	Head of Department IT
14	OEM	Business Analyst
15	Automotive Association	Product Manager
16	Mobility Startup	Data Analyst
17	Finance	Managing Director
18	Insurance	Technical Architect
19	OEM	Technical Architect
20	OEM	IT Project Manager
21	OEM	Business Project Manager

tain the appropriate infrastructure. Potential revenues offsetting these efforts are difficult to quantify in advance. The difficulty in defining the value of data is because it is not known which use cases, and therefore which data, is relevant for third parties. First experiences have shown that rather simple data is requested, which could also be collected by a mobile phone.

Securing of Own Market Position. The German automotive market is a market with few but large OEMs, which traditionally compete against each other. Although there were already first cooperations between these OEMs, e.g., the joint acquisition of the navigation system developer HERE [6] by Daimler, Audi, and BMW, each OEM tries to protect its market position. This also hinders the development of a common platform.

Change of Role From Vehicle Producer to IT Service Provider. The classic business model of OEMs is the production and sale of vehicles, as well as the subsequent absorption of profits on the aftermarket. This traditional business model is now increasingly threatened by new trends such as Mobility-as-a-Service and Shared Mobility. Thus, the automotive ecosystem changes as well as the OEMs role within that ecosystem. The OEMs new role creates challenges such as building new skills in software engineering and changes in mindset. Besides, the competition is expanded from a small number of other OEMs to include also mobility start-ups and large digital companies such as Google and Apple. Also, the new business models are deemed to be less profitable for OEMs. OEMs are therefore trying to exploit existing business models for as long as possible before disrupting their business model.

Lack of Market Pressure. A further aspect is missing market pressure from customers. End customers do not actively request new features and services in cars, and therefore there is no market pressure on the OEM to use or share data to enable new services.

Risk of Exposing Business Secrets. The provision of vehicle-generated data could enable far-reaching analyses of the vehicle itself. These analyses could provide insight into the technologies used or reveal deficiencies of individual vehicle models. Concerns that third parties might gain access to these business secrets relating to the OEM's core products, therefore, hamper the provision of specific data.

4.3 Social Barriers

Social barriers arise due to consumers' sentiments related to the sharing and value of vehicle-generated data. One social barrier has been identified.

Importance of Privacy (Especially in Germany). Customers fear that third parties could gain insight into their driving behavior based on collected data.

[6] https://www.here.com/

An example mentioned was that a driver's mood could be recognized, which could be relevant for insurance in case of an accident. Thus, customers often associate negative feelings with the sharing of data with third parties. Interviewees often mention that this barrier is especially relevant for the German market due to the traditionally conservative attitude in Germany towards data sharing. As a result, the high importance of privacy hampers customers' willingness to share data with the OEM. Furthermore, it also influences OEMs willingness to share data with third parties as they fear that data sharing could lead to a negative image, even when they meet the legal requirements.

4.4 Technological Barriers

The limitations of current technologies cause technological barriers. We identified four such barriers.

Expensive Data Transmission. The sensors of the car generate vehicle-generated data, which the car then transfers to a backend server via a mobile network. This architecture creates a technical challenge with regards to the data transfer between the vehicle and the backend server due to the significant amounts of data that can be generated by vehicle sensors. Existing mobile networks are not capable of transferring these amounts of data, and even the 5G network may not be sufficient in some instances, e.g., when a football match ends and several thousand cars try to leave the car park simultaneously. Besides, using mobile networks is particularly expensive in Germany compared to other countries.

Lack of Standardization. Standardization is a significant barrier for the advancement of an API Economy in the automotive sector since each OEM provides its proprietary platform for vehicle-generated data. The platforms realize different implementations of web services concerning data protocols, architecture paradigms used (e.g., REST, GraphQL), SLAs, billing models, etc. Also, the data differs in type and quality not only between different OEMs but also for various vehicle models, different configurations of a model, and the year of production. Although ExVe and Nevada already provide standardization approaches defining which resources a data platform interface should provide, the standards do not describe implementation details, since too high a degree of standardization could inhibit innovation. However, the remaining degree of freedom in the design of web services still leads to high efforts for third party providers when integrating vehicle-generated data of OEMs.

Ensuring API Quality. To enable third-party providers to build business models based on vehicle-generated data provided via an API, the API has to be of acceptable quality with regards to function as well as non-functional requirements. However, to guarantee the quality of an API, OEMs have first to ensure the quality of data internally, which can be cumbersome.

Increased Safety and Security Requirements. The malfunction of a vehicle, whether caused by a fault within the system or triggered by an attacker, can have devastating consequences. Safety and security, therefore, play a particularly important role in the automotive sector. The provision of a web service to access vehicle-generated data is associated with high requirements in terms of safety and security to avoid penetration of systems running in the vehicle.

4.5 Organizational Barriers

Organization barriers capture barriers caused by current organizational structures in data collecting and data processing organizations.

Lack of Data Interpretation Skills. A further challenge based on the significant amount of data is missing experiences and expertise with regards to data interpretation. Currently, OEMs, as well as startups, are missing these skills.

5 POTENTIAL MEASURES

In this section, potential measures to overcome some of the barriers for advancing the API Economy in the automotive sector will be presented. Overall, five measures have been derived based on the analysis of the interviews.

End-user Empowerment. Eleven interviewees mentioned end-user empowerment as a measure that could help overcome mainly social barriers. On the one hand, end-user empowerment aims at providing data owners with the power to control how their data is processed and by whom, including the option of not sharing data at all. Additionally, providers have to educate end-users on their data-related rights and the implications of both sharing data or not. Thus, end-user empowerment aims at creating trust on the side of the end-user.

Market Pressure. Nine interviewees mention market pressure, which can be exerted by different stakeholders. First, end users are changing their behavior and adapting to new digitized services in various domains, e.g., digitized health care apps. This trend leads to the end-users requesting integrated solutions also in the automotive sector, e.g., they want to access data generated by two cars of different brands belonging to

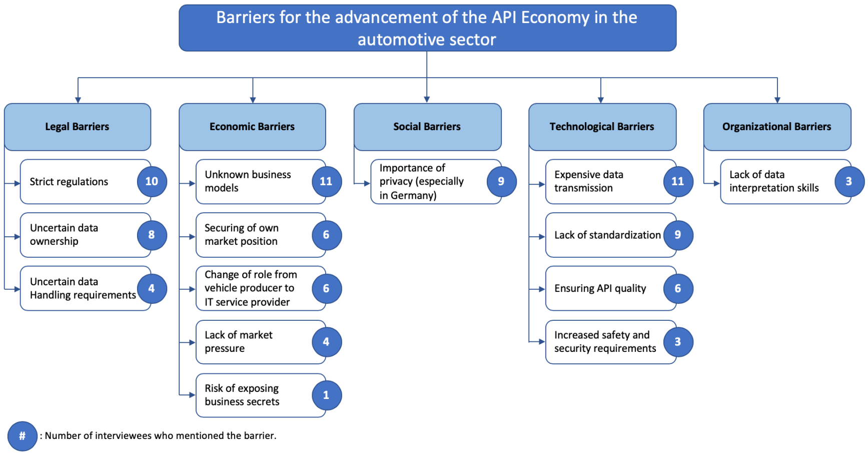

Figure 1: Overview of barriers for the advancement of the API Economy in the automotive sector.

the same household using a single platform. Furthermore, some interviewees expect that foreign competitors will start making vehicle-generated data available and realize associated business models, thus exerting pressure on the German automotive industry. Finally, several experts expect a significant first-mover advantage, with new business models, with new business models often being introduced by startups.

Clear and Legally-binding Government Regulation. Mentioned by eight interviewees, a further potential measure are clear and legally binding government regulations. On the one hand, clear means that new regulations should define a standard for the API design. On the other hand, clearness refers to the removal of uncertainties with regards to data ownership and data handling requirements. Furthermore, new regulations should be legally binding since only a few OEMs implemented the ExVe and the NEVADA standards, to which the OEMs commitment themselves. During the interviews, several comparisons with other domains have been drawn, e.g. the PSD2 in the banking sector or the HIPAA Privacy Rule for medical data in the US, which should be monitored and could be used as templates for a regulation for vehicle-generated data.

Edge Computing. Addressing technological barriers, especially the expensive data transmission, five interviewees suggested edge computing as a useful solution approach. The increasing amount of data generated in a vehicle could be preprocessed in the vehicle to reduce the amount of data before transferring it over the mobile network. However, preprocessing requires mounting expensive hardware in the car, e.g., powerful CPUs. Therefore, OEMs have to carefully consider the amount of logic implemented in the vehicle.

Collaboration between OEMs. Collaboration between OEMs was mentioned by three interviewees, who believe that OEMs should work together to provide a neutral server as suggested by the NEVADA standard. This measure would address the barrier of lacking standardization between data providers. However, the German automotive market is very competitive, and it was not detailed how OEMs should be motivated to collaborate.

6 CONCLUSION

The API Economy is a type of service ecosystem that promises value generation for organizations participating in it. However, there are sectoral differences within the API Economy, with specific sectors being more advanced than others. These observations lead to the question of what causes these differences. Addressing this research gap, we provide insights into barriers hampering the advancement of the API Economy for vehicle-generated data in the German automotive sector. To identify these barriers, we applied a Grounded Theory Methodology approach based on interviews with 21 experts. Overall, we identified 14 barriers. Furthermore, we derive five potential measures to overcome these barriers. Our findings contribute to the identification of barriers and drivers for the emergence of the API Economy. Furthermore, our results provide a starting point for analyzing the reasons for differences in the advancement of an API Economy between different sectors.

The analysis of the data shows legal, economic, social, technological, and organizational barriers. Legal barriers arise due to legal restrictions and uncertainty, which could be addressed with clear, legally binding government regulations. Focusing on economic aspects, barriers are concerned with unknown business models and the changing role of OEMs caused by current trends in the automotive industry, hampering the OEMs willingness to make vehicle-generated data accessible. These economic barriers could be overcome by forcing OEMs to provide access to vehicle-generated data using government regulations but also by building market pressure. An additional finding regarding economic barriers that we would like to mention is that several interviewees explained that the availability of a critical amount of data would be necessary to gain experiences with new business models. However, current legal regulations hamper the collection of data, i.e., purpose limitation, and the competitive situation in the automotive market. This creates a catch-22 situation, with data not being made accessible due to missing experiences and missing experiences due to missing data availability. Barriers in the social category arise due to a lack of trust of end-users in organizations handling their data. A measure to overcome this barrier could be end-user empowerment. Technological barriers are mainly concerned with large amounts of data that have to be transmitted, as well as a lack of standardization between data providers. Edge computing could address the first of these barriers, while the latter would profit from increased collaboration between OEMs. Even though we also identified organizational barriers, we deem them as insignificant since interviewees described them as easily solvable.

Limitations of the validity of the presented research arises from the focus on the German automotive market and the limited number of 21 interviewees. Future work could address these limitations by analyzing barriers and drivers for the emergence of the API Economy in other sectors to enable cross-case conclusions.

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