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Moving from tangible to intangible:
How carmakers deploy data monetization

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Abstract

This study aims at assessing data monetization as a potential profit source for carmakers through qualitative research with inductive and deductive analysis. Findings suggest that data monetization is currently neither often nor widely applied among carmakers, especially regarding data selling. Further investigation identified three potential issues: (1) carmakers lack data curation and exploitation capabilities; (2) carmakers aim to cover the whole data value chain internally; and (3) the market for data selling is underdeveloped. Therefore, data monetization seems to be at an early stage of development among carmakers and, to become an effective profit source, requires sharp business strategies.

Keywords: data monetization; automotive industry; carmakers; data value chain

Contents

1. Introduction

As the whole manufacturing sector, carmakers are experiencing transformational changes due to the rising interconnection and digitization of products, infrastructure and facilities (Becker, 2016). Hence, effective data usage may have huge impact on profits, but only for those who extract value from it (Derwisch, 2019). In fact, most companies do not utilize this resource, as only one in 12 monetizes data to a full extent (Gandhi, Thota, Kuchembuck, & Swartz, 2018).

Thus, while: (1) the automotive industry is changing and seeking for new profit sources; and (2) data monetization can monetarily capture the value created from data; only few companies are benefiting from it. There is, currently, no widely-accepted narrative describing how value from data can be monetized by carmakers or what the main obstacles in the process are. Hence, this study contributes to filling this gap by addressing the following research question:

How can carmakers enhance value creation through data monetization?

This question of interest is addressed by focusing on two research sub-questions:

How do carmakers currently deploy data monetization?

What are the issues hindering the deployment of data monetization by carmakers?

To address the research question, this study is organized as follows. A literature review illuminates the current state of research regarding data monetization and carmakers and reveals a research gap that is targeted by this study. The following section explains the methodology behind the qualitative research, consisting of three different methods. Next, in the results section, the research question is discussed by the two research sub-questions. The first research sub-question is addressed by the development of a framework for the usage of data monetization specifically applied to carmakers. The second research sub-question identifies the main issues hindering deployment of data monetization, based on an analysis along the data value chain.

2. Literature review

This section motivates the identified research questions by explaining current developments in the literature.

2.1 Carmakers

A carmaker is a vehicle manufacturer with the business model of producing cars, of which prominent examples are BMW and VW. Carmakers are understood, in this study, as traditional manufacturers, not including innovative disruptors, like Tesla.

In the past, profits for carmakers arose solely from manufacturing cars. Nowadays, the way of business is changing and projections forecast that by 2030 over half of the revenue from the automotive industry will come from disrupted areas (Dhawan, Hensley, & Padhi, 2019).

These changes are originated by both consumers and competition. Regarding the former, demand for cars is sinking (Ili, Albers, & Miller, 2010). This is due, in part, to consumers' taste in individual transportation shifting from ownership-driven towards lower asset intensity (Bouton & Knupfer, 2015). Furthermore, as environmental awareness raises (WHO, 2018), demand for cars decreases, as those contribute to a polluted air.

Competitive dynamics is also changing, as disruptive players enter the market. For one, cash-rich high-tech companies like Tesla, originally targeting niche segments, attract an increasing number of customers (Gao & Kaas, 2016). Furthermore, new mobility services entering the market are forecasted to be able to generate ten to 25 times more from one mile driven than carmakers currently do (Heineke, Padhi, & Pinner, 2019).

The described drivers lead to increasing profit pressure by decreasing demand and increasing competition for carmakers. Literature even talks of a second automotive revolution (Freyssenet, 2009) leading to visible consolidation of carmakers (Financial Times, 2019). Therefore, due to increasing profit pressure, carmakers need new value creation sources in order to survive and stay relevant in the changing business field.

2.2 Data monetization

Data is a relevant topic in the changing business environment, as the amount of data grows exponentially (Kettinger & Najjar, 2014). This phenomenon is named "big data", meaning to create a huge amount of data (Schroeder & Halsall, 2016). Companies use data to generate revenue, namely "data monetization", which means to use data for an "economic impact" (Gartner, 2019) or to convert "intangible value […] into real value" (Kettinger & Najjar, 2014). To monetize data, raw data can be transformed into a data product, implicating several forms of complexity and variety (Woerner & Wixom, 2015). With rising complexity, several steps are taken to add value. This is illustrated by the data value chain, in which the single value-adding steps are described (Miller & Mork, 2013).

Profit from data monetization is valued at 330 billion USD in 2018 and the compound annual growth rate (CAGR) is predicted to be 54% until 2024. This indicates the rising importance of data monetization itself and of successfully bringing economic impact from data monetization (Derwisch, 2019). Nevertheless, businesses perform only a gradual transformation towards monetizing data and companies are still exploring its utilization (Schroeder & Halsall, 2016).

Only 17% of companies have already established data monetization initiatives (Derwisch, 2019). This indicates that data monetization is still in an early-adopter stage (Laney, 2018). Attempts to deploy data monetization often fail, mostly due to incomplete data or poor quality, and issues in the usage of data regarding ownership and privacy that are not solved (Moore, 2015).

Concluding, data is becoming increasingly important as data monetization can lead to substantial value and, as such, has huge potential as a profit source. However, its application is not widely established, as barriers still exist.

3. Research question

3.1 Research gap

To survive in a rapidly-changing business environment, carmakers must find new profit sources, which makes data, as a potential candidate, increasingly important. As such, it becomes obvious that: (1) carmakers need a new value creation source to ensure profitability; and (2) data monetization can transform the value created by data into economic output. Furthermore, carmakers are among the producers of exponentially growing amounts of data, hence data monetization's huge potential as a new profit source (Schroeder & Halsall, 2016). However, currently, only whitepapers, published from leading consultancies like McKinsey (e.g. Heineke et al., 2019), discuss related issues. To my knowledge, no study in the extant literature addresses data monetization applied specifically to carmakers.

3.2 Research questions

This study contributes to filling this gap by adding content to the question of interest:

How can carmakers enhance value creation through data monetization?

This question of interest is addressed by discussing two accompanying research sub-questions. The first one assesses the current state of deployment and the second one identifies the main hindering issues.

How do carmakers currently deploy data monetization?

What are the issues hindering the deployment of data monetization by carmakers?

To address these research sub-questions, the study is organized by firstly, explaining the methodology behind the qualitative research, consisting of three different methods. Subsequently, both research questions are addressed by: (1) developing a theoretical framework about possible applications of data monetization for carmakers; and (2) identifying and analyzing the obstacles and issues along the data value chain that hinder carmakers from deploying data monetization.

4. Methodology

The following part illuminates reasons behind the choices for research design and data collection and evaluation.

4.1 Methodology construction

Methodology is defined in several ways, it can mean the study of methods, but can also refer to a range of methods (Mingers, 2001). The latter, being the umbrella term for different methods, is used in this study. To provide an overview of data monetization for carmakers, this study uses mixed-method research. Mixed-method research provides a broad understanding of complex phenomena (Manzoor, 2016). As such, it is suitable for the complex data monetization topic for carmakers. Traditionally, mixed methods are understood as combining qualitative and quantitative research but can also be applied to only qualitative methods (Mingers, 2001).

The methodology used, shown in Figure 1, differs in the development of frameworks and their application to use cases for carmakers. The qualitative methods used are mainly differentiated by literature-based and interview-based approaches, while the latter is further differentiated into inductive and deductive analysis. The illustrated clustering describes the methods used, not the study's structure. Meaning, in the results section, the first research sub-question is addressed by generating a framework through grounded theory, whereas the application to use cases for carmakers is done by deductive analysis. The second research sub-question is addressed by developing a data value chain through state-of-the-art review, whereas the application for issues hindering carmakers is done by deductive analysis. As explained in section 4.2.2, despite the different analysis procedures, only one round of interviews is conducted for all methods used.
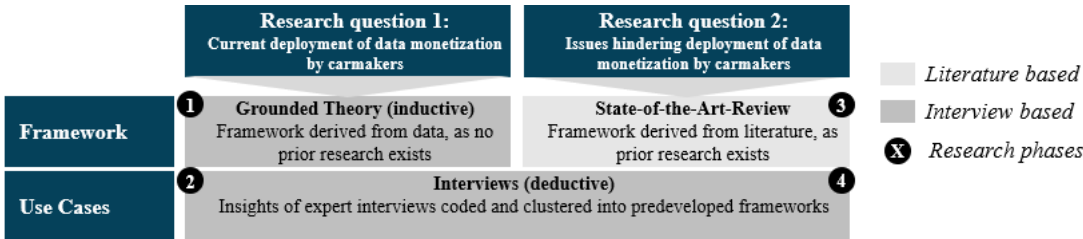

Figure 1: Mixed-method research methodology consisting of three qualitative methods (source: own research)

4.2 Research design

Overall a qualitative research design is used, as data monetization is a complex process involving many influencing factors. Mingers (2001) states that "research is not a discrete event but a process that has phases […] which predominate at different times." (Mingers, 2001, p. 245). Thus, this study's research design is divided in four different research phases, which are indicated by the black circled numbers in Figure 1 and discussed in the following section.

4.2.1 Research phases

Phase one: Study of general ways for carmakers to deploy data monetization

The aim of this phase is to develop a general framework for the application of data monetization grounded in the carmaker perspective. As no research in this field exists, the development is done in line with the approach of Eisenhardt (1989). The **grounded theory** approach is chosen, as it is strong in assessing unexplored areas (Glaser & Strauss, 1967). This is followed by the approach of Strauss & Corbin (1990), deriving theory solely from data, based on a purely qualitative approach. Subsequently, the coding of the underlying interviews is done by **inductive** codes.

Phase two: Study of concrete use cases of data monetization for carmakers

The use cases relevant for carmakers are demonstrated based on the developed framework by deriving knowledge from **interviews** with **experts** and coding them a priori to the preexisting framework. This means to have preassigned codes, emerging from the clusters found in phase one (Johnson & Christensen, 2016). **Deductive** codes are used to follow a structured approach to apply the carmaker use cases to the developed theory.

Phase three: Study of the process of value creation from data (data value chain)

To identify reasons for issues hindering data monetization in carmakers, discrepancies in the data value creation process are chosen as clustering drivers. Hence, first a general data value chain needs to be developed. To do so, literature review is applied, as a body of research already

exists. To reduce bias, a systematic process is chosen, meaning to have a clear question, "creation of a data value chain" and to have clear assessments of the sources, criteria for exclusion and tables to summarize findings (Booth, Papaioannou, & Sutton, 2016).

As type, the **state-of-the-art review** is chosen, because the issue just arises and, as such, current matters are addressed, hence the aim is aggregation of existing contributions towards one data value chain. The sources are restricted to Google Scholar, Google Search, and JSTOR, based on exclusion criteria build by articles found under the keywords "data value chain" and "data value creation". Google keyword search is enhanced by further searching for the top 40 images. The findings are summarized under results. Characterized by the SALSA framework, the review aims for a comprehensive search (S), while quality appraisal is not formally assessed (AL), the synthesis (S) is narrative and analysis (A) is based on research (Grant & Booth, 2009). As such, emphasis is put on the search process, not the quality. However, for a state-of-the-art review, it would be necessary to describe the data collection and analysis process in detail. Nevertheless, to answer the research questions empirical research methods based on interviews are used and the state-of-the-art review presented only builds a supporting framework to the second research sub-question, as such, no detailed process description is done.

Phase four: Study of the issues that hinder data monetization by carmakers

Next, to identify patterns of similarity and differences, discrepancies within the process of value creation by data among carmakers are analyzed by **interviewing experts,** asking for specific issues and mapping them to the corresponding step in the value chain or identifying them as overarching ones. The same applies as in phase two, but the deductive coding of interviews is used towards the developed data value chain in phase three (Johnson & Christensen, 2016).

The approaches of the four phases mainly differ in interview-based (phases one, two and four) and literature-based (phase three). In the following section the interview-based design, is described, as it builds the main body of this research.

4.2.2 Interview design

As the existing body of research fails to answer the research sub-questions, test subjects in form of experts are needed (Eisenhardt, 1989). The research is performed by conducting a single round of semi-structured in-depth interviews with open-ended questions to ensure responses are not biased and flexibility is given for open discussion.

For the grounded theory approach (used in phase one) and the interview method with deductive coding (used in phases two and four) the same interviews are considered. Also, in order to derive maximum expertise, two different questionnaires are constructed: (1) employees working for carmakers, and (2) experts dealing with the sector (Eisenhardt, 1989). All interviews are in English and consist of 15 questions (details in Appendix 1).

The questions are clustered in categories and subcategories, allowing for personalized or new topics. First, starting to *build trust* by asking about interviewees' activity and experience to data usage. Next, questions about *data monetization* are asked, more concretely how it is currently implemented using specific examples. Then, data usage for the whole sector or the specific company is assessed. Subsequently, *influencing factors* are discussed by asking for specific problems or factors ensuring success. Concluding, questions are asked about the desired *future outlooks* and space is given for topics not yet covered.

4.3 Interview data collection

For all interview-based approaches, deductive and inductive coding (phases one, two and four), the same interviews are considered, hence data collection is similar and only described once.

In qualitative research, trustworthiness is important to ensure reliability and make the evolving theory more robust for future generalization, hence multiple test objects are questioned (Yin, 1994). Therefore, a series of interviews is conducted serving to disagree or confirm (Yin, 1984). As the purpose is not to test, but to develop theory, the appropriate sampling is of theoretical nature (Eisenhardt & Graebner, 2007). Accordingly, "polar types" of interviewees are chosen including employees working for carmakers and automotive-focused experts for data

monetization, as they are helpful for an overview (Eisenhardt & Graebner, 2007). Further bias is reduced by satisfying triangulation, meaning to collect different data kinds (Klenke, 2008). After six interviews, the contribution of the last two interviews was little to the evolving knowledge as repetition arose, such, saturation was considered (Suddaby, 2006). The interviews are referred to by the ID shown in Table 1, details of the content can be found in Appendix 2.

ID	Company	Interviewee	Location
I1	Carmaker	Project Manager Urban Air Mobility	Germany
I2	Automotive data consulting	Director of Strategic Initiatives	Israel
I3	Automotive Innovation platform	Director of Partnerships	Germany
I4	Smart mobility consulting	Founder	France
I5	Carmaker	Business Developer	Germany
I6	Carmaker	Data Business Developer	Germany

Table 1: Overview of interviewees (source: own interviews and company websites)

4.4 Interview data evaluation

For data evaluation, a coding technique is applied with the purpose to identify patterns by transforming individual responses into categories (Klenke, 2008). Data evaluation is different for inductive coding (phase one) and deductive coding (phases two and four). Hence, both approaches are discussed separately.

4.4.1 Inductive coding

Simultaneous and continuous involvement in data collection and analysis is performed. For that, after each interview, data is analyzed based on a posteriori coding (Charmaz, 1996) . This means codes are developed inductively, following the method of Strauss and Corbin to use "open coding, axial coding and selective coding" (Moghaddam, 2006, p.52). First, *open coding* is the process of data that is "broken down analytically" and represents the inductive principle of grounded theory, to derive theory from the data (Böhm, 2004). Raw statements are coded towards broader categories by being directly labeled (first-order codes) with in-vivo codes

adjusted to the interviewee's language (Böhm, 2004). This helps to compare and conceptualize responses (Saldaña, 2015). Secondly, *axial coding* is used to cluster the assigned codes theoretically (second-order codes). Finally, *selective codes* are used to identify dependencies for overarching dimensions, as main categories (Saldaña, 2015).

The described constant comparative approach is performed by repeatedly investigating theoretical codes to assess central categories (Böhm, 2004). Hence, established codes are used to create a new category or rename and refine an existing one, not to agree or disagree to statements (Strauss & Corbin, 1990). However, one should note that coding is a subjective analysis and may differ among authors (Gioia, Corley, & Hamilton, 2013). The coding procedure for developing a data monetization framework evolved in two overarching dimensions, four second-order codes, and 15 first-order codes, as depicted in Appendix 3.

4.4.2 Deductive coding

The purpose of coding stays the same when evaluating individual replies from interviewees towards broader categories to detect clusters and patterns for problems of carmakers in data monetization (Klenke, 2008). A priori coding are deductive codes, meaning to assign codes from the prescribed data value chain as broader categories and map the interviewee answers (Johnson & Christensen, 2016). This analysis method is criticized to limit analysis as no open coding procedure is done, meaning codes cannot be added or adjusted (Booth et al., 2016).

However, deductive codes are chosen for phases two and four as the aim is to map insights given by experts towards the derived categories. Nevertheless, to overcome the limitation described, besides deductive coding, overall observations are also analyzed.

For phase two, each data monetization category is used as one code, hence, four codes arose (Saldaña, 2015), as shown in Appendix 4. For phase four, to identify patterns in issues, each step in the value chain is used as one code (Saldaña, 2015), demonstrated in Appendix 5. Additionally, overall observations are derived.

5. **Results**

In this section the two research sub-questions are discussed. It is important to note that each research sub-question is assessed independently, even though findings can be interrelated. To discuss research sub-question one, namely how carmakers monetize data, first a framework of monetizing data for carmakers is developed. In a second step this framework is assessed for concrete use cases relevant for carmakers. Research sub-question two, about issues for carmakers, is discussed by analyzing the data value creation process before monetization can happen and identifying major issues for carmakers.

5.1 How carmakers currently deploy data monetization

5.1.1 Framework for the deployment of data monetization by carmakers

5.1.1.1 Framework development

The following framework for the application of data monetization is developed by using the grounded theory approach which implies inductive coding and a resulting framework.
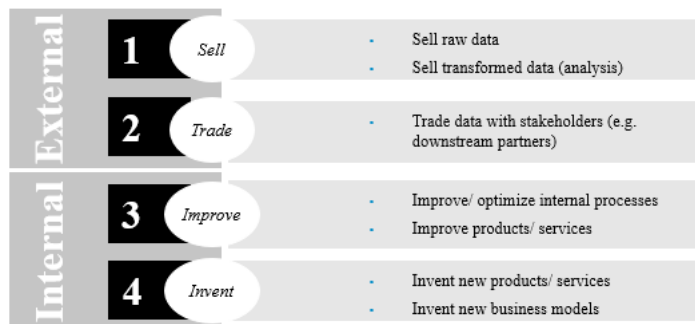
Figure 2: Framework for the usage of data monetization (source: own research)

Generally, data can be used externally or internally, as indicated by the overarching dimensions. The differentiation is not based on what happens with the data itself, but on the aim of the action, hence, what it is ultimately used for.

As indicated by nearly all interviewees data can be *sold* or *traded* **externally**. Regarding the former, as mentioned by I6, data can be sold raw (i.e. as collected) or as a more personalized product (i.e. after transformation and analysis). In fact, as pointed out by I4, it is hard to categorize the variety of personalized data products that could be created. Regarding trading

data with business partners, I3 confirms this practice with an example of the joint-ventures of BMW and Daimler, which currently start several partnering initiatives and share their data to get a broader picture of potential opportunities.

As stated by all interviewees data is used **internally** to *improve* existing processes and products/ services. Process improvement is named by four interviewees. Furthermore, I2 and I3 state that data is also used to *invent* and develop new products/ services or entirely new business models.

5.1.1.2 Comparison with literature

As the grounded theory approach is used, the derived model must be compared with the literature. Usually, this is part of the discussion section, however, as the framework is directly applied in the following section, it is necessary to discuss it at an earlier point.

Derwisch (2019) focuses only on selling data, from raw to analyzed and aggregated data, which confirms a part of the proposed model. In contrast, Walker (2015) clusters data monetization among the actions performed with data and differentiates between keeping the data, trading it, selling it or making it available to everyone for free. The clustering does not disagree with the proposed framework, but simply puts more emphasis on how the data is used instead of how it creates value. Making data available for free is not included in the developed framework, as it might have indirect economic impact, but no direct impact is derived. Laney (2018) talks about direct and indirect monetization, focusing on the difference between directly exchanging data for goods, services, cash or other data, and indirectly improving efficiencies, reducing risks or building solid relationships with partners. In comparison with Laney (2018), the developed model focuses more on direct monetization and less on soft factors like building solid relationships. Nevertheless, he also notes that, for indirect monetization, it is important to state measures to make sure there is an economic impact (Laney, 2018). Wixom & Ross (2017) cluster the practice of data monetization into "improving internal processes", "wrapping information around products" and "selling data" (Wixom & Ross, 2017, p. 10-11). Similarly,

Gottlieb & Rifai (2017) cluster the topic in: (1) adding new services, (2) developing new business models and (3) joining with similar companies to create shared data utility. The names differ, but all named concepts are covered in the developed framework.

Concluding, the approaches to describe data monetization from literature are in line with the developed framework based on data monetization for carmakers. Even though different clustering approaches can be recognized, all relevant categories are included in the model that fit to the described definition.

5.1.2 Use cases of data monetization among carmakers

Data monetization is a relevant topic for carmakers as confirmed by every interviewee. Interestingly, when asked about examples for data monetization, except for I6, every interviewee gave general answers about "projects that surely exist". I3 and I1 even added "realistic specific examples are hard, I don't know any". When asked about current projects, most examples are based on internal data usage, namely, four about improving existing products and two about creating new ones. Another two examples referred to trading data to business partners, both of which came from outside experts, not from employees working for a carmaker. This illustrates that not much emphasis is currently put on trading data. Nevertheless, I6 could give an actual example of selling data and added that they are "frontrunners" among carmakers. Interestingly, in contrast to not being able to provide concrete examples, all interviewees named selling data as type of data monetization. This indicates the importance of selling data as a mean of monetization, but implementation seems to be hard.

Concluding, data monetization is considered a relevant topic for carmakers, however, it is hard for interviewees to find implemented examples. Hence, as indicated by I5, usage is not transparent. If data monetization projects exist within companies, they are barely shared and even employees working in the field of business development or data-based development are

not aware of them. This indicates that data monetization is still in an early stage of development, not yet generating revenue. Selling data is not yet an option for most carmakers.

Hence, by discussing the first research sub-question, two main findings are derived.

Finding 1: Data monetization is neither often nor widely applied by carmakers yet.

Finding 2: Data monetization, when applied by carmakers, is more often with an internal (improve products/process) than with an external (sell/trade data) focus.

Issues hindering the deployment are addressed by the next research sub-question. However, it is important to note findings are not mutually exclusive, but this is not discussed in this study.

5.2 Issues hindering the deployment of data monetization by carmakers

The second research sub-question is addressed by analyzing the process of data monetization for carmakers. However, it is worth mentioning that this discussion is independent from the previous findings. First, the data value chain needs to be identified and analyzed. To do so, a state-of-the-art review is performed. Subsequently, the data value chain is used to analyze the monetization problems for carmakers.

5.2.1 Framework for data value chain

A state-of-the-art review is conducted to derive a data value chain for carmakers. By applying the review, six data value chains could be extracted from literature, detailed results are shown in Appendix 6. The carmaker value chain is shown in Figure 3 and explained below.
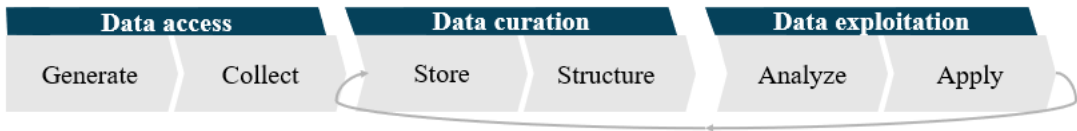
Figure 3: The data value chain (source: own research)

In the beginning of the data value chain, generation and collection of data is necessary, as named by all literature approaches. Despite some different naming, like data acquisition (Curry, 2016), data sourcing (Jony, Rony, & Rahman, 2016), in most cases this step is referred to as data generation or collection. As in the automotive industry the generation of data from software or hardware plays a huge role, both are separated in the illustration and clustered as "data access".

As data is generated (e.g. from a moving vehicle), in order to make it a valuable resource, it is necessary to collect the gathered it (Curry, 2016).

Differences in literature approaches come from different orders of data analysis and curation. Curry et al. (2016) argue that first, data should be analyzed to have an aim when starting with the curation. However, as in the analysis by carmakers different data sources are included, a previous storing and structuring is necessary. Hence, data needs to be stored and structured, to ensure that is interoperable (Open Data Watch, n.d.). This is called the data curation phase, which is important as actions taken have an impact on the usability throughout the life-cycle of the data (Open Data Watch, n.d.). Storage of the collected data is done by different technologies able to deal with huge amounts of data (Strohbach, Daubert, Ravkin, & Lischka, 2016). After the data is stored it needs to be structured, a "key data management process" (Freitas & Curry, 2016, p. 87). It includes cleaning and transforming different formats of data, so they can be appropriately assessed (Stonebraker, Bruckner, & Ihab, 2009). This is an important step to increase the potential value derived, as data is prepared to be analyzed (Jony et al., 2016).

Next, data is ready to be exploited. First, it is analyzed with different methods, another important step in increasing value. Whereas descriptive analysis aims simply to describe what happens, predictive analysis investigates reasons for the happening and prescriptive analysis focusses on the future "what is needed" (Jony, et al., 2016). Then, the analyzed data has to be applied to generate business value (Becker, 2016). Application can be non-monetary (e.g. supporting business decisions) or monetary, as demonstrated in previous chapters.

Most studies discuss the characteristic of data as "circular" (OECD, March 2019) and reusable (Open Data Watch, n.d.). To illustrate this, the lifecycle component is added, indicating that the resource "data" is not exhausted after the value chain ended. It can be reused and might even improve in quality when reused.

5.2.2 Issues identified along the data value chain

To address the second research sub-question, the developed data value chain is used for analyzing issues hindering the deployment of data monetization for carmakers. The three main findings are explained below. The first finding is derived by deductive coding among the value chain categories and the other findings are overall observations.

Finding 1: Carmakers lack data curation and exploitation capabilities

As illustrated in Figure 4, problems named by carmakers are coded into the field of data curation and data exploitation. Not a single problem is stated in the field of accessing data, in fact, even reserved carmakers are confident about having a broad database. This is also indicated by I1, who said, "enough data exists in our company" and I4 "OEMs have all the data you need".
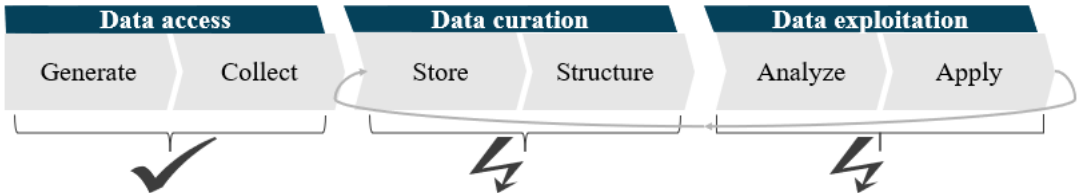
Figure 4: Problems are concentrated in data curation and data exploitation (source: own research)

However, data curation and exploitation present several issues. Problems stated in data curation include: costly access of stored data, storage in disconnected silos, non-existent data infrastructure, lack of skilled personnel, and data anonymization requirements. Problems mentioned in data exploitation include, particularly, lack of skills and expertise.

Finding 2: Carmakers aim to cover the whole data value chain internally

Through the conducted interviews another general observation was derived. Carmakers seem to want to keep data exclusively proprietary and, as a result, cover the whole data value chain internally, illustrated in Figure 5. This means building up capabilities in all steps of the data value chain, which not only takes up a lot of resources, but is also costly and time consuming.

Figure 5: Carmakers want to cover the whole data value chain internally (source: own research)

This insight is derived from several observations. First, all problems named refer to the data curation and exploitation stage when performed by the carmakers themselves. No problems are named indicating willingness to perform only some parts of the data value chain.

Furthermore, the value of data is still unpredictable and competition about leading designs is high, as I2 stated "a race of being 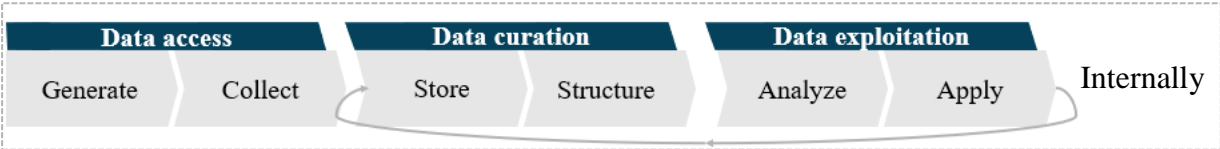the first one". Carmakers seem to fear losing an important profit source when only concentrating on one part of the data value chain. I5 argued that, even within companies, every department wants to cover every single step: "Everyone wants to have the best idea for a data monetization initiative, everything is kept secretly". The different departments do not seem to exchange data. Concluding, carmakers do not perceive concentrating on one part of the data value chain as a reasonable approach.

Finding 3: The market for data selling is underdeveloped

The third observation from the interviews refers to the last step of the value chain, as shown in Figure 6. Implicating that the market for selling data is widely underdeveloped.
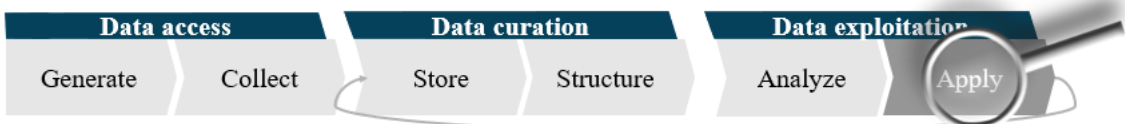
Figure 6: The market of selling data is underdeveloped for curated and analyzed data (source: own research)

This observation is derived from nearly all interviewees naming troubles in finding a practical way of selling data. I4 stated for instance, that it is hard to imagine what a good data product could look like. Problems occur not only on the supply side (i.e. within carmakers) but also on the demand side, as pointed out by I6, who, after selling data, experienced troubles on the customer infrastructure to use it. Furthermore, pricing mechanism differs, as data is created in an ongoing basis which makes traditional one-time selling hard.

Concluding, the market for selling data is underdeveloped which makes its implementation hard for every player in the market.

6. Discussion

6.1 Managerial implications

This study's findings suggest that, while data monetization may have the potential to become a significant profit source for carmakers, it is not living up to its potential yet, due to carmakers attempting to cover the full data value chain without proper skills in data curation and exploitation. Carmakers have access to data, which means they could potentially play the role of "data suppliers", relying on facilitators in form of consultancies, infrastructure or analysis providers for data curation and exploitation (Schroeder & Halsall, 2016). Hence, the following strategic options arise for carmakers:

Option 1: Build data curation and exploitation capabilities internally

Option 2: Sell data to companies with data curation and exploitation capabilities

Option 3: Partner with companies with data curation and exploitation capabilities

Selecting the best option depends on the specific situation of each carmaker, however, successfully enhancing value creation through data monetization requires sharp strategic focus.

6.2 Limitations

This study contributes to theory development by adding to the body of research on the topic of data monetization. However, it is important to state its limitations.

First and foremost, it is worth mentioning that, the use of purely **qualitative methodology** implies that findings must be considered as hypotheses to be validated in future quantitative studies in order to assess their potential real impact. Then, it is also understood that **mixed methods** are, generally, subjectively chosen and might bring biases (Mingers, 2001). Furthermore, **grounded theory** is criticized as judgmental, as the coding procedure is mainly based on the researchers' interpretation and no statistical testing can be applied (Böhm, 2004). Limitations regarding **interviewees** also arise. Experts chosen are working solely for/with carmakers as defined in this study, not for/with disruptive entrants or innovative mobility

players. Furthermore, interviewees are only from Europe and all carmakers are from Germany. Also, only a low number of examples were identified. Moreover, choosing the point of saturation is a pragmatic concept. The outcome might change when other or more experts are asked (Suddaby, 2006).

Finally, among the **issues found**, the two findings are not mutually exclusively and collectively exhaustive (MECE), as selling data is one part of the overall data monetization. Interdependencies of issues are not assessed and might influence the findings or could lead to further findings.

6.3 Further research

Based on the findings and limitations assessed, recommendations for further research is given. Further research must be conducted in data monetization for carmakers, as it is still so little developed, that only few people within companies have knowledge about it. Hence, the body of research needs to grow, and successful real-life examples should be published. In fact, each finding provides a basis for further research to assess its details. Furthermore, as mentioned above, quantitative methods are needed to validate the proposed findings.

This study focuses solely on carmakers. However, it is conceivable that the developed frameworks could be applied to several industries. Further research in the form of application of the principles discussed to other industries could enhance findings and patterns, especially as other industries seem to be further developed in terms of data monetization, which could bring crucial learnings to the field.

6.4 Conclusion

This study's aim is to assess data monetization as a potential profit source for carmakers. For that, it focuses on the overall question of interest: "How can carmakers enhance value creation through data monetization?", which is addressed through the discussion of two research sub-

questions: (1) the current application of data monetization by carmakers and (2) the major issues hindering the deployment of data monetization by carmakers.

Findings suggest that carmakers currently apply data monetization only to a little extent or, in some cases, such as selling data, almost not at all. Explanations for the currently low application involved three main findings: (1) carmakers lack data curation and exploitation capabilities; (2) carmakers aim to cover the whole data value chain internally; and (3) the market for data selling is underdeveloped.

Therefore, this study has achieved its stated aim, ensuring theoretical relevance by contributing to a growing research body and identifying opportunities for further research, as well as practical relevance by providing concrete strategic recommendations for carmakers to enhance value creation through data monetization.

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8. Appendices:

Appendix 1: Interview Guideline

#	Topic	Question Topic	Interview Guideline for carmaker experts	Interview Guideline for employees of carmakers
1	Warm-up	Role of Interviewee	Can you describe your current activity?	
2			How did you develop expertise regarding car data monetization?	How does your activity relate to data monetization?
3	Data monetization for carmakers	Usage	What can data monetization be used for?	
4			----------------	Is data monetization practiced in your company?
5			Can you give examples of usage from carmakers?	
6			How do you think data monetization is used by carmakers?	
7			Can you give an existing example of selling data from carmakers?	
8		Problem fields	Which are the major problems regarding monetizing data for carmakers?	Which problems did occur to you when monetizing data?
9			How can they be overcome?	
10			----------------	Which are the major problems regarding data monetization for all carmakers?
11		Success factors	What are data-based success factors	
12			What are strategic success factors?	
13		Future Outlook	How do you think the role of data monetization will evolve in the future for carmakers?	What works well/ needs improvement to enhance data monetization in your company in the future?
14	End	Closing	How do you think will carmakers position themselves in data monetization?	How do you think will your company position themselves in data monetization?
15		Other aspects	Are there any other relevant aspects you would like to add?	

Appendix 2: Interview summaries

Interview 1 (I1): Carmaker; Project Manager Urban Air Mobility; Germany

#1:
- Working for an OEM in Germany for 2 years now, for 4 months project manager of urban air mobility
- Before consulting in the field of future mobility

#2:
- Group internal race about who will be able to perform urban air mobility, only one company will do
- Data monetization important for everyone, especially in new fields of business and for automotive sector

#3:
- Data monetization means selling data, as it is, mainly for revenue generation
- Data is currently mainly used by tech companies, they sell all their data available

#4:
- No, **realistic examples are hard to find I don't know any** from my company

#5:
- Carmakers could generate revenue by selling their data, this should be easy for us as we interact with the customer directly and as such have all the data about them, I truly believe **enough data exists in our company**

#6:
- Tracking car data for optimization:
  - You can record every kilometer and then, when a car is in the workshop you are able to track the parts and hence can analyze the whole vehicle. You can see the development of the parts, which parts last longer and which parts are replaced early
- Use customer data to choose a perfect product design:
  - For example, it is possible to do local adjustments by deriving insights from data about your local customers. It could be that my main customer for one car is male in Germany but female in China and as such I might need to adjust the color that is available for the car towards a male or female taste in the according country
  - Generally, the whole design process can be improved by data. When in the past only our quality improvement department tested and told us what they didn't like, now the data from actual customers can be used to track what kind of features they use most, and feedback can be evaluated

#7:
- Not that I know of, I don't think this yet exists for us

#8:
- There are a lot of problems, maybe one is, how we can use the data that we have, we don't really know to what extend we need to anonymize the data that we have
- We are missing the skills and know-how to sell the data that we have
- It is hard to identify the purpose, which data can be used for what and why

#9:
- This will probably depend on several factors, I need the awareness of everyone in the company towards data monetization, the ideation process needs to be everywhere

#10:
- I guess the same as I said for us explicitly, there is not much interaction between companies or even between departments in this topic

#11:
- Data quality is important
- Data accessibility needs to be ensured, a lot of data is still in silos

#12.
- The overall openness of employee towards data monetization
- Also having skilled people to succeed with processing data

#13:
- Hard to answer, I think it is not as concrete yet, overall purposes need to be found

#14:
- I think it is not possible to state yet if data-based business models will become relevant for us or to what extent we can succeed in such market

#15:
- No, thank you

Interview 2 (I2): Automotive data consulting; Director of Strategic Initiatives; Israel

#1:
- Director of partnerships and strategic initiatives at Otonomo, 4 years ago established and support the commercial team when it comes to putting the data to use, working on use cases implementing this data. I support our team worldwide (US, Europe & Japan)

#2:
- We help, as 3rd party, so that carmakers can access their data and are able to use it. We partner with car manufacturers, connecting their back data from the data source and normalize the data to have one unified picture. We expose this through API in real time

#3:
- Today there is no standard about how data can be used, but there are different levels of maturity about how data is used, but surely the topic is of huge importance for automotive OEMs
- New revenue stream, generally it is a lot about costs savings and time, money & resources, as well to improve the overall user experience

#4:

#5:
- Location-based services:
    - One of our clients was able to offer their customers location-based services. Customer traffic behavior data is an important variable here. Currently, every location-based service, or most of them, rely on mobile phone data so you can add a lot of value to the services when you take additional vehicle data

#6:
- I know from my work that it is possible to generate a **new product** by using the data correctly, or offering a **new service**, I guess this is what was done by the carsharing offerings from automotive OEMs, but sometimes also whole **new business** models evolve

#7:
- I think they exist, but I cannot tell you a concrete example

#8:
- The biggest problem is costs in terms of resources and time
- reliable data, too complicated data resources and inefficiencies about getting data from connected vehicles today
- Data is unavailable, it is there but not accessible, you want to access as many vehicles as possible to derive value and to make statistical assumptions, I think automotive OEMs can do so, they have a lot of data, but they need us to help them to harmonize it

#9:
- Our service can help to solve a lot of problems for automotive OEMs, we harmonize data and also help to keep the topic more in focus

#10:

#11:
- I think the quality of data is crucial and therefore we founded the company, we want to help OEMs to work on the harmonization of different data kinds and we offer them analysis possibilities

#12:

- It depends on your company background, for example Daimler & Porsche deal with the way of being the first one to make data available and accessible, it is a **race for being the first one** for them and being in a race is always hard they become like start-ups

#13:
- I think data monetization is an important topic and will be come more and more important due to the ongoing digitalization

#14:
- The landscape will be a mixture between startups and traditional firms:
  o a lot of innovations come from the start ups and they are usually early adopters or fast movers, so we encourage and support such players in the ecosystems, they are a driver of new services and products
  o still the traditional companies have an advantage, as they do have a lot of data, so they are in the pole position to use it

#15:

- I think, there is still a lot of resilience about restrictions and how to proceed the topic of data monetization. There has been a shift in recent years, 4 years ago you couldn't talk about opening, now companies understand, they must. But still everyone talks about data monetization, but actual performance is not seen yet

#1:
- We are initiated by a big OEM in Germany, but have our headquarter in the US
- We work together with innovative startups and help them to make cooperation's with OEMs and automotive suppliers and all other players in the automotive industry, so they can get involved
- I take care of our German industry partners, around 27 partners (Daimler, Porsche, ZF, Eberspächer) and I do a business development and partnership management job, to find new partners and maintain the existent

#2:
- I think all innovative ideas in the automotive sector currently deal with digitalization and mainly with data, data becomes the new oil

#3:
- Of course, monetization means selling the data that is generated
- just providing and sharing the data with others
- Finding supplement business models for alternative ways to generate revenue
- Processes will be more efficiently designed when analyzed through data

#4:

#5:
- In my opinion this can be seen best with the **new ventures of Daimler and BMW**, they partner together, who would have thought so a couple of years ago. In my opinion the basis of this partnership is to access a lot more data, they partnered together by putting not only tangible valuables together, but also by trading their data. They get a lot more powerful when having broader knowledge about customers

#6:
- In my opinion it should be mainly used to develop **new business models** or just new ways for revenue, like to have a new offering
- Also, by it is possible to broaden your internal data by enhancing it with external data provided from your partner

#7:
- It would be stupid by carmakers to not sell data in the future, all cities need data that lies within cars and hence the data from automotive OEMs about the movement around the city
- Nevertheless, you need a working infrastructure to sell the data, this is really challenging and as such **realistic examples are still hard to find**

#8:
- What I see is that there is no good digital infrastructure for most manufacturers, this is really a problem as data needs a robust infrastructure to provide a solid ground for further usage and purpose identification
- A huge problem is everything is still so new that OEMs struggle to keep up with the law, so e.g. Uber drivers just filed a lawsuit against Uber in the UK claiming that they do not fulfill the GDPR regulations, OEMs do not want this to happen, so they might wait

#9:
- To overcome problems a consolidation of partners will be key, a lot of pressure arises, and players will not be able to survive (e.g. just now new pressure arises by topics like e-scooters). OEMs do not have time and resources to survive on their own

#10:

#11:
- With data it is always the problem that you need a critical mass of data, so I think this is performed quite well by established players, but not by new and innovative startups. But, right now traditional players are more hesitant to move forward. Is it worth to spend that much money for a business model that is currently not working?

#12:
- From a strategic point of view it is hard to get the analysis skills right, people actually lag behind, there are so many employees who are educated before the digital raise and they lag the capabilities to transform data into value

#13:
- If you look at this from a connectivity point of view, everything gets more and more connected and more data is generated, and better utilized. We see this in the market, every player sees the potential to leverage this and sell data or trade data and use it to make money out of it

#14:
- I think it will not be about carmakers, moreover cities will become more important. They are underestimating what kind of power they have: which players should they allowed to run which business model, they could restrict that and profit from it. What is already ongoing now is that cities become more power and advancing, big metropolitan areas create a strategy and realize they have a lot of power (e.g. scooters lie around, only under certain requirements you are allowed)

#15:
- What I want to say is that it is just not clear which player will become dominant or how data will be monetized, there are too many white spots still

Interview 4 (I4): Smart mobility consulting; Founder; France

#1:
- I interact across the globe, even though European based within my niche boutique company by giving advisory to start ups and Pes, we also have operating roles that go well beyond consulting especially for ventures financing at an early stage we provide a lot of knowledge
- We take the idea to market when the prototype is developed, we support in the whole preparation to take innovations to the market the last mile

#2:
- What we are doing is the application of data and IoT into smart cities/ energies/ generally mobility and we want to cover end-to-end everything around this area

#3:
- Selling data is one very important topic, but there are so many different modes that data can be sold that it is hard to put them into categories. Mainly it is possible to **sell every kind of data as a product** imaginable
- As such it is also hard to imagine **what is good or what is bad**. A **data product has so little history** up until now that it could come in every possible form

#4:

#5:
- You can use data from the roads to reduce costs
  - Take data from the digitalization of roads (e.g. from point of interests and sights) and provide them to logistic companies that need to do the handling of goods. A big part of their cost structure is shipping & delivery. When you minimize the way to get packages from multiple companies and minimize the nr. of packages that are delivered you have lower costs. In a way that you offer reliability and insurance, as the order is going to get there without any problems. Data is powerful to organize the logistic & transportation processes. For example, when a transportation company knows the trucks are out around areas where they need to drive slowly due to bad conditions, then you know there is a correlation with the costs to the drive as it needs longer

#6:
- OEMs try to not get a total disruption. I think they are simply trying to monetize what they already do, so more in the form of improving the existent way how they do business, but they are not going all in
- Also new players arise that are very focused on different segments where data can be monetized, which might be also a possibility for manufacturers. For examples the geolocation/ mapping market is also becoming very important. Here is a very focused company and the core of the company is data

#7:

#8:
- For big companies generated data is a byproduct, not core business, they have been trying to not get a total disruption. As I said, startup companies can go all in and build up a data-driven business, they have the money because they get financed to bis disruptive

#9:

- The key is to know what you want to do, the strategy and what use case you are addressing
- You need to understand the data value chain, by this you understand the data that is needed for what you are trying to solve. You need to know about the whole life-cycle of your data

#10:

#11:
- Access to data is important, not everyone realizes this, god data startups might have better access to experienced data scientists, but data access is hard for them. Sourcing data is a capability that a company must build
- A lot of people underestimate how costly it is to build up a reasonable data storage, data amounts can be huge, and companies tend to underestimate the costs. This is why it is also very important to know what you want to store, otherwise this will become a huge cost driver

#12:
- People skills is crucial, this is what startups can provide, a whole set of skills is needed here
- You need to begin with an end in mind, companies need strategies, you can do data monetization in two different ways
  o I got a lot of data and then I figure out what I want to do with it. I need access to high quality and start to understand what use cases could serve. What is the underlying value of this use case and assess whether you need to complement it? Important is to choose wisely
  o Or the other approach is you don't have data, or you only have very little data, but what you do have is new ideas for monetization, more ideas are coming from this ankle (e.g. if you look in Waze they only share the data they have, so only based on selected cars and the users that use it to navigate the cars)

#13:
- Well for us we didn't decide yet where we want to play in the market

#14:
- On a broader basis around data monetization, companies need guidance about how to do data monetization, this is really the key. For example, **OEMs have all the data you need**, they probably have more data than anyone else and I think they also know about it. It is just the quality or accessibility that is usually bad or maybe they don't know what to do with the data they have, but the amount of data is not the problem

#15:
- No

Interview 5 (I5): Carmaker; Business Developer; Germany

#1:
- I work in the business development for 15 years now with the same company, currently we have ongoing projects in regard to digitalization and future initiatives, but they are top secret

#2:
- Business development for us becomes more and more focused on projects focusing on utilization of data, of course I am not an expert in this, we work together with several consultancies

#3:
- When I think about data monetization what comes to my mind is of course the pure selling of data. I think this is the meaning that most people understand when data monetization is talked about. What comes to my mind is companies like Facebook that can sell personalized data, the exactly know their customers and can personalize the data offering to a huge extent. They have the best analysis capabilities in the world

#4:
- On an internal basis we are using data monetization to the personalization of products, as such we reach to improve our products. Smarter product recommendations are given everywhere, so we want to do this as well. So, we try to reach customers directly by personalizing the infotainment on board. For examples cars are now increasingly used by more than one customer. We have enabled the car to save your seating position, so whenever you yourself go back to your car, by your own key, the car will recognize and adjust the seating position

#5:
- A major issue in our company is that the data we have seems to be one-sided, I think data monetization should be done by enhancing the data that we have. We could use more external data and we have so much data to give to others that we cannot use, but this is not done yet

#6:
- I think what is done the most is to optimize the internal manufacturing by data provided. This is the easiest, as the data is easy to reach by the workshops that order new parts directly from us and so we can track which parts are ordered often. Or even further by analyzing current processes, it is possible to see where a lot of time and cost is gone and to optimize this
- Also, as new services arise everywhere, also automotive companies seek for new profit sources in the form of innovative service developments. Carsharing is probably the most recent examples of new services that arose by analyzing the demand side

#7:
- I am not sure. I think this is not transparent, the whole data monetization topic is **not transparent** in our company. I would have to ask around, but probably I wouldn't be allowed to tell

#8:
- A lot of data exists, but it is a problem to harmonize it
- Maybe already earlier it is hard to access the data that is searched, the storage is complex and sometimes data is not even stored

#9:
- I am not deep enough into the topic to give a good and reliable answer here

#10:
- I think the problems that I mentioned do not only apply for us, but for every OEM. There shouldn't be a lot of differences, but I don't want to say this about our competitors.

#11:
- So, I think the data needs to be harmonized in order to success
- Further, the complex storage structure needs to be changed, it cannot be that nobody knows where data is stored that needs to be accessed

#12:
- In my opinion transparency is the biggest issues, I really don't know maybe someone else in another department has the answer to a problem I have, but I don't know of, so I think the company should aim to get more transparency and a central approach

#13:
- I don't think it is possible to predict this

#14:
- Well I think this is about being in the best competitive situation. Everyone wants to have the best idea for a data monetization initiative, everything is kept secretly. Within our company even within departments data is not really shared or maybe there are initiatives that I don't know of, but I feel like we want to keep everything secret until we are the best in selling the data we have. I feel like this is the same among a lot of players in this industry

#15:
- No

Interview 6 (I6): Carmaker; Data Business Developer; Germany

#1+#2:

- I work for a subsidiary in the data business development and am with my team responsible for selling of our data products. We are working closely with the data-business related team from the main company, they provide us with the data product and the also do all the storing and transformation of the data. It is more of legal nature that we are working within a subsidiary, we do all the strategic business development for selling and serve our clients

#3:

- Data monetization comes mainly in the form of selling analyzed data, we do this by providing an internet platform
- Maybe data monetization could be also more internally, in the form of optimizing the internal process. For us as carmakers I think this would be especially be in optimizing all the process of manufacturing, but I am not an expert on this. I am sure though that this exists in our company, it is probably within several departments

#4:

- Yes, it is, as we are a very innovative company, we were in the past frontrunners among a lot of topics and I think for data monetization we see us a frontrunner as well

#5:

- Slippery roads:
    o A famous example of us, we are cooperating with the winter service in the Zollernalb district to reduce the risk of accidents by improving the efficiency of the winter service in this district. Our cars are equipped with sensors that recognize slippery road conditions and then send the information and the GPS data into the vehicle backend. In real-time it is anonymized and can be displayed on a digital map in the two road maintenance depots of the Zollernalb district
- Pay as you drive insurance (PAYD):
    o This is one way how we by the usage of data came up with a new product or rather service. We offer to pay insurance exactly coupled with the amount that customers drive. The product can be used among our product range, not all vehicles are included yet, but details can be seen on our website. The rates are adjusted on the actual miles that are driven which fits perfectly to our customer needs, especially people who need a car but maybe do not need to drive on a constant basis, they can further save with this insurance mechanism

#6:

- Data can be sold in different formats and forms, I think it could be sold as it is collected, so in a **raw format** or also there is a contingency to how much value can be added. The data product as such gets more and more personalized

#7:

- **Yes sure**. We have a whole platform only for this. Our products are in the form of API and we provide them over a separated website.
- As I said, I think we are a very innovative company and are also known among carmakers to be traditionally innovative, so I think we see ourselves as **"frontrunners"** among our competitors. Of course, I am not able to look inside others or to see what they do, and we don't want to judge, but I think from what is visible, we are playing in the front row

#8:

- I think the **major problems** is not with us, but it is more with **our customers**, for example when talking about selling a data-product, we talked to existing customers, like gas stations and they told us that it is a nice idea to be able to show ads inside cars that

are nearly fuel empty, but they cannot proceed the data that we provide them, they are simply missing the infrastructure and the experience

- Further, we also face the problem of having a good use case for utilizing data and making profit out of it. Therefore, we do expert circles where we invite for examples members of the city council or mobility experts so they can tell us what the biggest pain points are. Then we collect those pain points, aggregate them and try to see how we could find a solution to this with our data

#9:

- Only the future can help to overcome such problems. The market for data monetization in general is not far developed. We are also discussing pricing options a lot, no one knows how a data product should best be priced, maybe be value-based pricing, but this is hard to assess. Pilot projects, like the slippery roads project can hopefully help

#10:

- I think a lot of players in the automotive industry are currently in the same phase that we are, we want to know what the market needs and especially our customers. What are their main issues and how can we contribute towards a solution? Of course, then there are also other criteria that need to be considered before piloting a use case

#11:

- I think our main success factor is that in comparison to a smartphone device, the vehicle still has better data access. A car has a lot more technology and hence in the long-term it offers the possibility to generate more reliable data. I mean for example a smartphone you can forget at home when you leave the house, it is not a consistent data source. Whereas, when you are in the car this is a consistent data creation. Maybe the smartphone is a bad example, but I hope you can see the point

#12:

- This is hard to answer, I think it is more about the developments and skills that we can build up. But then finally it could also be lucky to be the first one to move in this field

#13:

- A lot of studies exist how much profit is within this field of business. From what I know they are all quite high, but in the end, it is about the details. How could such product look like and how can it bring us as automotive OEMs and original manufacturers more value? I think it is also important to realize that it is also within us, we need to provide a product that is valuable for potential customers, I think this is where we need to be good in, knowing what is wanted and how it can bring us value

#14:

- Surely data becomes increasingly important and, in our company, there are more and more data task forces, especially for safety relevant traffic data. There is a division 0 within cities we cooperate with they have the aim to reduce traffic jams up until 0 by 2050, there are a lot of political initiatives. We have a lot of safety relevant data and as they are currently of huge importance, this is our time to shine. Even though we also know that there is a social responsibility to it, if the data can help people, we have to think about providing them for free

#15:

- No not really, but if you want you can send me the questions you raised and if I can think of any more details or other aspects, I will come back to you

Appendix 3: Inductive coding for grounded theory

	First order code	Second order code	Overarching dimension
I3	Putting internal & external data together	Trade data	External
I5	Wider data acccess		
I1	Sell raw data	Sell data	
I4	Sell raw data		
I4	Sell analyzed data		
I5	Sell analyzed data		
I6	Sell analyzed data		
I2	Improve internal process	Improve existing	Internal
I3	More efficient processes		
I6	Optimize manufacturing processes		
I5	Optimize manufacturing processes		
I5	Personalize products		
I2	Improve customer experience		
I2	Generate new revenue streams	Generate new	
I5	Innovative service development		
I2	New products		
I2	New services		
I3	Supplement business model		

Appendix 4: Deductive coding to map examples to data monetization usage

Detailed examples	Topic	Deductive codes		
"Daimler and BMW partner together. The basis of this partnership is to access more data, they partnered together by putting not only tangible valuables together, but also by trading their data, to get more powerful customer insights"	2 carmakers trade data to enhance reach	Trade data		External
"A cooperation between Daimler and the winter service in the Zollernalb district to improve the efficiency of the winter service. Mercedes Benz cars are equipped with sensors that recognize slippery roads and send the information to the vehicle backend. In real-time it is anonymized and shown via digital maps in the road maintenance depots of the Zollernalb district"	Road conditions	Sell data		
"It is possible to do local adjustments by deriving insights from data about local customers. The main customer for one car is male in Germany but female in China and as such adjustments to the colors availabe for each country need to be different."	Cultural preference in taste of product (e.g. color)	Improve existing		Internal
"When a car is in the workshop you are able to track the parts and analyze their performance, to see the development , which parts last longer and which are replaced early."	Track performance of parts for possible improvement			
"Generally, the whole design process can be improved by data. Now data from actual customers can be used to track what kind of features they use most"	Improve design process			
"We reach customers directly by personalizing the infotainment on board. For examples cars are now increasingly used by more than one customer. We have enabled the car to save seating positions, so whenever you go back to your car, by your own key, the car will recognize and adjust the seating position"	Personalized infotainment options	Generate new		
"Customer traffic behavior data is an important variable . Currently, every location-based service, or most of them, rely on mobile phone data so you can add a lot of value to the services when you take additional vehicle data"	Location-based services			
" We offer to pay insurance exactly by the amount that customers drive. Not all vehicles are included yet,but the rates are adjusted on the actual miles that are driven. Especially people who not constanly need a car, can save with this insurance mechanism"	Individual insurance "pay as you drive"			

Appendix 5: Deductive coding for issues hindering carmakers along the value chain

	Issues for autmotive OEMs	Deductive codes		
I2	Access to data	Store	Data curation	
I5				
I1	Silos in storage			
I4	Costly storage			
I1	Annonymization of data	Structure		
I1	Employee skills to structure data			
I3	Good data infrastructure			
I5	Harmonize data			
I1	Analysis possibilities	Analyse	Data exploitation	
I3	Analysis skills			
I1	Expertise for selling	Apply		
I6	Use case options			
I1	Purpose of application			

Appendix 6: State-of-the-art literature review for data value chain

OECD. (March 2019). Analytics for Integrity. Data-Driven Approaches for Enhancing Corruption and Fraud Risk Assessments. OECD.

1

Data Collection/ generation	Data processing	Data Sharing	Data (re)use – information	Data (re)use – decision making

Miller, G., & Mork, P. (2013). From Data to Decision: A value chain for big data. IT Professional, 57-59.

2

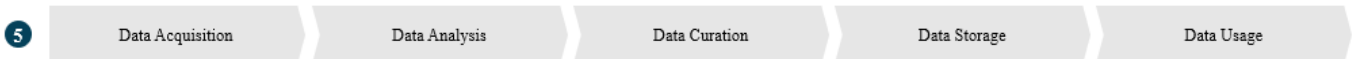| Data discovery			Data integration	Data exploitation		
Collect & annotate	Prepare	Organize	Integrate	Analyze	Visualize	Make decisions

Open Data Watch. (n.d.). The Data Value Chain: Moving from Production to Impact. Retrieved from Opendatawatch.com: https://opendatawatch.com/wp-content/uploads/2018/03/Data_Value_Chain-WR-1803126.pdf (accessed on 15 December 2019)

3

Collection			Publication			Uptake			Impact		
Identify	Collect	Process	Analyze	Release	Disseminate	Connect	Incentivize	Influence	Use	Change	Reuse

Jony, R., Rony, R., & Rahman, M. (2016). Big Data Characteristics, value chain and challenges. Bangladesh: Conference paper of 1st international conference on advanced information and communication technology.

4

Data	Information	Knowledge
Data source, types and accessibility	Preprocessing and storing	Processing and visualization

Curry, E. (2016). The big data value chain: definitions, concepts, and theoretical approaches. In New horizons for a data-driven economy (pp. 29-37). Springer, Cham.

5

Data Acquisition	Data Analysis	Data Curation	Data Storage	Data Usage

European Parliament. (2016). Economic Impact of Big Data. European Parliament Infographics.

6

Generation & Acquisition	Analysis & Processing	Storage & Curation	Services & Visualization