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Influence of Big Data & Analytics on Corporate Social Responsibility

Lennart Hammerström

PhD Candidate, University Kaposvár, Hungary; Director Operations Engineering Electronics & Head of Corporate Competence Center Industry 4.0, HELLA GmbH & Co. KGaA, Germany

Carsten Giebe

PhD Candidate, University Kaposvár, Hungary; Senior Referent Data Analytics, S Rating und Risikosysteme GmbH, Germany

Dirk Zwerenz

PhD Candidate, University Kaposvár, Hungary; Head of Major Project Service, German Doka formwork technology GmbH, Germany

Abstract

This paper summarizes current corporate policy activities through Corporate Social Responsibility (CSR). In this context, the use of Big Data & Analytics (BD&A) will be discussed. The main purpose of the research is the pursuit of CSR, as the topic has been enormously advanced for companies in recent years. And there are many reasons for this. The consumption of the environment, the deposition of residues into air, ground and water by companies and also the labor conditions within the work environment is on outmost interest of the society. Companies try to avoid respectively reduce the negative impact that comes along with their value creation processes due to their competitive situation, public pressure, marketing reasons or because they are forced by legal requirements and regulations. Those improvements are often publicized in CSR/sustainability reports. Many companies set themselves CSR targets that refer to a particular baseline. With doing so the companies can find the right areas for improvement, measure their progress, apply different methodologies and create measures to further enhance their situation. Some of those measures are driven by digitalization and with the progress that is made within this area of research new opportunities to reduce the negative impact arise. The potential that lies within digitalization to improve CSR indicators is widely underestimated. To emphasize the impact that digitalization can have on the value creation process, a very specific methodology from the field of digitalization, the *analysis of big data*, was chosen exemplarily for this analysis. The systematization of research and approaches to solving the problem will show that Big Data & Analytics is underemployed in the area of Corporate Social Responsibility. The research results summarized in the paper confirm and prove that companies need not be primarily interested in CSR. Economic interests usually go hand in hand with this. To make Big Data & Analytics a contributor to Corporate Social Responsibility investments are necessary. The potential of Big Data & Analytics that is elaborated in this article can help to justify the investments into this field of application. The paper is processed in the following logical order: After an introductory section, Big Data & Analytics will present its contribution to Corporate Social Responsibility. After establishing a hypothesis, the analysis part comes in the form of a field application. In the further course, the influence of CSR on the Internet of Things (IoT) will be dealt with in a business case. The article will give an insight into the sustainability reports of the companies BMW, Deutsche Telekom and the Linde Group. The topics CSR and BD&A in the automotive industry will be investigated, as well. The expected savings in energy consumption by BD&DA are discussed here. The paper is concluded with a critical appraisal.

Keywords: big data & analytics, corporate social responsibility (csr), data analytics, energy consumption, investment decision, sustainability.

1. Introduction

The *main driver* for Big Data & Analytics (in the following BD&A) in profit oriented companies is often to improve the existing business by reducing scarp, reducing downtime, improving the technical availability, to understand the coaction of the "6M"[1], to improve the end-to-end supply chain or to enhance the stability and durability of the products that were provided to the customer. This list of drivers can be extended, the scope of applications for BD&A is quite a broad one. Big Data & Analytics is applied to improve the gross margin of production facilities and to become more competitive. Unfortunately, the Corporate Social Responsibility is in most cases not the real driver for the application of Big Data & Analytics but the results that are achieved with it are most often published in the sustainability reports.

Big Data & Analytics

The abbreviation Big Data & Analytics is a combination of two terms that together result in the approach for optimizations based on data. *Big Data* is characterized by three primary factors, such as *volume* (there is too much data to handle and it is stored in many cases but is often not used any more), *velocity* (the data flowing in and out is too fast for analysis) and its *variety* (the range of data types is to big). The data can have different sources, such as a value creation process, field data (e.g. by cars that communicate with a central or decentralised database), data that is coming from the environment (such as weather or satellite data) or from customers. The data itself is not generating any value (at least as it is not the article of trade itself). But with the application of *analytical* methodologies a value can be created. Big Data & Analytics therefore can provide better insights into hidden patterns and relationships, to come to the right conclusions and to improve the decision process. The analytic itself is a conjunction of different mathematical methodologies and requires a different compound of methods, experts and applicants. The methods of BD&A always have to fit to the problem that has to be solved, otherwise the result is questionable. There are different methods available, such as logistic regression, decision trees, neural networks, discriminant analysis or random forest. The use of one of these techniques requires expertise and experience to interpret the results in the right way and to come to the right conclusions. Before any BD analysis can be done the data needs to be prepared and organized in a manner that an analyst can work with the data and create information based on the data.

The contribution of Big Data & Analytics to Corporate Social Responsibility

In most cases, BD&A is coming with high costs (investment into soft- and hardware and into experts such as business arithmetic's specialists or IT specialists) and those costs have to pay back according to the financial rules of the company. To make those investments justifiable a business case has to be set up and the payback period needs to be calculated and explained to the shareholders. Therefore, the project often has a strong focus on the financial KPIs[2], such as the ROI. By focusing on the ROI a lot of potential optimization capabilities are out of focus! These optimization capabilities are not considered for further projects and due to this; it is not utilized within the process. CSR as a factor is not taken into consideration for such kind of decisions.

From a broad perspective, there are three areas on the investment into BD&A:

It is necessary to establish a connection between the Corporate Social Responsibility of a company and the Return of Investment to get an understanding where a company is positioned. The graph below explains the disposition of a company to invest into areas of CSR and its expectation regarding the pay back period.

Justification for additional investments into Big data & analytics

Even if an investment into the optimization of the production process cannot be justified from an economic point of view and it is not meaningful from a shareholders point of view, there are other rationales still to do the investment.

Such rationales can be the public perception of a company in the industry or in the media. By doing so, the appearance of the company is improved and this is influencing other areas such as the capability of a company

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[1] The 6 M: The 6 M represent the main determining factors within an Ishikawa diagram. Those are **m**aterial, **m**achine, **m**ethod, **m**an, **m**easurement and **m**ilieu. There are extensions possible, e. g. **m**anagement and **m**oney

[2] Key Performance Indicators (KPI) are performance figures that often refer to the performance, the result or the capacity load of a company, a business unit or a machine

to find and hire the best employees (Kauflin, 2017) and can therefore serve shareholders' interest in another way while also serving those of the larger community.
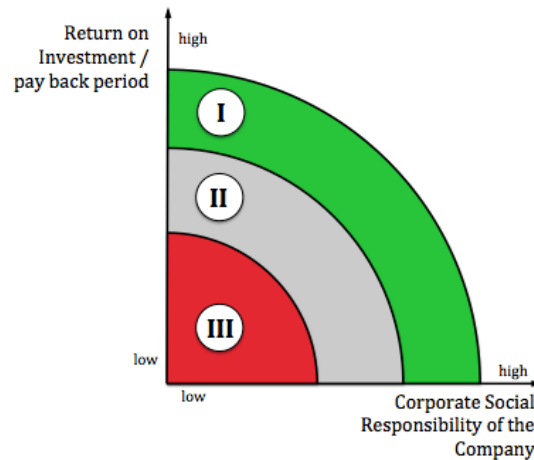

Figure 1. KPI vs. CSR level

1. Area I: The 'green' area

2. Area II: The 'grey' area

3. Area III: The 'red' area

Area I and III 'overlap' in the 'grey' area because the parameters for a decision are not the same for each use case.

Area I

The financial KPIs clearly state that it makes sense to invest into the findings, to set up a project team and to improve the situation. Investments are released from shareholders.

Area II

Investments are critical; the payback period is longer than permissible and does not meet the company's investment targets. Investments are often not released from shareholders. However, this area is the interesting one for the Corporate Social Responsibility! This area offers many opportunities to contribute to CSR, i.e. reduction of the consumption of environment, an optimization of the CO_2 footprint, better working conditions and at the end a contribution to society.

Area III

Investments do not make any sense from a business and CSR point of view. The investment will create for example more environmental disadvantages than advantages.

Literature Review

There are *3 main category groups of the literature* that we used to work on this article.

The *first category* is the data that we needed to explore the energy consumption of the companies we wanted to investigate. This literature is provided by the companies itself; they are constrained to publish this information as part of an annual statement.

To conduct the analysis of the contribution and the engagement of the investigated companies the data that those companies provided was used. This was done to ensure that the data is has the highest quality possible and to avoid that the analytical results can be put into question. In the case of the DAIMLER Corporation the data is taken from the annual report (Annual report Daimler, 2009; Annual report Daimler, 2011; Annual report Daimler, 2014; Annual report Daimler, 2016). It is not necessary to analyse each year of the annual report of the DAIMLER Corporation because the company is providing a historical review for several years. We checked if the data in the historical review is correct and it was accurate in all cases.

Just like the DAIMLER Corporation encloses the data for the energy consumption in their annual report, the GENERAL MOTORS COMPANY provides the data in the form 10-K. The 10-K is the denomination of a form that is requested by the United States Security and Exchange Commission (SEC) on an annual basis. The 10-K is, contrarily to the annual report, a chastely report which is highly standardized. All 10-K's can be accessed in the *Electronic Data-Gathering, Analysis, and Retrieval* (EDGAR) database (United States Securities and Exchange Commission, 2010; United States Securities and Exchange Commission, 2012; United States Securities and Exchange Commission, 2014).

The VOLKSWAGEN Corporation provided the data as part of the annual report, but not in all reports within the same section; an analysis of complete report and a close comparison of the annual reports of different years was necessary to avoid biasing the data by unwanted influencing factors (VOLKSWAGEN Aktiengesellschaft Geschäftsbericht 2008; VOLKSWAGEN Aktiengesellschaft Geschäftsbericht 2010; VOLKSWAGEN Aktiengesellschaft Geschäftsbericht 2013). We believe that this was done due to reasons of expedience and to explain other, for VOLKSWAGEN more important issues in a better way.

The *second category* of literature is standard CSR literature as well as latest articles that are related to it.

The literature that was used to build the necessary framework of the fundament of the Corporate Social Responsibility (CSR) is both, part of the basic literature to engage into CSR (Brakmann, et al., 2006; Carroll, 1991; Ostrom, 2010; Spector, 2008) and also articles that were ranked as highly influential in recent years (Chung et al., 2017; Report of the Commission on Science and Technology, 2016; Zadek, 2012) to grasp and to ensure that recent developments in the area of CSR are taken into consideration sufficiently.

The *third category* of literature is literature that enabled us to a.) ascertain what influence the data analytics has on the reduction on the consumption of energy (Anderl, 2016; Brakman et al., 2006; Colotla, 2018; G20 Digital Economy Ministerial Declaration, 2017) and b.) how strong its impact is most likely to be (Innovationen & Produkte, 2016; Houston et al., 2017; McAfee, 2009; Nunan et al., 2017; OECD Digital Economy Outlook, 2017).

Methodology, research methods and results

Hypothesis

The Industrial Internet of Things (IIoT) is already influencing the Corporate Social Responsibility of production processes. The value creation processes and the end-to-end supply chain. This transformation process does not only directly influence the Corporate Social Responsibility. It can also become the *driver for the investment into IIoT technologies*. Therefore, CSR can become an influencing factor for earlier or even more investment into new technologies if it is made as part of the agenda of a company.

Example of a field application

By analysing the vast amount of data that is already available in most of the companies, today a huge contribution to the Corporate Sustainability and Responsibility can be created. This field of application is called Big Data & Analytics (BD&A). Its contribution is often not employed because the focus of Big Data & Analytics (BD&A) is in many cases not on CSR.

Example of a BD&A application

The example focuses on an application within the industry sector and is narrowed down a lot. It is not about the analysis of 'public' data (Boyd, Crawford, 2011), not about the ethical problems (Richards, King, 2014) that come along with digitalization or a complete new field such as the replacement of legal profession (Remus, Levy, 2016). The first example is a very common one for BD&A applications that is quite often communicated at conferences and by consultants that provide professional advice in the field of IoT. It is about the prediction of the point in time when a roller bearing is going to fail. This is a case that most people can understand because many of them had a bearing in their hand already and learned about its scope of application at their university as a student. Bearings are also part of nearly every machine with mobile parts and it is important to take care of those, as they are vital for the function of a machine. Secondly, the range of consequence when a roller bearing is going to fail is easy to understand. The machine could fail and stop operating. In the best case there is only unplanned downtime, in the worst case life can be endangered.

Finally yet importantly can a roller bearing be a huge investment for a company[3]. Therefore, companies are interested in a permanent monitoring of the conditions of the bearing and to always know its status and to prevent its damage. A roller bearing changes its behaviour before it finally fails. For example the noise level, the temperature and the resistance to rolling increases. Everyone can understand those factors. However, unfortunately those factors indicate already a damage of the roller bearing and the behaviour only changes some hours or minutes before the bearing finally fails. From a competitive standpoint, it would be better to know the point in time before a roller bearing starts to be damaged and to predict when it will fail in the future. Those factors are much harder to identify and are not as obvious as the factors that were mentioned before.

Influence of CSR on the IIoT business case

The BD&A example is a focused one and cannot be simply transferred to all IIoT applications. A business case has to be validated case by case and should highlight the 'deliverables' of each investment. It is not and might never be finally decided who is fully responsible for CSR and there are representatives for different tendencies, such as the businesses and the public sector (Brakmann et al., 2017). It can be argued that the business side is fully accountable (Spector, 2008) but there are also strong voices that classify the responsibility for CSR on the side of the public sector (Caroll, 1991). Zadek (Zadek, 2012) arguments that companies pursue a CSR strategy to:

1. Defend their reputation.

2. Justify benefits over costs.

3. Integrate CSR into their (corporate) strategy.

4. Learn, innovate and manage risk.

Depending on the CSR strategy of a company one (or more) of the points that Zadek specifies can help to justify the investment into CSR.

IIoT measures in sustainability reports

Based on the ranking of the sustainability reports 2015 (Institute for ecological business development) in Germany the best-ranked companies are global operating companies with their own CSR reporting (e. g. Miele & Cie KG, Deutsche Telekom AG, Hannover Rück SE et al). Those companies have an integrated CSR strategy within their overall business. The reports from BMW, DEUTSCHE TELEKOM and the LINDE GROUP were explored to find indications and references regarding investments into IIoT in general and into BD&A in specific as those companies are operating on a global basis within different industries (Rankink Nachaltigkeitsberichte, 2015).

Insight of the sustainability report from BMW

The sustainability report from BMW allows insights how the CSR strategy is integrated into the company's overall strategy. Unfortunately, there are only indirect references available regarding the use of IIoT measures. For example BMW focuses on the consumption of energy (renewable energy and consumed energy per vehicle produced), water (consumption per vehicle produced), CO_2 emission, waste for scrapping per vehicle. BMW sets also goals (such as the reduction of the use of resources to build a vehicle by 45% till 2020 (BMW Group Nachhaltigkeitsbericht, 2016). IIoT is only mentioned within the area of research & development, and there it is focused on the digitalization of the final product.

Insight of the sustainability report from Deutsche Telekom

Like BMW, the Deutsche Telekom has a set of operating figures that are measured against the last couple of years. There are also targets given such as sustainable purchasing, sustainable investment, renewable energies and CO_2 emission. There is also very little information how these key figures shall be improved and if IIoT is playing a vital role in it.

Insight of the sustainability report from The Linde Group

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[3] ThyssenKrupp build in 2017 the biggest roller bearing of all times with 18-meter diameter and a weight of 190 tons.

There are several CSR reports available from the Linde Group and the company releases a lot of information and documentation (Innovationen & Produkte, 2017; Ökonomische, ökologische und soziale Leistung, 2016). The link between CSR and the investment into IIoT can be found within the reports in the section of innovation & products and its explanations. For Linde the investment into IIoT is a broad topic that is summarized in the working field of *digitalization*. Linde states clearly that the digitalization will change the business model and the method of operation for the company. The company invested into competence centres, expertise and into the automation of processes with artificial intelligence.

Conclusion from the CSR websites

Although there is data and information regarding digitalization available on the websites of the companies, its link to IIoT is not emphasized clearly. The link between CSR and BD&A can be constructed but it is not stated by the companies as something they really want to transport to the customer or the visitor of the website. Some of the statements just come along with the pressure that the market puts on the companies and that they have to do something to not lose track in comparison to their competitors. Exploring the websites can induce the impression that the companies are really interested in driving CSR and that they invest into it (for example with dedicated teams and budgets) but looking deeper and comparing to the corporate strategy it became obvious that the CSR strategy is subordinated to the business goals.

CSR and BD&A within the automotive industry

The exploration of the sustainability reports of BMW, DEUTSCHE TELEKOM and the LINDE GROUP indicates that the companies do not see BD&A as one of the drivers of CSR. To prove that BD&A can have an impact on the CSR strategy an analysis of the factor 'consumed energy per vehicle produced' has been done. The comparison was done between two German automotive companies (DAIMLER AG and VOLKSWAGEN AG) and the US based (GENERAL MOTORS) company (Geschäftsbericht DAIMLER AG, 2009, 2011, 2014, 2016; United States Securities and Exchange Commission GENERAL MOTORS COMPANY, 2010, 2012, 2014, 2016; Geschäftsbericht VOLKSWAGEN, 2008, 2010, 2013). Those three companies were chosen because they have plants worldwide, have a portfolio that can be compared with each other, operate in the same industry (automotive) and have similar production processes. For the comparison the information had to be gathered from different sources, e.g. because the value is only publicized from GENERAL MOTORS completely. For VOLKSWAGEN AG there are some values available but some had to be averaged. For DAIMLER AG the numbers had to be calculated based on the numbers of different reports, such as the annual report (Geschäftsbericht DAIMLER AG, 2009, 2011, 2014, 2016). The information from this analysis is then used to estimate the savings that are likely to be generated with BD&A within the production process of the automobile industry. The result is then used to support the hypothesis that BD&A can support the CSR strategy and those investments into BD&A can be positive or at least neutral for the companies.

Explanation of the analysis

Automotive companies publish every year a sustainability report to make their goals and achievements transparent. Those reports are a good source for firsthand information and allow the comparison of different companies. In this article, the consumption of energy that is necessary to produce one vehicle (in MWh per produced vehicle) is compared for the three Original Equipment Manufacturers (OEM). The overall aim for this comparison is to validate if the companies work on the achievement of the targets they set for themselves. This helps to prove or rebut the statements of the companies and to scrutinize the quality of the report. The comparison is done for the following figures: First, the improvement resp. deterioration in the consumption of energy that is necessary to produce a car within a company is visualized. These numbers indicate if a company is really working on the goals that were set or not. Second the numbers allow a mutual comparison of the different companies and gives a rough indication what company is producing in a more energy efficient way. Finally, the analysis of the numbers creates more transparency for some of the numbers that are shown in the report. There are for example reductions of the energy consumption declared that supposedly are not coming from internal but external factors that the company cannot influence.

Energy consumption per vehicle build

The comparison is done for the General Motors Corp., the Volkswagen AG and the Daimler AG. Those companies were chosen because they operate in the same industry, have a comparable portfolio (e.g. passenger vehicles, light and heavy trucks, SUVs, sports cars) and use similar types of drive (gasoline, diesel, electric

drive). The energy consumption for the production per vehicle has been chosen because it is an important factor for the environment protection and saving energy has a direct impact on the community members (e.g. clean air), the environment (reduction of the consumption of environment, e.g. destruction of landscape for coal mining) and the natural resources (e.g. savings of oil, gas, coal for later generations).
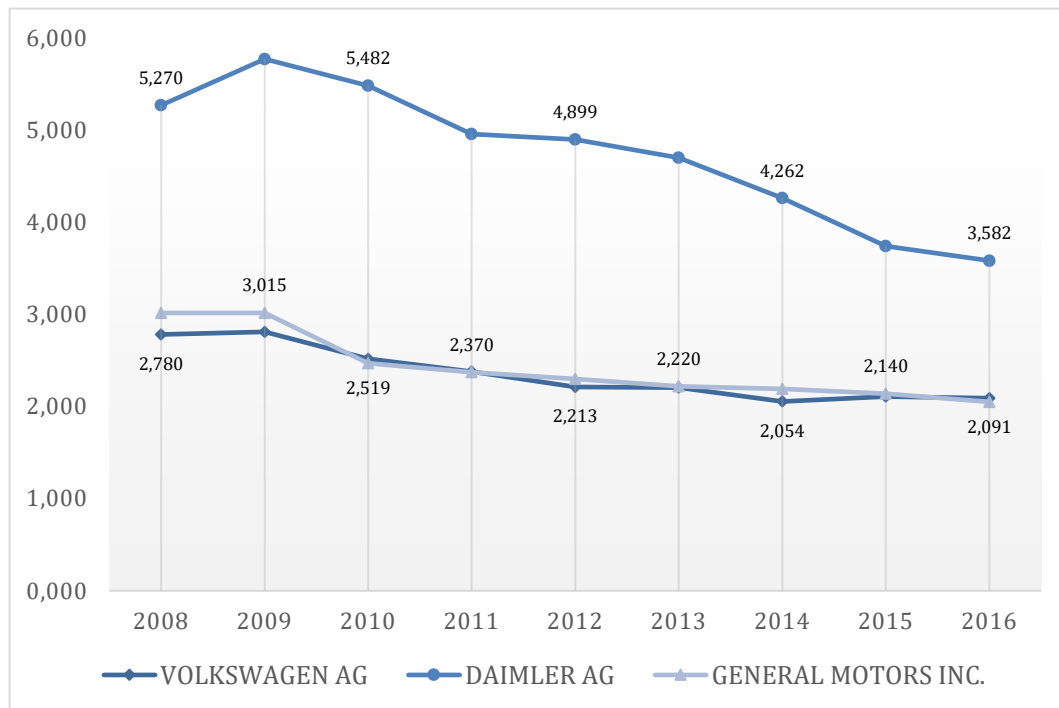
Graph 1. Energy consumption per vehicle produced

The graph reflects the differences in energy demand for the production of one vehicle for each of the 3 investigated car manufacturers. The diagram accentuates that both the VOLKSWAGEN AG and the GENERAL MOTORS INC. have a very similar profile for their consumption of energy and that the DAIMLER AG stands out. Feasible reason for the higher consumption of energy of the DAIMLER AG is explained in the main text.

The graph indicates that all three companies work on the reduction of energy consumption for the production of automobiles and transportation vehicles[4]. Most of the analyzed years the companies are capable to reduce the amount of energy that is needed to produce a vehicle (exceptions are DAIMLER AG in 2009 and VOLKSWAGEN AG in 2015). The obviously higher demand of DAIMLER AG is presumably coming from the disproportionally high number of heavy vehicles that the company builds. It is market leader for heavy trucks and the consumption of energy to build a heavy truck is higher compared to a passenger vehicle.

Expected savings in energy consumption due to BD&A

The basic principles to analyze data that is considered 'big data' (amount of data, velocity and variety) exist since decades, if not centuries (the statistics). But the capability to execute the analysis is not available for long and is still evolving (together with the further development of the mass, velocity and variety of the data). There are several reasons why the estimation of the contribution of Big Data & Analytics to the saving of energy cannot be done exactly. The reason for this is that the savings that can be realized are intensively influenced by several different factors, such as the production environment, the customer requirements, the availability of production data, and the share of cost for digitalization or the kind of industry. Big Data & analytic for example is jointly using the IIoT platform with other IIoT applications. The costs for the platform are shared with those applications, too. Another reason is that BD&A has a different impact on the different fields of application. Using BD&A within the field of logistics can have another impact than on using it for the reduction of scrap. Also the product itself [is it considered a 'smart' product or not, its complexity, its field

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[4] The numbers for GENERAL MOTORS INC. for the years 2008 and 2009 had to be averaged based on the numbers of 2005 and 2010 because numbers for 2006, 2007, 2008 and 2009 were not published.

of use, the status of its lifecycle (e.g. new technologies come often with a higher scrap rate because the technology is not fully under control)] is influencing the range of the realizable savings. Digitalization can reduce the freight cost by intelligent logistic hubs, a smarter production process can reduce the scrap cost, the warranty cost can be lowered due to products that are more reliable and the maintenance cost with a smart management system for the spare parts. Big Data & Analytics is part of digitalization and therefore only one part of the savings that can be accomplished.
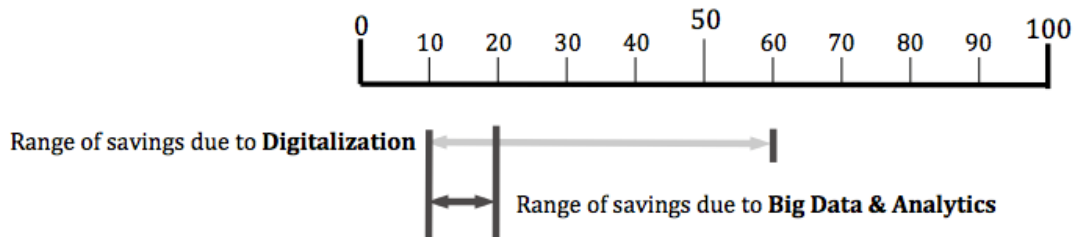

Figure 2. Range of expected savings due to Big Data & Analytics [%]

It is expected that with the digitalization of production the consumption of energy, resp. the necessary amount of energy for one part produced, will decline. Due to the wide field of digitalization the impact of Big Data & Analytics on the energy consumption has been evaluated. According to the literature we analysed Big Data & Analytics will have a significant positive impact on the consumption of energy in the future.

Within Digitalization, the expected savings vary from single-digit to low double-digit numbers. For the production of vehicles, savings in energy from 3% for facilities up to 12% for high-energy consuming processes can be found (MacAfee, 2009; Houston et al., 2017; OECD Digital Economy Outlook, 2017). For this article there were four exemplary fields chosen (freight-, scrap-, warranty- and maintenance cost) in which digitalization can have an influence (there are much more, the four ones were chosen because those are commonly known and easy to understand examples.
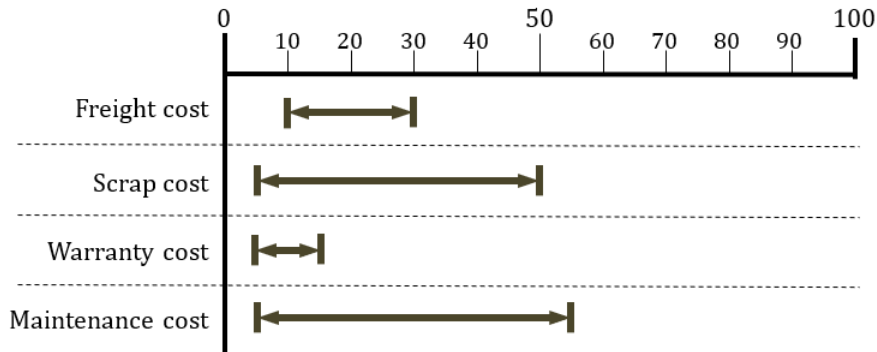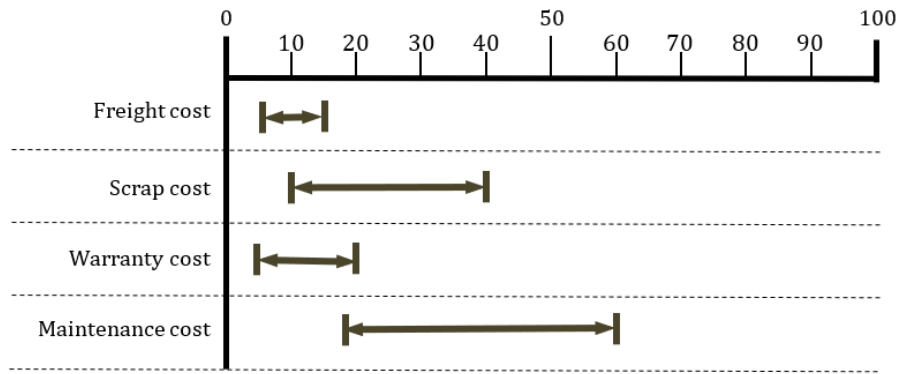

Figure 3. Range of expected savings due to digitalization [%]

For a better understanding we believe it is essential to distinguish the impact of the digitalization on different fields within the production of vehicles that consume energy. We focused on main areas that were emphasized in the literature we analysed; a main impact is expected on the cost of freight, scrap, warranty and maintenance.

The freight costs are influenced by BD&A in different areas. There will be cost savings within the optimization of the transportation routes (e.g. optimized routes due to intelligent planning with algorithms from operations research) or the load that a truck carries can be increased (trucks are often not fully loaded and are only partly stowed). The scrap cost can be further reduced when other measures (such measures that come from Lean Production or Six Sigma) do not support the solution process any more. BD&A can also support reducing the warranty cost for failure types that may or may not have its reasons within the company. There might be failure types that cannot be understood (and due to this not solved) only with the internal data. There are combinations of influences thinkable that can only be analyzed with BD&A. Maintenance cost is already a wide field for BD&A and there are several examples for its application (see introduction of this article). For a truck, this could mean a higher disposability and therefore an increased utilization.

**Figure 4. Range of expected savings due to Big Data & Analytics [%]**

In this graph we illustrate the reduction of energy consumption due to Big Data & Analytics in a more detailed way. This detailing is necessary to calculate the future impact on energy consumption for the preceding expected savings due to digitalization. The main cost savers are within maintenance and in the reduction of scrap.

The range of saving shown in figure 4 can be found in several publications and articles (Harnessing the Power of Connectivity, 2017; Foresight for digital development, 2016; Anderl et al., 2016; Colotla et al., 2018). Those numbers represent the savings for *digitalization*; *BD&A* is part of the digitalization and its range of saving depends on the above-explained factors.
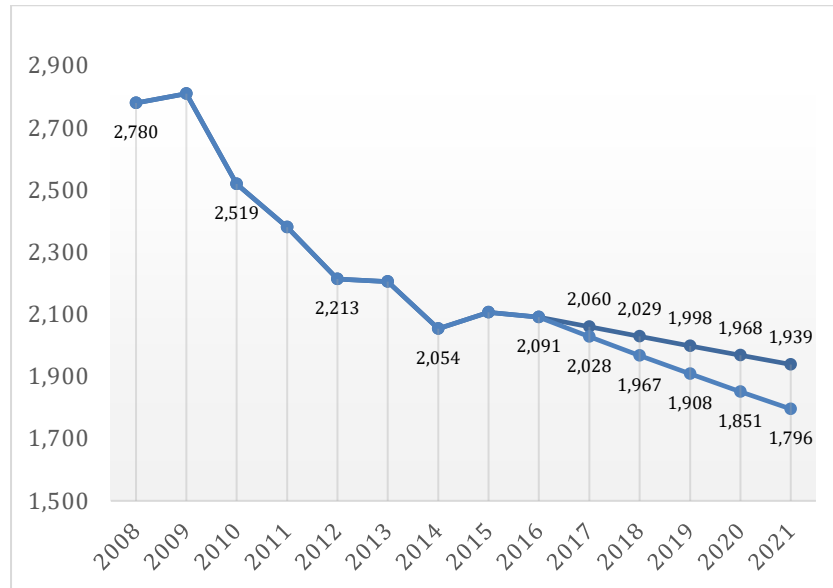
Impact on Energy consumption

The savings that can be generated with BD&A vary from 5…60% (McAfee, 2009; G20 Digital Economy Ministerial Declaration, 2007; Anderl et al., 2016) but only part of those savings are coming from the energy consumption the percentages are much lower for the complete system. For the production of vehicles, the savings can be realistically estimated to have a range from 0.5 up to 3%. Graph shows the two scenarios for the influence of BD&A on the energy consumption within the production of vehicles. The medium scenario is done with 1.5% savings, the high scenario is done with an expected saving of 3%.

Graph 2 is showing the extrapolation of the savings that can be generated by BD&A within the DAIMLER AG for both scenarios (from 2016 on). Other measures that the companies are driving are excluded from this graph.
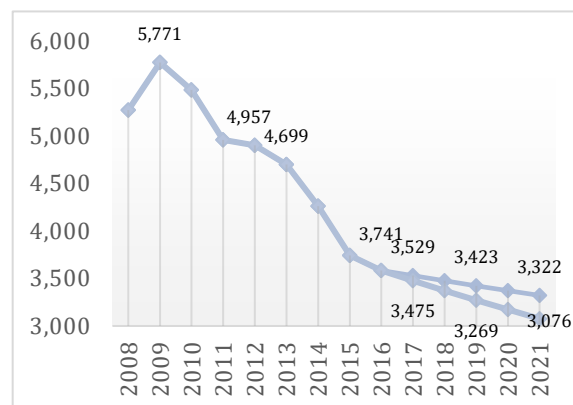
Graph 2. Energy consumption of the DAIMLER AG per produced vehicle [MWh]

Graph 3 is showing the extrapolation of the savings that can be generated by BD&A within the VOLKSWAGEN AG for both scenarios (from 2016 on). Other measures that the companies are driving are excluded from this graph.

Graph 3. Energy consumption of the VOLKSWAGEN AG per produced vehicle [MWh]

Graph 3 demonstrates that the company's efforts in reducing the consumption of energy (in MWh) are effective and that the company is on the right path to fulfill its commitments to reduce the consumption of energy for the production of vehicles. The decline is massive and it can be understood as a true commitment of the company to contribute to the Corporate Social Responsibility. The upper limit is the expected further reduction of the consumption of energy without the application of Big Data & Analytics and the lower extrapolation is the expected energy consumption with the implementation of Big Data & Analytics.

The VOLKSWAGEN AG is successful in reducing its energy consumption for the production of vehicles (in MWh), too. The upper limit is the expected further reduction of the consumption of energy without the application of Big Data & Analytics and the lower extrapolation is the expected energy consumption with the implementation of Big Data & Analytics.

Similar savings as at VOLKSWAGEN AG can be expected at GENERAL MOTORS INC. due to the similar energy consumption.

Conclusions, discussions and recommendations

The savings that can be achieved by the implementation of BD&A per produced vehicle seem to be small. For VOLKSWAGEN AG it is only 0.031MWh in the medium scenario and 0.063MWh in the high scenario (see table 1). Higher savings can be expected for DAIMLER AG due to the portfolio of the company.

Table 1. Annual saving per vehicle produced [MWh]

	2017	2018	2019	2020	2021
VOLKSWAGEN AG Medium scenario with 1,5%	0,031	0,031	0,030	0,030	0,030
VOLKSWAGEN AG High scenario with 3,0%	0,063	0,061	0,059	0,057	0,056
DAIMLER AG Medium scenario with 1,5%	0,054	0,053	0,052	0,051	0,051
DAIMLER AG High scenario with 3,0%	0,107	0,104	0,101	0,098	0,095
GENERAL MOTORS INC. Medium scenario with 1,5%	0,031	0,030	0,030	0,029	0,029
GENERAL MOTORS INC. High scenario with 3,0%	0,061	0,060	0,058	0,056	0,054

The predictions of the reduction of energy consumption that is coming along with the application of Big Data & Analytics vary depending on the sources. Therefore, we decided to build a minimum scenario with 1.5% reduction and a maximum scenario with a reduction of 3.0%. The table presents the 2 different scenarios for the 3 different companies in MWh.

To depict the savings in a more concrete way and to emphasize the contribution of BD&A to the Corporate Social Responsibility the savings were converted into *oil equivalents*[5], [oe]. The numbers demonstrate that with BD&A the consumption of oil can be reduced by 2.70 to 5.39 liters per vehicle produced for VOLKSWAGEN AG. The numbers are even higher for DAIMLER AG. Those numbers can be a high contribution to the sustainability and the social responsibility of any automotive company.

Table 2. Annual saving per vehicle produced [oe]

	2017	2018	2019	2020	2021
VOLKSWAGEN AG Medium scenario with 1,5%	2,70	2,66	2,62	2,58	2,54
VOLKSWAGEN AG High scenario with 3,0%	5,39	5,23	5,08	4,92	4,78
DAIMLER AG Medium scenario with 1,5%	4,62	4,55	4,48	4,42	4,35
DAIMLER AG High scenario with 3,0%	9,24	8,96	8,69	8,43	8,18
GENERAL MOTORS INC. Medium scenario with 1,5%	2,64	2,60	2,57	2,53	2,49
GENERAL MOTORS INC. High scenario with 3,0%	5,29	5,13	4,98	4,83	4,68

To make our point clearer we decided to convert the calculation that is based on MWh into the so-called oil equivalent (oe). The oil equivalent is a scale unit for the energy quantity that is released when one kilogram of oil is combusted. This figure makes the high amount of energy, that is consumed, more comprehensible and more concrete for the reader.

The numbers are more impressive when the savings are connected with the produced numbers of vehicles of the companies and converted into $US[6]. Then the contribution of Big Data & Analytics can also be justified from a financial point of view, not only from a social responsibility point of view. The investments that are necessary to start respectively strengthen BD&A within the companies can be driven to an amount that the savings would be fully consumed. This would be acceptable from a CSR point of view but not from a business point of view. Therefore, the calculation of the savings is supporting the investment and the activities of BD&A.

Table 3. Annual saving for company [mUS$]

	2017	2018	2019	2020	2021
VOLKSWAGEN AG Medium scenario with 1,5%	10,45 mUSD	10,29 mUSD	10,14 mUSD	9,98 mUSD	9,84 mUSD
VOLKSWAGEN AG High scenario with 3,0%	20,90 mUSD	20,27 mUSD	19,66 mUSD	19,07 mUSD	18,50 mUSD
DAIMLER AG Medium scenario with 1,5%	3,13 mUSD	3,09 mUSD	3,04 mUSD	3,00 mUSD	2,95 mUSD
DAIMLER AG High scenario with 3,0%	6,27 mUSD	6,08 mUSD	5,90 mUSD	5,72 mUSD	5,55 mUSD
GENERAL MOTORS INC. Medium scenario with 1,5%	10,24 mUSD	10,09 mUSD	9,94 mUSD	9,79 mUSD	9,64 mUSD
GENERAL MOTORS INC. High scenario with 3,0%	20,49 mUSD	19,87 mUSD	19,28 mUSD	18,70 mUSD	18,14 mUSD

To get to a certain number of energies consumed in a main currency we converted the oe unit into dollar US. Both numbers, oe unit and currency, show the high potential of savings that the 3 companies can liquidate from the application of Big Data & Analytics.

The social respectively business dilemma

Since decades debates are going on regarding public and private property and have been discussed from legal, social and economic point of view (Spector, 2008; Ostrom and Hess, 2007). The presented result of the Big Data analysis is such kind of a problem. In the example, the public sector is influenced in a negative way due

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[5] The oil equivalent [oe] is a normalized unit of energy. By convention it is equivalent to the approximate amount of energy that can be extracted from one liter of crude oil. It is a standardized unit, assigned a net caloric value of 41.868MJ per liter.
[6] The production volumes for the companies for the years 2017 to 2021 are based on the volumes of 2016.

to the waste of resources. There is obviously a way to produce in a more sustainable way but it is up to the company to decide about it. It is a commons pool problem but it is not a *legal* one and only to certain extends an *economic* one. In the free market economy it is not forbidden to produce only with a certain amount of scrap (it is a competitive disadvantage but this is a different question). Within the pyramid of Social Responsibility (Carroll, 1991) this dilemma is an *ethical* one and can only be answered by the company itself. It is for sure right, just and fair to work on such kind of topics but it cannot be enforced.

Outlook for CSR within the IIoT

It is impressive to see that the discussion regarding the responsibility for sustainability is quite an old but still an undecided one. In Germany, for example the protection of the youth as part of the responsibility and sustainability has a long history. However, this protection has its origin not within a humanistic view of the world. The main reason to protect children from working, e. g. in mines (or in other physical straining jobs) for long hours was that when they reached the age to join the compulsory military service many of them were already broken and not able to withstand the military drill and least of all a combat situation. The protection of the youth therefore was primarily an economic one. The discussion regarding the responsibility of CSR is an ongoing one and there can be found proponents on both sides. Some bring forward the argument that companies should not be invested into any kind of sustainability because the reason for a company is to make profit, not to develop or protect the society, to develop their staff or to guard the environment. On the opposite, there is the argument that by saving the environment and by fostering the society the overall achievement for everyone is much greater than in any other case and society will flourish and improve much more. Companies are there for the people, not the people for the companies. For CSR within the Industrial Internet of Things I personally see many chances for its further development. There are many opportunities where the IIoT can and will be influenced by the idea of CSR and the gain for the society will be high. This process is not a self-driven one and CSR in most companies has to prove its benefit to the company. The technology was often developed for other industries and is then applied to new applications (Nunan and Di Domenico, 2017). There will be several opportunities if the management is willing to invest into such an opportunity but more important might be external motivation resp. external pressure to further improve the CSR within companies. It is most likely that companies with an above average value creation are also willing to invest more into the application of relatively new technologies like Big Data & Analytics (Rohrbeck and Schwarz, (2013). Otherwise, the link between IIoT and CSR will stay a theoretical one and will not be applied practically within the industry. In addition, the awareness of Corporate Social Responsibility needs to be driven, either by internal or external motivators. To bridge the CSR with the IIoT a business case, likely based on the numbers that were presented in this article, will be necessary. It is possible to close the theoretical gap between CSR and IIoT with the right approach and calculation methodology.

Criticism

There are two things to be criticized of the findings in this article. The first one is the analysis and the interpretation that the Corporate Social Responsibility and the Sustainability are a reason for companies to invest into the field of Big Data & Analytics. One could state that companies are looking in the first instance for a reduction of their production cost including their spending for energy. The companies optimize their cost structure to gain a higher profit or a better position in the market. If the energy saving can also be 'sold' as a measure for sustainability it is even better. Saving energy is not the in the main interest of the companies that were used for the analysis. The second kind of criticism is coming from the source of the data itself. By looking into the sustainability, reports of the VOLKSWAGEN AG and DAIMLER AG there can be discrepancies found within the publicized data. For example, VOLKSWAGEN states in its sustainability report for 2010 energy consumption per produced vehicle of 2.55MWh. In the sustainability report for 2011 the number for 2010 has changed to 2.65MWh. In addition, in the sustainability report for 2016 the number has changed to 2.52MWh. The aberration is small but significant. The DAIMLER AG on the other hand states a reduction of 17% of the consumption of energy from 2008 to 2009. The DAIMLER AG does not provide the ratio of energy to produced units. Therefore, the statement of the percentage has no real value from a sustainability point of view. In 2008 the automobile industry was in a crisis and the number of produced units at DAIMLER AG dropped from 2.07m units to 1.55m units (this is more than 25%). Therefore, the drop in the energy consumption cannot be ascribed to sustainability measures that the company might have initiated. It is most likely that the DAIMLER AG did not made this statement in its CSR report by purpose. Making false statements in a CSR report is not accepted in companies with such a reputation and such a strong focus by

shareholders. Most people avoid false statements, even if they could gain a personal profit out of this (Chung and Hsu, 2017). Therefore, it is unlikely that this statement was made by purpose. This finding indicates that the numbers are not recorded in an accurate manner. If this is the case for some of the data, it can be questioned if the complete dataset that the companies provide is correct.

References

1. Anderl, Reiner et al. (2016). Fortschreibung der Anwendungsszenarien der Plattform Industrie 4.0; Bundesministerium für Wirtschaft und Energie (MMWi) Öffentlichkeitsarbeit, 11019 Berlin; http://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/fortschreibung-anwendungsszenarien.pdf?__blob=publicationFile&v=7.
2. Annual report DAIMLER AG (2009). Available at: daimler-ir-geschaeftsbericht-2009.pdf; https://www.daimler.com/dokumente/investoren/berichte/geschaeftsberichte/daimler/daimler-ir-geschaeftsbericht-2009.pdf.
3. Annual report DAIMLER AG (2011). Available at: daimler-ir-geschaeftsbericht-2011.pdf; https://www.daimler.com/dokumente/investoren/berichte/geschaeftsberichte/daimler/daimler-ir-geschaeftsbericht-2011.pdf.
4. Annual report DAIMLER AG (2014). Available at: daimler-ir-geschaeftsbericht-2014.pdf; https://www.daimler.com/dokumente/investoren/berichte/geschaeftsberichte/daimler/daimler-ir-geschaeftsbericht-2014.pdf.
5. Annual report DAIMLER AG (2016). Available at: daimler-ir-geschaeftsbericht-2016.pdf; https://www.daimler.com/dokumente/investoren/berichte/geschaeftsberichte/daimler/daimler-ir-geschaeftsbericht-2016.pdf.
6. BMW-Group-Nachhaltigkeitsbericht (2016). Available at: https://www.bmwgroup.com/content/dam/bmw-group-websites/bmwgroup_com/ir/downloads/de/2016/BMW-Group-Nachhaltigkeitsbericht-2016--DE.pdf.
7. Boyd, D., & Crawford, K. (2011, September). Six provocations for big data. In *A decade in internet time: Symposium on the dynamics of the internet and society* (Vol. 21). Oxford, UK: Oxford Internet Institute.
8. Brakman, S., Garretsen, H., Van Marrewijk, C., & Van Witteloostuijn, A. (2006). *Nations and firms in the global economy: an introduction to international economics and business*. Cambridge university press.
9. Carroll, A. B. (1991). The pyramid of corporate social responsibility: Toward the moral management of organizational stakeholders. *Business horizons*, *34*(4), 39-48.
10. Colotla, Ian et al (2018). Avoiding the Hidden Hazards of Industry 4.0; https://www.bcg.com/publications/2018/avoiding-hidden-hazards-industry-4.0.aspx.
11. Chung, J. O., & Hsu, S. H. (2017). The effect of cognitive moral development on honesty in managerial reporting. *Journal of Business Ethics*, *145*(3), 563-575.
12. Foresight for digital development; Report for the Secretary-General; Commission on Science and Technology for Development; Nineteenth session; Geneva, 9-13 May 2016.
13. G20 Digital Economy Ministerial Declaration; Shaping Digitalization for an Interconnected World; Düsseldorf, 6-7 April 2017.
14. Harnessing the Power of Connectivity; Mapping your transformation into a digital economy with GCI (2017).
15. Innovationen & Produkte - The Linde Group Corporate Responsibility Report (2016). Available at: corporateresponsibility.linde.de/cr-bericht/2016/unternehmensfuehrung/innovationen-produkte.html.
16. Houston, C., Gooberman-Hill, S., Mathie, R., Kennedy, A., Li, Y., & Baiz, P. (2017). Case Study for the Return on Investment of Internet of Things Using Agent-Based Modelling and Data Science. *Systems*, *5*(1), 4.
17. Kauflin, Jeff: The most attractive employers for business students in 2017; https://www.forbes.com/sites/jeffkauflin/2017/04/27/the-most-attractive-employers-for-business-students-in-2017/#4c3192994dd7.
18. Key Performance Indicator (KPI), Gabler Wirtschaftslexikon, http://wirtschaftslexikon.gabler.de/Definition/key-performance-indicator-kpi.html.
19. McAfee, A. (2009). *Enterprise 2.0: New collaborative tools for your organization's toughest challenges*. Harvard Business Press.

20. Nunan, D., & Di Domenico, M. (2017). Big data: a normal accident waiting to happen?. *Journal of Business Ethics*, *145*(3), 481-491.

21. OECD Digital Economy Outlook 2017, OECD Publishing; doi: 10.1787/9789264276284-en.

22. Ökonomische, ökologische und soziale Leistung; http://corporateresponsibility.linde.de/cr-bericht/2016/serviceseiten/downloads/files/input_output_linde_crb2016.pdf.

23. Ostrom, E., & Hess, C. (2010). Private and common property rights. *Property law and economics*, *5*, 53.

24. Ranking_Nachhaltigkeitsberichte_2015_Ergebnisbericht_mit_Branchenauswertung.pdf; http://www.ranking-nachhaltigkeitsberichte.de/data/ranking/user_upload/2015/Ranking_Nachhaltigkeitsberichte_2015_Ergebnisbericht_mit_Branchenauswertung.pdf.

25. Remus, D., & Levy, F. (2017). Can robots be lawyers: Computers, lawyers, and the practice of law. *Geo. J. Legal Ethics*, *30*, 501.

26. Richards, N. M., & King, J. H. (2014). Big data ethics. *Wake Forest L. Rev.*, *49*, 393.

27. Rohrbeck, R., & Schwarz, J. O. (2013). The value contribution of strategic foresight: Insights from an empirical study of large European companies. *Technological Forecasting and Social Change*, *80*(8), 1593-1606.

28. Spector, B. (2008). "Business Responsibilities in a Divided World": The Cold War Roots of the Corporate Social Responsibility Movement. *Enterprise & Society*, *9*(2), 314-336.

29. tk: größte Wälzlager der Welt, stahl-online.de; https://www.stahl-online.de/index.php/tk-groesste-waelzlager-der-welt/.

30. United States Securities and Exchange Commission; annual report pursuant to section 13 or 15(d) of the securities exchange act fo 1934, for the fiscal year ended December 31, 2012; commission file number 001-34960, GENERAL MOTORS COMPANY; Form 10-K; Washington, DC.

31. United States Securities and Exchange Commission; annual report pursuant to section 13 or 15(d) of the securities exchange act fo 1934, for the fiscal year ended December 31, 2014; commission file number 001-34960, GENERAL MOTORS COMPANY; Form 10-K; Washington, DC.

32. United States Securities and Exchange Commission; annual report pursuant to section 13 or 15(d) of the securities exchange act fo 1934, for the fiscal year ended December 31, 2016; commission file number 001-34960, GENERAL MOTORS COMPANY; Form 10-K; Washington, DC.

33. United States Securities and Exchange Commission; annual report pursuant to section 13 or 15(d) of the securities exchange act fo 1934, for the fiscal year ended December 31, 2010; commission file number 001-34960, GENERAL MOTORS COMPANY; Form 10-K; Washington, DC.

34. VOLKSWAGEN Aktiengesellschaft; Geschäftsbericht 2008; https://www.volkswagen-media-services.com/documents/10541/126436/GB_2008_D.PDF.

35. VOLKSWAGEN Aktiengesellschaft; Geschäftsbericht 2010; http://www.equitystory.com/Download/Companies/VW/Annual%20Reports/DE0007664039-JA-2010-EQ-D-00.pdf.

36. VOLKSWAGEN Aktiengesellschaft; Geschäftsbericht 2013; http://www.equitystory.com/download/companies/VW/Annual%20Reports/DE0007664039-JA-2013-EQ-D-00.pdf.

37. Zadek, S. (2012). *The civil corporation*. Routledge.