Leveraging Big Data for Competitive Advantage

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Abstract: - Big data means data sets which are too large, too unstructured and too fast changing, to use traditional data management methods. Enterprises that want to collect and process this data need new solutions for data processing and analysis. The aim of this paper is to identify the potential of big data analytics (BDA) as a source of competitive advantage of manufacturing companies in the market. The aim was achieved using the desk research methodology and interviews with managers of large manufacturing enterprises.
The article is divided into several sections, which cover the essence of big data, the competitive advantage of an enterprise from the Resource-based approach as well as big data analytics methods and analytic capabilities. The following parts discuss the architecture for big data analytics and provide some examples of big data analytics for business. The results of the study on the possibilities of using big data analytics as a source of competitive advantage in the market are also presented. The findings showed that big data can be a strategic resource and combined with analytics capabilities can create competitive factors both in cost strategy and in differentiation strategy.

Key-Words: - big data, big data analytics, analytics capabilities, competitive advantage

1 Introduction

Over the past decade, the 'big data' era has quietly descended on many communities, from governments and e-commerce to health and sports organisations [1].

This data is generated from the Web, online transactions, emails, videos, audios, images, click streams, logs, posts, search queries, health records, social media, science data, sensors and mobile phones and their applications.

Within the next decade, the amount of information will increase by 50 times while the number of information technology specialists who keep up with all this data will increase by 1,5 times.

Information overload [2] is one of the most serious problems in the big data environment. For information users, searching for what they need from the vast amounts of information accurately is becoming more difficult [3]. However, if companies are able to collect, process and analyse large data sets, then gathered information can be extremely valuable. In the era of exponential growth of business information, the acceleration of data accessibility is becoming vital.

Eurostat data indicates that in European Union, on average 10% of companies use big data analytics in their daily operation, in Poland this percentage is below the European average and amounts to 6%. Interestingly, there is no correlation between the degree of economic development of a country and the widespread use of big data by enterprises. In economically highly developed Germany, the percentage of companies that analyse big data is 6%, in Spain 8%, and in Italy 9%. In Estonia this indicator is 13%, in Malta and the Netherlands is the highest and amounts to 19% each [4].

Enterprise database systems, search systems, advanced data, text and Web analytics are becoming important for turning data into actionable knowledge and intelligence. As the data volume is large, the analytics can only be possible if we have highly efficient algorithms and software.

Big data introduces for companies a new source of competitive advantage in the market.

Using a resource-based approach, it can be shown that big data, if characterized by VRIN attributes (Value, Rare, Inimitability and Non-substitutability), is a resource which can provide a competitive advantage of a company in the market. Having a unique analytics capabilities is the key to successful competition using big data.

The issue of big data in the context of ways to create competitive advantage was presented in the

report from research carried out by the A.T. Kearney - consulting firm [5]. Managers, based on analytical models, found that big data analytics primarily drive innovation, but also significantly improve the economic efficiency of operations and increase profitability.

Companies that operate within e-business models naturally see the potential of the Internet and modern IT as key factors in their development [6]. Especially companies in the e-commerce sector recognize the value obtained by analysing large unstructured data sets provided by, for example, customers. Big data analytics is used in customer behaviour analysis, personalization of offers, or in the preparation of recommendations.

The question arises as to whether companies that operate in a traditional model and make little use of the Internet as a medium of communication with customers and business partners recognize the potential of big data? This article attempts to answer this question by focusing attention on manufacturing companies in the so-called traditional industries such as metallurgy, mining, cement plants and machinery.

The purpose of the paper is to identify the potential of big data analytics (BDA) as a source of competitive advantage of manufacturing companies in the market. The point of reference is a resource-based approach, which sees sources of competitive advantage in having unique resources such as information and knowledge that big data can deliver for a company. In the resource-based view, competitive advantage can be also gained by having key competences - in this case by having analytics capabilities. The following sections present the essence of big data, the resource-based approach as well as big data analytics methods and analytics capabilities. The results of preliminary study on the possibilities of using big data analytics as a source of competitive advantage in the market are also presented.

2 The essence of big data

The current explosion of data that is being generated is due to three main reasons [7]:

1. Hundreds of applications such as mobile sensors, social media services, and other related devices are collecting information continuously.
2. Storage capacity has improved so much that collecting data is cheaper than ever, making preferable to buy more storage space rather than deciding what to delete.
3. Machine learning and information retrieval approaches have reached a significant improvement in the last years, thus enabling the acquisition of higher degree of knowledge from data.

Figure 1 shows the relations between increasing data variety and complexity and the memory size of databases from megabytes to petabytes. It is shown that ERP systems generate data which companies collect and process in databases or data warehouses. Nevertheless CRM and Web systems have the biggest influence on the rapid increase in the amount of data.

Figure 1 also presents the main sources of data for big data.

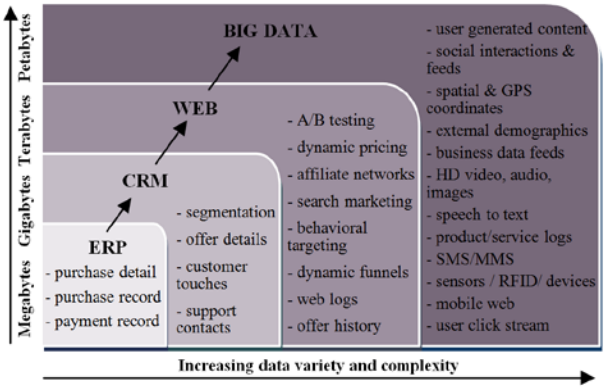

Fig. 1. Big data – variety and complexity [8]

The concept of big data is, however, broader than just large data sets. The most important challenge is not to increase data sets but to search for a new approach to the analysis.

Wielki [9] indicates, that big data is mainly characterised by:

- type of data - data unstructured,
- size of data - 100 terabytes to petabytes,
- way of information flow - a permanent inflow of data to the organisation (in real time),
- basic analytical method - machine learning,
- primary purpose – creation of new products.

The big data phenomenon differs as a data source from the previously used sources such as databases or data warehouses. Davenport and others [10] emphasise that organisations which capitalise on big data stand apart from traditional data analysis environments in three key ways:

1. They pay attention to data flows as opposed to stocks.
2. They rely on data scientists and product and process developers rather than data analysts.

3. They are moving analytics away from the IT function and into core business, operational and production functions.

Big data requires a revolutionary step forward from traditional data analysis, characterised by its four main components: volume, velocity, veracity, variety [11, 12]. These are shown in Figure 2.

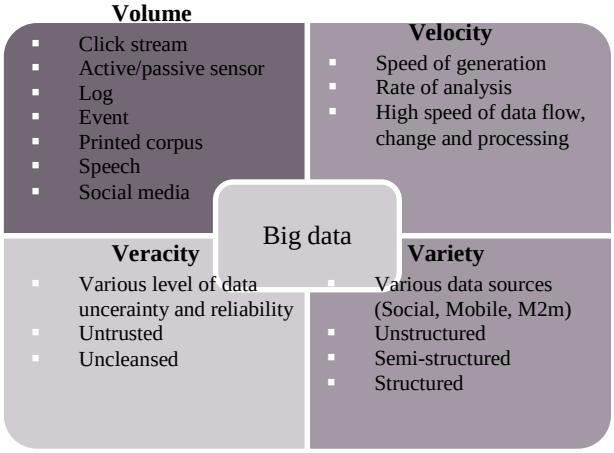

Fig. 2. Four Vs of big data.

Each component presented in Figure 2 is shortly expressed below.

Variety makes big data really big. Big data comes from a great variety of sources and generally has three types: structured, semi-structured and unstructured. Structured data insert a data warehouse already tagged and easily sorted but unstructured data are random and difficult to analyse. Semi-structured data do not conform to fixed fields but contains tags to separate data elements [13, 14].

Volume or the size of data now is larger than terabytes and petabytes. The grand scale and rise of data outstrip traditional store and analysis techniques [13, 14].

Velocity is required not only for big data, but also all processes. For time limited processes, big data should be used as it streams into the organisation in order to maximise its value [13, 14].

Veracity: big data is sourced from many different places, as a result the veracity/quality of the data need to be tested.

B. Frank states that all of the above-mentioned definitions of the "V" dimensions are secondary to the importance of data value. This parameter was defined by B. Frank as "Uber-V" because it points out the business value that data is for the company. The other dimensions are merely ancillary. B. Frank believes that the complicity, volume and format of data are not important, however the knowledge of how to process them in a way relevant to the enterprise is essential [15].

All these facts are known as the 4V's of big data, [16] which lead to the definition given by Steve Todd at Berkeley University: big data is when the normal application of current technology does not enable users to obtain timely, cost-effective, and quality answers to data-driven questions.

Other examples of definitions underline the unstructured character of data, i.e. accordingly to Rouse [17] big data is a general term used to describe the voluminous amount of unstructured and semi-structured data a company creates - data that would take too much time and cost too much money to load into a relational database for analysis.

Pawełoszek and Wieczorkowski [18] proposed "three-aspect approach", identifying three essential aspects of big data: technological, business and social. The technological aspect represents a focus on the methods of big data analysis and information technology used. The business aspect focuses on applications of big data, especially on its role in decision support. The social aspect of big data is associated with social consequences of data processing results. When making decisions on implementing solutions for big data analytics all three mentioned aspects should be considered.

3 The competitive advantage of enterprise. The Resource-based approach

Each enterprise constantly seeks sources of success expressed by the achievement of competitive advantage and high profits. Depending on the adopted approach eg. the design school, the planning school, the positioning school, the entrepreneurial school or resource-based approach various sources of competitive advantage can be identified. This paper adopts a resource-based view as an approach to achieve competitive advantage.

In the resource-based view, an enterprise is a unique collection of resources, but not all the resources have potential for creation of competitive advantage. Specifically, a resource is capable of generating sustainable performance advantages when it satisfies following criteria [19, 20]:

– resources must be valuable such that they help firms increase efficiency or enhance buyers' willingness to pay premium prices,
– resources need to be sufficiently rare so that they are not readily available to competitors,
– resources must not be easy for competitors to imitate or substitute.

The characteristic of this approach is to treat key competences [21] and dynamic capabilities [22] as

sources of competitive advantage. Especially valuable is the ability to uniquely (on a market scale) combine resources and competences. Dynamic capabilities allow organizations to rapidly adapt to the changing conditions of the environment.

In view of the above considerations, the following assumptions were made: big data can be a unique resource and the capability of analysing large unstructured data sets can be a distinctive competence of a company. Thus the unique combinations of big data and analytics capabilities can be a source of competitive advantage in the market.

Business competitiveness is most often understood as the ability to consolidate and improve position in the marketplace, while remaining efficient. A company adopts a differentiation strategy to create a unique offer for buyers which will strengthen the company's position in the market. Adoption of cost strategy, through cost reduction, allows a company to achieve good financial results.

4 Big data analytics methods and analytic capabilities

Big data is not just data, but also IT infrastructure, analytical systems and employees with high analytical skills.

Big data analytics is the process of examining large data sets to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information.

Big data analytics may show new relations between data, reveal unseen earlier trends and contribute to the creation of new knowledge, which can then be used to increase the effectiveness and improve the profitability of the company. In the long term, these can compensate for the costs associated with the purchase of specialised software and hiring specialists [23].

There are many differences between the conventional and big data analytics. Even though some of them are very fuzzy, Table 1 presents a summary of differences.

Table 1. The differences between big data analytics and traditional analytics [24]

	BIG DATA ANALYTICS	TRADITIONAL ANALYTICS
Type of data	Unstructured formats	Formatted in rows and columns
Volume of data	100 terabytes to petabytes	Tens of terabytes or less
Flow of data	Constant flow of data	Static pool of data
Analysis methods	Machine learning	Hypothesis-based
Primary purpose	Data-based products	Internal decision support and service

Changes in the analysis of big data relate to three main areas [25]:

– the ability to analyse large amounts of data, while not having to use smaller data sets,
– readiness to deal with unstructured data, characterised by low accuracy,
– rising importance of correlations, which tend to look for relations between phenomena rather than their causes.

While analysing big data the focus should be placed on the search for correlations and patterns, which indicate that "something is happening", instead of explaining the reasons "why it is happening". This means that previously used method of hypothesis and seeking arguments to verify them is reversed. The discovery of unexpected correlations can only be a stimulus to formulate hypotheses.

Big data process continuously incoming data from the environment and from inside the company. Thus, the big data analytics is based on data collected in real time, and that is why the results of the analysis are accurate and generated without delay.

Analytic applications are universal and have a wide range of functionality, useful in both large companies and small companies from the SME sector. They allow for integration of complex business processes and quick response to any changes on the operational level, as well as in the business environment. Thanks to them, companies are able to track on a regular basis the status of each process and rapidly response to events through flexible modification of the processes.

The analysis of big data involves analytical methods for traditional data and big data, analytical architecture for big data, and software used for analysis of big data [26].

The list of methods for analysing big data is very long and not complete as new methods of extracting information and knowledge from big data sets constantly appear. Enterprises from almost every sector develop the concept of information and data as company's strategic asset.

As organizations evolve, so must their analytics capabilities, moving from basic and anticipatory to the more mature predictive analysis (see Table 2).

Table 2. The evolution of analytic capabilities [27]

ANALYTIC CAPABILITY	TECHNIQUES
Basic – Provides a static, historical	**Query and drill down** *Where is the problem?*

view of business performance – Draws on basic scorecards and static reports	**Ad hoc reporting** *How many? How often? Where?* **Standard reporting** *What happened?*
Anticipatory – Creates transparency into past and potential future performance drivers – Uses systems and processes to perform a range of descriptive analytics	**Segmentation analysis** *What are the unique drivers?* **Statistical analysis** *Why is this happening?* **Sensitivity analysis** *What if conditions change?*
Predictive – Offers dynamic, forward-looking, insights with quantified trade-offs – Requires high-quality integrated data and complex mathematical capabilities	**Optimization** *What is the best that can happen?* **Simulation** *What would happen if …. ?* **Predictive modelling** *What could happen next?*

Basic analytics provide a historic view of business performance: what happened, where it happened, how many times it happened. Anticipatory analytics identify unique drivers, root causes, and sensitivities. Predictive analytics perform business modelling and simulations and try to predict what will happen.

Highly skilled executives in terms of gathering and using knowledge, who also have analytical skills, are nowadays among most competitive factors of the company.

5 Architecture for big data analytics

Four main components of big data: volume, velocity, veracity and variety are the reason why big data is difficult to process, and what's more analyse and draw conclusions. For effective use of big data companies need new IT architectures, that is a configuration of hardware and software in a way which ensures efficient processing of big data. Cloud computing technologies can provide unlimited resources on demand. It could be a solution to the problem of growing volume of data and could allow effective data management [28]. The most common architecture for big data is Apache Hadoop.

Many organisations looking to collect, process and analyse big data have turned to a newer class of technologies that includes Hadoop and related tools such as YARN, MapReduce, Spark, Hive and Pig as well as NoSQL databases [29].

Hadoop is essentially a distributed data infrastructure: It distributes massive data collections across multiple nodes within a cluster of commodity servers, which means you do not need to buy and maintain expensive custom hardware. It also indexes and keeps track of that data, enabling big data processing and analytics far more effectively than was possible previously.

Hadoop quickly emerged as a foundation for big data processing tasks, such as scientific analytics, business and sales planning, and processing enormous volumes of sensor data, including from internet of things sensors.

Apache Hadoop is used by large corporations such as Yahoo, Facebook, Amazon, eBay, The New York Times, Chevron and IBM.

6 Big data analytics for business

Managers increasingly adopt strategies based on acquiring, processing and using high-quality data for the decision-making (data-driven decision-making approach). Thus far, such solutions as business intelligence [30] and data mining were mainly used.

Research carried out by EMC Forum 2013 indicate that:

– 39% of entrepreneurs believe that big data provide business success,
– 19% of entrepreneurs are of the opinion that with big data they have achieved a competitive advantage,
– 36% of entrepreneurs believe that the introduction of big data will increase the safety and security of their data.

The researchers from the Economist Intelligence Unit survey [31], sought the answer to the question 'Which of the following business processes do you believe are the most important priorities for the application of big data now, and which will be most important in three years?'. The results of the study are presented in Figure 3.

Fig. 3. Priorities for the application of big data [31]

Customer processes are currently a priority for the application of big data, according to 42% of the C-level executives. Financial planning with 32% and sales with 29% are the following indications for big data analytics. Other priorities include operations, risk management and performance management as well as the evolution of product life cycle and same others. A long list of priorities suggests broad opportunities for big data solutions enterprise-wide. In three years, these priorities will become even harder to segregate. According to respondents a customer insights and targeting will remain the top priority, however it will drop in relative terms as several others emerge.

Big data is produced in every segment in manufacturing. For enterprise performance, big data helps to identify the product demands, productivity and performance via diverse business objectives. For production, big data makes it possible to detect the right facility causing the product flaw.

Big data analytics is used in enterprise management in the following areas and activities:

- transformation of key organisational business processes,
- strategic decision support,
- identification of the most cost-effective suppliers in delivering products on-time,
- product development,
- flag machinery and process variances that might be indicators of quality problems,
- analysis of receivables, an anticipation of payments, asset management,
- identification of which marketing promotions and campaigns are most effective in driving customer traffic, engagement, and sales,
- predictions of customer behaviour,
- customer relations management,
- optimization of marketing mixes given marketing goals,
- optimization of sales resource assignments, product mix,
- redefinition of product,
- collaborative filtering,
- supply-demand analysis.

The concept of big data is still relatively new, so its implementation in companies often faces barriers. The big data + Report indicated that Polish companies, primarily face the following difficulties [32]:

- shortage of qualified specialists - 29%,
- high exploitation costs - 27%,
- unclearly defined purpose and justification for the implementation of big data - 22%,
- complicated technology, which does not bring the expected profits - 7%.

Some institutions take steps to eliminate identified barriers. For example, universities educate "data science" and "data analysis" specialists while IT companies try to develop cheaper, more effective and "user-friendly" solutions. Nevertheless, the most difficult barriers to overcome are the mental barriers, lack of knowledge about big data and resistance to change.

7 Big data as a source of competitive advantage in the market. Research findings

More and more enterprises build their strategies effectively using big data analytics. The examples are the UPS express courier services provider which uses big data to improve its performance, Kayak tourist portal that uses big data analytics to predict prices of airline tickets or Netflix and the sector of video rental that created a unique system of offer personalization [33]. In light of the above example, the question arises: If so, how the manufacturing companies use (or can use) big data analytics? The author attempted to find the answer by using the desk research and interview methodologies. The basis for the desk research analysis were publications from two areas: big data analytics and resource-based approach for the competitive advantage of manufacturing companies.

The desk research analyses resulted in identification of the sources of competitive advantage resulting from using big data analytics and analytics capabilities of manufacturing enterprises.

Business competitiveness factors derived from the analysis of large unstructured data sets for the differentiated strategy of the offer are:

1. The use of BDA in customer relationship management.
2. The use of BDA in the process of creating innovations and the development of new market proposals.
3. Forecasting consumer trends based on buyer data and macroeconomic data

The cost factors of enterprise competitiveness derived from the use of big data analytics are:

1. The use of BDA in value creation.
2. The use of BDA in production management, especially in planning and improving production quality.
3. Support decision-making in the area of human capital management.
4. Support revenue management.

5. More efficient distribution.

The aim of the interviews with the managers of 14 large manufacturing companies was to verify and supplement the above list with the potential sources of competitive advantage resulting from using big data analytics in business. The research sample consisted of 14 large manufacturing enterprises including 6 metallurgical companies, 3 mining companies, 1 cement plant and 4 machinery companies. The interviews were made in person in the enterprises' headquarters in March - April 2017.

Each interview consisted of three thematic sections. The first part concerned changes in information resources, including quantitative and qualitative changes, new sources of information, and information availability in enterprises' own resources. The second part contained questions about the essence of big data and the concepts supporting the analysis of the big data. Part three concerned the competitive factors that result from using big data analytics.

The factors identified through desk research have been verified during interviews with managers.

When asked about the increase in the amount of data in the company's resources, all managers agreed that they did not see a substantial increase in the amount of unstructured data in the resources of their enterprises. The answers to the question about new data sources and their value for enterprises were not so consistent (see Fig.4).

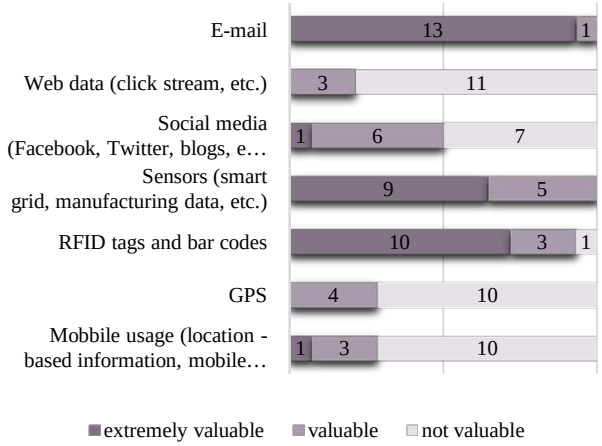

Fig. 4. Value of the new sources of data for organizations [own research]

Almost all respondents appreciate the value of email correspondence, data gathered by sensors, monitoring systems as well as automated logistics and storage systems (RFID). Mobile usage, GPS, web and social media were considered as less important data sources for manufacturing enterprises.

Respondents do not experience problems with acquisition of information from the information systems.

In the second part of the interview, managers were asked about the concept of big data. The interviewees were familiar with the concept of big data, its potential for advanced analyses and the detection of relationships. Without going into detail, this solution was compared to business intelligence, data mining and knowledge discovery systems. One of the respondents concluded that there is lack of experts and analysts who are familiar with the metal industry and can properly interpret the obtained results of the analyses. Several years ago the enterprise implemented an ERP system with the module of manager dashboard, which is not fully used since users do not have sufficient competencies in terms of the analytics and interpretation of the data and construction of prediction models [33].

Respondents, by analysing the competitive factors that could potentially be achieved using the big data analytics, confirmed that they first and foremost see new possibilities in innovation creation and in customer relationship management.

Big data can allow for faster innovation, especially due to the evolving Internet of Things. For example sensors installed in machines can transmit real-time data on their state of use, material consumption level, etc. With this data, engineers can quickly acquire knowledge and introduce new, better solutions.

For large manufacturing enterprises, the most numerous group of recipients includes corporate customers. Recognition of their needs is realized differently than in the case of individual clients, especially those from e-commerce model. Interviewers see the potential for big data analytics in customer relationship management, however for corporate customers, social and web data are less important.

Questions about the cost factors of enterprise competitiveness derived from using big data analytics, confirmed that, traditional manufacturing industries see the greatest potential of using BDA in production management, especially in planning and improving production quality and more efficient distribution.

Most respondents indicated that big data analytics can change the decision-making processes. It helps to make decision quicker (provide more

frequent, accurate analysis), better (estimate the impact using cross-organizational analysis) and proactive (use predictive analytics to forecast customer and market dynamics).

It is also important to notice that interviewed managers declared willingness to improve their competences in the field of using analysis of big data.

When asked about the future of BDA in manufacturing companies, all the managers agreed that it is a promising solution, which, facing the increasingly competitive environment, may turn out to be a substantial support in decision-making and the source of inspiration in seeking competitive advantage in the market.

8 Conclusions

In the turbulently changing environment, making a decision is associated with a high risk, which may hinder the access to relevant information and reliable analysis, delivered when you need them. Advanced analytical tools, supported by innovative ways of processing big data become necessary to expand enterprises. Research of Brynjolfsson, Hitt and Kim [34] confirmed that the efficiency is higher in organisations which base their decisions on data and analytics systems. In turn, presented in the article results of preliminary research showed that even manufacturing enterprises in the so-called traditional industries such as metallurgy, mining, cement plants and machinery see big data analytics as a potential source of competitive advantage. It can lead to more effective innovation processes, customer relationship management, new revenue opportunities, improved operational efficiency and delivery system, and other business benefits.

As a conclusion, a list of recommendations for companies that wish to implement big data solutions is presented below:

1. Verify company's information strategy in terms of big data requirements, which include hardware platform, software, application landscape of big data analytics and human resources - "data science" and "data analyst" specialists.
2. Adjust the "new" information strategy to the business strategy and the business strategies to new business processes opportunities.
3. Create flexible business models.
4. Build information culture in the organisation. The first question a data-driven organisation asks itself is not "What do we think?" But "What do we known?".
5. Change the decision-making model. Data-driven decisions tend to be better decisions.
6. Collect, process and use data which already exist in the information resources of the company.
7. Identify other data that should be collected.
8. Identify new sources of data.
9. Use big data analytics in real time, because with time some data cease to be useful.

In the era of big data and new, more advanced analytical capabilities, companies can gain a competitive advantage on the market, by competing on analytics. The analytics is a part of the increasingly exposed current studies on decision-making on the basis of data.

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