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BUSINESS-MAKING SUPPORTED VIA THE APPLICATION OF BIG DATA TO ACHIEVE ECONOMIC SUSTAINABILITY[*]

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Abstract. Decision-making of managers in companies is currently significantly influenced by instantly available information. This phenomenon was caused by advances in information and communication technologies (ICT) and the development of a new generation of machines and systems that create an abundance of diverse data. For managers, this data is a source of information that needs to be obtained in an appropriate manner using different technologies. Technologies that enable the acquisition of this information from available data become an essential part of each company and its management processes. Since technology is currently entering the decision-making process in a significant way, this can be seen as the digital transformation of decision-making processes in companies. The ability to capture, process and assess a very large amount of available data represents the implementation of decisions that make the company's activity more efficient and sustainable (e.g., achieving a competitive advantage, increasing sales or profits, development of new products, etc.). The article presents the results of the conducted research focused on identifying the benefits of implementing Big Data solutions in companies. The main method applied was content analysis of multiple cases followed by the categorization of data extracted. The research hypothesis was stated as follows: There are significant reasons that justify the application of Big Data in managerial decision-making to support the achievement of economic sustainability. The findings from the research (categories) support the importance of the Big Data solutions applied in the managerial decision-making for ensuring the sustainable operation of companies with the current trend of generating and processing a large variety of data.

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1. Introduction

Traditional business information systems (Zheng, et al., 2020) are not able to distribute the required information created from the data to managers in the decision-making process (Wu, et al., 2021; Zhang, et al., 2021), especially from the time perspective. This is the reason for the development of new technologies (Li, Wang, 2019) aimed at rapid and efficient processing of many diverse data types, i.e., Big Data (Katal, et al., 2013; Yan, et al., 2021). This solution for the processing of a large variety of data (Talwar, et al., 2021) is a way to expand and improve the decision-making process to ensure the sustainable entrepreneurship via decision-making in companies (Raut, et al., 2019), with data being generated in larger quantities that may contain a potentially significant informational value (Hajjaji, et al., 2020; Blštáková, et al., 2020). The aim of the article is to present the theoretical basis of the Big Data solution, and the results of the research carried out via the content analysis. The research was focused on analysing the cases of the Big Data solutions' implementation and its effect on sustainable operation of companies via the support of managerial decision-making.

Based on the results of the analysis, the benefits of the Big Data solution were identified in companies that justify the use of the Big Data solution in the decision-making process, allowing companies to ensure economic sustainability with the ever-increasing amount of data generated at present (Elkhwesky, et al., 2022).

2. Theoretical background

The analysis of the theoretical background consists of three subchapters. The first one describes managerial decision-making in companies. The second chapter focuses on a brief definition and description of the Big Data technology. This is followed by the setting of research questions and hypothesis.

2.1. Decision-making

Decision making is the most important activity of business managers (Ikram et al., 2020; Holubčík, Soviar, 2021). This activity is an extensive process consisting of partial steps leading to a decision that can help achieve sustainable operation and development of companies (Worthington, 2013). Due to the rapid development of computing technology, information from source data is becoming the key input to the decision-making process in the swiftly changing social trends, along with the managers' experience and abilities (Treurniet, Wolbers, 2021). Instantly available, trustworthy, true, and relevant information have a significant impact on the correctness of managerial decisions, especially in the current global market environment (Holubčík, et al., 2018).

The customers' requirements are also constantly changing (Owen, et al., 2016; Kubina, Lendel, 2015). This leads to the need of a continuous decision-making processes in companies (Deverell, et al., 2019). A variety of different data that may contain potentially significant information value is being generated because ICT are currently affordable both for companies and customers and various social media are still expanding (Stacho, et al., 2015; Andronie, et al., 2021; Fakunle, Ajani, 2021).

Many **techniques** are being developed and used to help companies obtain, process, and use the necessary data to support the effectiveness of their decision-making. Kamble et al. in their study focused on *a large group decision-making technique* they used to identify and evaluate *the best big-data-driven circular economy (BDDCE) practices in the auto-component industry.* The results of this study were specific factors that formed an aspect of the economic sustainability of the surveyed companies. These included, for example: *plan for reuse, recycle, recovery of material, parts, and reduction of the process waste at the design stage, or minimization of the raw material consumption* (2021).

Decision-making as a process is characterized by defining specific **indicators,** based on which it is possible to choose one of the variants of solving the analysed situation (Goodwin, Wright, 1998). Decision-making indicators are used in companies in activities such as: *goal setting, performance evaluation, monitoring, or control* (Huovila, et al., 2019). The choice of the most suitable combination of indicators is critical for the success of the whole process on the one hand, but on the other hand it is objectively demanding. Therefore, it is essential to use and improve expertise in this area, as well as to look for new methods and techniques that will help managers streamline the decision-making process (Sousa, Rocha, 2020).

Different *indicator standards* are set for different areas. For example, in the Smart City area, some standards are narrowly focused on output indicators that assess progress in implementing smart urban ICT solutions (Huovila, et al., 2019).

Following the information provided in the previous paragraphs, it can be argued that the use of formal methods or decision-making techniques can be used to improve the overall **sustainability** of the company (Zavadskas et al., 2016). In this case, the decision-making process is associated with the area of sustainability (Sulich et al., 2021). Based on this relationship, it is possible to support the efficiency, speed, and reliability of decision-making using various solutions (including Big Data), which will bring economic sustainability of the company.

The impact of decision-making on sustainability is being explored by numerous authors. Diaz et al. in their study focused on examining the implications of adopting a specific strategy for decision-making in *the sustainable product development (SPD) process* (2021).

2.2. Big Data as the platform for the company's decision-making process leading to sustainability

We are currently living in the Big Data era where, using Big Data technologies intended for processing large volume of data, companies can improve their decision-making and thereby ensure sustainable growth. The difference between the decisions made without this technology and with it can significantly differ (Cheng et al., 2018). The Big Data topic is not entirely new. From a historical perspective, the evolution of Big Data can be dated back to the 1960s. It was then that data centres were being built and databases were being developed to store data. A significant milestone in Big Data was the year 2005 with the development of social media and social networking. Users of social networks started generating large amounts of heterogeneous data. This data can contain significant informational value whereby its use grows in proportion to the increasing trend of data being generated daily. (Husamaldin, Saeed, 2021) Big Data represent a loosely defined term that describes large quantity of complex data sets and, at the same time, the advanced technologies for collection and storage of such large data quantities (Keen, 1991 There are many definitions of Big Data, but there is no single and exact one. Definitions differ, representing different opinions of various authors. From a broader perspective, Big Data can be considered as an element that connects and integrates the physical world, people, and cyberspace. (Favaretto et al., 2020) The term Big Data applies to the group of hardware and software tools specifically designed for solutions related to the complexity of data. (Calic, Ghasemaghaei, 2020) These tools can work simultaneously with several sets of data, which are characterized by their volume, diversity, rapidity, and veracity, and which it is complicated to manage by means of traditional data management technologies (Romero et al., 2017). Big Data can be defined as when data sets are so big that traditional technologies and tools for their extraction are no longer usable within reasonable time frame and are ineffective in terms costs (Bakshi, 2014, Rawat, Yadav, 2021). Big Data are coming from various sources, such as transaction records, boot files, social media, sensors, third parties, web applications, etc. However, Big Data are not only large quantities of data, but they are also exceptionally diverse data types, distributed with various speed and frequency (Stanimirović, Mišković, 2014, Haili et al., 2021). These data types can be generally divided into structured, semi-structured, and unstructured. Preliminary processing of unstructured data, their conversion to structured data, and their subsequent storing is very important for their further extraction. Full utilization of Big Data depends on effective management, which makes data

extraction easier (Wu et al., 2018). Three main issues related to Big Data include: quantity of collected data, speed required for data analysis, and various data formats that are collected (Mattmann et al., 2014; Favaretto et al., 2020).

Based on similarities of the definitions listed above, Big Data can be understood as very large quantity of data continuously generated from various sources, the processing of which by traditional technologies is not manageable for the company considering both time and costs. It also includes new technologies aimed at advanced collection, storage, and analysis of data. (Aghaali et al., 2022) This utilization of data by the Big Data technology is characterized by high speed, whereas diverse data are processed. The ability to process large quantities of diverse data has substantial impact on obtaining significant information, revealing business opportunities, and streamlining activities in decision-making processes of companies. It is therefore apparent that the Big Data solutions significantly contribute to the sustainability via the decision-making in the company. (Ranjan, 2019; Fidlerová, et al., 2022)

Companies are by being aware of the potential of the Big Data technology. It results in investments into the business intelligence and utilization of Big Data analyses to understanding the wider context (Muntean, 2018, Hariri et al., 2019). Innovations in the field of Big Data are not related only to the significant increase in volume, diversity, speed, and veracity of data, but they also refer to the way how these data are applied and how new innovations are distributed in the whole company (Kharrazi et al., 2016). Big Data are also defined as methods and technologies to identify hidden value from large and complex datasets. Big Data enables the company to share data faster and more complexly. This way, it is possible to establish more effective and faster processes (Arena, Pau, 2020). The information obtained via Big Data solutions positively impact the area of innovation in the company. (Meiyou, Ye, 2022)

From the perspective of decision-making, the Big Data technology represents a way how to achieve sustainability with the aim to create competitive advantage (Batista, Francisco, 2018). Strategic decision-making is a key factor for sustainability and development of the company. It does not only affect the future implementation of strategies, but also the survival of the company itself (Wu et al., 2017). For the companies to be competitive, decisions must be quick, effective, and made in alignment with strengthening sustainability. (Phuyal et al., 2020) Despite obvious awareness of managers about the issue of sustainability, problems with its integration into the decision-making process and implementation in the praxis persist (Le Roux, 2016, 7 Mishra et al., 2021).

One of the ways how to integrate sustainability into the decision-making process and how to subsequently implement this process into the company is the utilization of the Big Data technology. That means the implementation and integration of the Big Data platform into individual decision-making processes of the company, as referred to by the performed research.

2.3 Setting research questions and research hypothesis

Based on researching the theoretical basis, the following research questions were set for this research project:
- Does the application of the Big Data technology influence the efficiency of business processes in a positive way?
- Does the application of the Big Data technology help companies build better relationships with their customers?
- Are the Big Data solutions currently on such a level that their implementation in companies brings effects that are positively reflected in their economic situation?
- Are there examples of implementing the Big Data technology that can be labelled as the best practice?

The questions stated above led to the formulation of the research hypothesis H_0, whose validity is tested in the research. The hypothesis H_1 is stated as well, as a negation of hypothesis H_0.

H_0: *There are significant reasons that justify the application of Big Data in managerial decision-making to support the achievement of economic sustainability.*

H_1: *There are no significant reasons that justify the application of Big Data in managerial decision-making to support the achievement of economic sustainability.*

3. Research objective and methodology

The research was carried out in 2021. It was conducted in the form of *multiple case analysis*. The main purpose of the case analysis was to identify the benefits of implementing the Big Data solution to support decision-making in a company leading to its economic sustainability. Additional activities have been defined to ensure that the main objective of the analysis is met:

- to identify companies that have implemented Big Data solutions,
- to identify reasons, which led the company to the implementation of the Big Data solution,
- to identify benefits achieved by the company via the implementation of the Big Data solution in relation to the decision-making support,
- to categorize the data included in the cases based on the content and the frequency of occurrence.

The analysis was conducted as the case studies analysis in combination with the content analysis of documents, which was used as the technique for data collection for qualitative analysis and evaluation. The materials analysed described the cases of the Big Data solution implementation in particular companies, i.e., new case studies were not created, but existing cases were collected, categorized, and analysed.

According to Yin (1994), a case study can be defined as the strategy for examination of a phenomenon specified in advance in the present, within its actual context. According to Hendl (2016), it can be assumed that examination of one case can contribute to better understanding of other similar cases and help generalize conclusions from the examination performed in wider context.

Similarly to the creation of a case study (Yin, 1994; Hendl, 2016), in the analysis performed it was also important to consider whether it is sufficient to work with one case or several cases, i.e., multi-case approach. Statistical evaluation cannot be applied since the choice of studies is targeted and not random.

Thus, the choice of objects for the analysis was made by the method of intentional selection, i.e., the best available entities (companies) were chosen. The choice was targeted and subject to previously defined criteria. The replication approach was used in combination with intentional choice to achieve outputs required. Several case studies were analysed individually, with separate evaluation in relation to the performed analysis. The literary replication was used regarding the logic of the approach (Yin, 1994). The cases where similar generalized results (benefits from the implementation of the Big Data solution) could be expected were included in the analysis.

As the research performed was qualitative, the data obtained were continuously being evaluated during their analysis. Case studies contain the description of one or several cases that are subject to detailed study. Therefore, several data points were collected from each case while the relationships within the complex entities studied are described.

The source documents were collected online. These included websites, books, and other online documents with the content corresponding with the scope and aim of the analysis.

The analysis was aimed at large companies that implemented Big Data solutions for the support of decision-making, or which were able to obtain certain benefits from the implemented solution. These benefits had to have potential to be generalized in relation to the support of managerial decision-making. The target group of the analysis was formed by companies that implemented the Big Data solutions. Cases included in the target group had to meet the following criteria:

- The company had to be classified as a large company in relation to the number of employees, i.e., having more than 250 employees.
- The company had to present the implementation of a Big Data solution for processing diverse types of data.

The number of cases analysed was not exactly specified in advance. Since qualitative evaluation was selected, the following method for including new cases was used – expansion of the research sample in the qualitative research (in this case the number of the cases examined) ends when the researcher is no longer obtaining new pieces of information from the data gathered (Donato, 2014). This was met when no new generalized benefits from the implementation of Big Data solutions emerged from additional cases studied.

4. Results and discussion

Data obtained by the analysis performed were obtained from available documents, which described specific cases examined. Relevancy of such cases in relation to the analysis and the main research objective was ensured by previously defined criteria a particular case had to meet to be included. Several methods of data processing were used during the examination of individual cases to obtain necessary information via the qualitative evaluation:

- intuitive approach,
- qualitative evaluation,
- data generalization,
- data categorization,
- comparative analysis,
- holistic approach to data assessment,
- replication approach to data analysis.

As data obtained by the analysis of cases of the Big Data solutions' implementation in companies were qualitative, they were not subject to statistical analysis.

The following procedure was defined to ensure obtaining of the required information from individual cases examined in the analysis:

1. Assessment of relevancy of the examined case according to the criteria defined.
2. Description of the company including basic information about the business subject and the details about the Big Data solution implementation.
3. Description of the reasons for the implementation of the Big Data solution, i.e., reasons that led the company to implement the Big Data solution.
4. Description of the benefits from the implementation of the Big Data solution that were achieved in the company by the implementation of the Big Data solution.
5. Case evaluation containing the summary of the findings and their generalization from a particular case of the Big Data solution implementation in the company.

Each case was analysed applying the described procedure individually, whereas the data obtained from individual cases were summarized in the end. The pieces of information extracted were used for the formulation of conclusions regarding the research objective. Following companies were examined by the procedure within the analysis: Mercedes AMG, Walmart, Nokia, Aetna, and UPS.

In relation to the scope of research, the paper contains only information emerging from point 5 and the final evaluation of the analytical procedure.

4.1. Evaluation of the Mercedes AMG case

Literary sources (Donato, 2014; Overby, 2014; Mercedes-AMG GmbH, 2018) were used in the analysis of the Mercedes AMG case. Product testing represents one of the most demanding activities regarding time and financial costs in the field of car development in the company Mercedes-AMG. The possibility of accelerating testing of car components significantly affects not only the reduction of costs, but also the increase of competitiveness and sustainability of the company. Due to the implementation of the Big Data solution the company was able to shorten the time of processing and evaluating large quantity of data, which significantly affects the whole process of testing. Financial and time costs can be reduced in the company already during the testing process due to the processing, comparison (of current and historical data), visualization and prediction from generated data in real time and even the smallest deviations from standards can be revealed. The company can thus quickly react to the situation by ending the process of product testing within a very short time (in the order of minutes). This helps remove downtimes as compared to the testing process before the implementation of the Big Data solution, when results could be evaluated only after the completion of testing (app. an hour). Time saving in the testing process represents a possibility to increase the number of tested products per day and to improve the quality of resulting products according to the customers' needs and requirements. The main benefit from the implementation of the Big Data solution in the Mercedes-AMG company is in the saving of time from product (engine) testing processes. Other benefits from the implementation of the Big Data solution in form of saving operating costs, increasing sales, implementing corrective measures on the grounds of predictions from several diverse data types subsequently follow. The implementation of the Big Data solution in this company was justified via the reasons identified. The summary of reasons and benefits from the implementation of the Big Data solution in the Mercedes-AMG company is included in Table 1.

To further process the data obtained via the analysis of the selected cases, the summary tables (Tables 1 to 5) have been supplemented by the author's column "Category". The information obtained was divided into ten categories: *data, quality, costs, wastage, process, product, real-time, decision-making, customer, competitiveness/prediction.*

Table 1. Reasons for the implementation and the benefits of the Big Data solution in the Mercedes-AMG company

Reasons to implement the Big Data solution	Benefits for the company after the implementation of the Big Data solution	*Category*
Need to utilize large quantity of diverse data	Processing and visualizing data in real-time	*Data*
Reduction of production operations' costs	Predicting errors Reducing operating costs	*Costs*
Streamlining the production process	Increasing the capacity of tested products	*Process*
Elimination of downtimes and wastage	Analysing data from the process of product testing in real-time Shortening the time of testing defective products Transmitting data about testing results to employees' devices (tablet, PC) Testing larger number of products during the same time than before the solution's implementation	*Wastage*
Management of product portfolio production	Quickly identifying shortcomings by means of complex analytical tools	*Product*
Identification of customer needs	Identifying customers' needs and wishes via processing diverse data from the customers and the configuration system	*Customer*

Improvement of product quality	Historically the most successful year for the company regarding product sales Increasing time for implementation of measures and incorporation of customer requirements	*Quality*
Increase of the company's competitiveness	Expanding the product portfolio with three new models	*Competitiveness/ prediction*
Improvement of decision-making processes	Predicting errors Supporting innovations Supporting processes within the whole company	*Decision-making*
Obtaining data for the support of company processes in very short time	Usability of the solution in the whole company	*Data*
Streamlining the product testing process	Predicting errors Quickly revealing deviations	*Product*
Possibility of historical data correlation	Comparing the current and historical data in real-time	*Data*
Becoming a "real-time" company	Processing data in real-time Usability of the solution for the support of processes within the whole Daimler Group	*Real-time*

4.2. Evaluation of the Walmart case

Literary sources (Ďuricová, 2011; Mayer-Schönberg, Cukier, 2013; Van Rijmenam, 2013; Ruby, 2014; Seetharan, 2015; Walmart Inc., 2018a; Walmart Inc., 2018b) were used in the analysis of the Walmart case. The implemented Big Data solution allows the company to process and utilize large quantity of diverse data from millions of users and various data sources. The solution enables to analyse key words from millions of customers in real time. Obtaining the necessary information from available sources for the support of the company's decision-making enables to better understand consumers' behaviour, and thus to meet their needs and requirements, thereby to ensure the sustainable development of the Walmart company. At the same time, it allows the company to identify various associations from the sale, to modify the layout of products in the shop, to optimize logistic processes, etc. The benefit from utilization of information obtained from the data combined from various sources can be demonstrated on the example of the sale of strawberry cakes where the company revealed that as soon as the warning of impending tornado is announced, the sale of these cakes grows by seven times on average. Therefore, these cakes are placed directly at the cash desk in the shops before the hurricane.

Using the Big Data solution, it was also possible to increase the sale of products and support decisions about the launch of new products based on data from social networks. The company can market products in which customers are interested immediately when they discuss them. Based on available data, the company is also able to create various predictive analyses and forecasts using which it is possible to plan further operations and activities, such as pricing of products on the grounds of market situation, or to propose measures for minimizing adverse impacts of the current situation (such as to compensate the higher price by a special discount or a gift voucher). Predictive analyses are important for the company also from the perspective of stock reduction. The company can build stock of only those products for which there is high demand. In this way it is possible not only to plan the stock, but also to identify products in which customers are not interested and subsequently to monitor the level of stock within the whole Walmart chain. The summary of reasons and benefits of the implementation of the Big Data solution in the Walmart company is presented in Table 2.

Table 2. Reasons for the implementation and the benefits of the Big Data solution in the Walmart company

Reasons to implement the Big Data solution	Benefits for the company after the implementation of the Big Data solution	Category
Large quantity of data generated	Capturing, storing, and processing large quantities of diverse data from various sources	*Data*
Need to integrate a large quantity of unstructured data within one database	Creating a single database structure	*Quality*
Possibility of mutual combination of diverse data for analysing and obtaining of results	Analysing the data from various sources in a single database structure	*Decision-making*
Increasing competitiveness	Reducing the time spent with customers at the cash desk Increasing the earnings from online sales by 10-15%	*Competitiveness/ prediction*
Need of better identification of the customers' needs and requirements	Using a mobile application with the function of evaluating customer needs Analysing millions of data points about customers and their friends in real-time	*Customers*
Predicting customer needs	Using a mobile application with the function of evaluating customer needs Analysing millions of data points about customers and their friends in real-time	*Real-time*
Predicting buying habits of consumers	Using a mobile application with the function of evaluating customer needs on the grounds of their position within the shop or by voice analysis of their requirements	*Product*
Monitoring the customers' behaviour	Using a mobile application with the function of evaluating customer needs on the grounds of their position within the shop or by voice analysis of their requirements Processing data from sensors in shops	*Customers*
Need to adapt products to customers' requirements	Recommending products to customers via specific applications of the Walmart company	*Costs*
Need to optimize logistic processes	Planning stock and equipment of shops based on predictive analyses	*Wastage*
Need to obtain data from consumers' mobile devices	Obtaining data about customers via mobile applications	*Customers*
Creating the tools for customers to support the buying process	Using specific applications from the Walmart company	*Process*

4.3. Evaluation of the Nokia case

Literary sources (Kosuru, Tommaney, 2012; Jia, Yin, 2015) were used in the analysis of the Nokia case. Development in the field of ICT caused the creation of many database structures in the company Nokia, which were available individually according to the needs of individual departments. Original systems for the collection and processing of data were insufficient in relation to finance, time, and information value from generated data. Therefore, the company decided to implement the Hadoop solution for processing large quantity of diverse data. Due to this Big Data solution, Nokia was able to integrate data from various data sources into a single database structure available for all employees and combine data from own and other sources to obtain information value for the support of decision-making within the whole company. The company can analyse data from its customers in real time. Therefore, it can understand the buying behaviour of its consumers on individual markets and make decisions for higher satisfaction of their needs than the competition. At the same time, the company can create various predictive models from generated data on the grounds of which it can foresee future events and make decisions about possible corrective measures to mitigate possible impacts on the company from predicted events. The summary of reasons and benefits from the implementation of the Big Data solution in the Nokia company is presented in the Table 3.

Table 3. Reasons for the implementation and the benefits of the Big Data solution in the Nokia company

Reasons to implement the Big Data solution	Benefits for the company after the implementation of the Big Data solution	Category
Creation of a single database of data	Integrating data from all company systems into one database structure	*Real-time*
Prevention of data duplicity and access of all employees to the data	Integrating data from all company systems into one database structure Data available in real-time for all employees	*Customer*
Need to obtain higher information value from data	Analysing data from various sources in real-time	*Decision-making*
Understanding the buying behaviour of consumers on the market	Better understanding customer needs from analysing data from mobile devices in combination with other data sources	*Product*
Need to capture and process large quantity of diverse data	Quickly identifying shortcomings via of complex analytical tools	*Quality*
Need to combine data from various sources	Obtaining data from various data sources and storing them in a single database structure to obtain information value	*Data*
Automated processing of unstructured data to structured data	Automatically transferring data between data centres of the company	*Process*
Implementation of financially and time affordable solution for processing large quantities of diverse data	Up to ten times lower price in case of storing one terabyte of data as compared to the original solution of the company	*Costs*

4.4. Evaluation of the Aetna case

Literary sources (Higginbotham, 2012; Aetna Inc., 2018; Steinberg, 2018) were used in the analysis of the Aetna case. The company Aetna, using modern technologies in the field of collection and processing of diverse data, was able to improve its decision-making processes and thus ensure sustainable development in relation to the business activity. By implementing the Big Data solution, the company gained a platform for obtaining, storing,

and analysing large quantity of diverse data about its customers, patients. This enabled the company to make sustainable decisions, as various predictive models enter the decision-making process, and their information value allows the company to approach patients individually. Thus, the company can make effective decision regarding costs and required medical care of the patient. The summary of reasons and benefits from the implementation of the Big Data solution in the Aetna company is presented in Table 4.

Table 4. Reasons for the implementation and the benefits of the Big Data solution in the Aetna company

Reasons to implement the Big Data solution	Benefits for the company after the implementation of the Big Data solution	Category
Processing large quantities of diverse data	Processing data from various sources (medical records, laboratory tests, biometric results, demographic data, etc.)	Data
Obtaining information value from available data in short time	Obtaining information from medical records, laboratory tests, demographic data, monitoring systems of the hospital etc.	Decision-making
Optimal transmission of information and results	Possibility of distribution of data to the doctor to ensure the prescription of suitable treatment procedure	Product
Removal of unsuitable treatment plans and procedures with impact on the patient	Making accurate decisions on the grounds of predictions and data analysis	Process
Provision of the best individual care for the patient	Possibility to create individual treatment plans (supported by predictions)	Real-time
Understanding and influencing behavior of patients	Processing data from various sources Prediction of risks	Customer
Creation of predictions from available data	Supporting predictive analyses	Competitiveness/ predictions
Improvement of communication between the patient, doctor, and the insurance company	Automatic transfer of data between the patient, doctor, and the insurance company	Quality
Improvement of health care for patients	Better prediction of occurrence of problems with impact on the health of patients Creation of individual treatment plans, continuous monitoring of the patient and adjustment of the plan Reduction of risk of disease formation by 90%	Quality
Reduction of costs	Making accurate decisions based on predictions and data analysis	Costs

4.5. Evaluation of the UPS case

Literary sources (Davenport, Dyché, 2013; Bessis, Dobre, 2014; Samuels, 2017; Bidgoli, 2018; Maar, 2018; Sahoo, 2021) were used for the analysis of the UPS case. The company UPS belongs to global leaders in the field of shipment delivery. Numerous machines and pieces of equipment are used for the company activity, which generate large quantities of diverse data. By using the data, the company can make decisions to ensure the management of the whole product delivery process due to the implementation and utilization of the Big Data solution. At the same time, the company can make sustainable decisions, which allow optimizing the route of company vehicles in the field and saving the environment (Pollák, et al., 2021). This way, it is possible to accelerate the delivery process, reduce costs, meet requirements of customers, and, eventually, ensure sustainable development of the company. The summary of reasons and benefits from the implementation of the Big Data solution in the UPS company is presented in Table 5.

Table 5. Reasons for the implementation and the benefits of the Big Data solution in the UPS company

Reasons to implement the Big Data solution	Benefits for the company after the implementation of the Big Data solution	Category
Reduction of costs	Saving 10 million gallons of natural gas Saving 30 million dollars	Costs
Acceleration of shipment delivery time	Identification of vehicle activity (elimination of routes with left turns)	Product
Optimizing route of vehicles in the field	Saving 85 million miles	Quality
Combining data from various sources to obtain necessary information	Processing diverse data (sensors, routes, weather conditions, etc.)	Data
Need to monitor all packages during the whole delivery process	Monitoring daily performance of the company (monitoring shipments in real-time)	Process
Decision-making support	Monitoring online map of shipments with the possibility of route correction in real-time	Decision-making
Working with diverse data in real-time	Monitoring daily performance of the company (monitoring shipments in real-time)	Real-time
Understanding customer requirements	Streamlining and speeding up the delivery process Reducing costs to better meet the customer requirements	Customer

4.6. Conclusion of the analysis of cases describing the implementation of the Big Data solution in companies

The analysis of cases of the Big Data solutions' implementation in companies can be evaluated using the data from the performed research in relation to the tasks defined to achieve the main objective.

The first task was to identify companies that implemented Big Data solutions. The following subjects were analysed: Mercedes-MG, Walmart, Nokia, Aetna, and UPS. These subjects were chosen intentionally, i.e., they represented companies that could provide the best information in relation to the implementation and utilization of the Big Data solution for the support of decision-making leading to sustainability. Chosen examined subjects can be considered relevant as they met defined selection criteria:

- all examined subjects can be classified as large companies (with more than 250 employees),
- individual examined cases describe the implementation of a solution for processing large quantities of diverse data – Big Data, i.e., solutions SAP HANA (Mercedes-AMG) and Hadoop (Walmart, Nokia, Aetna, UPS).

It can be established hat examined companies implemented Big Data solutions to process large quantities of diverse data, thus the first partial objective of the analysis was fulfilled. The second partial objective was to identify reasons that led the companies to implement the Big Data solutions.

Companies had the following needs before the implementation of the Big Data solutions that justified their implementation and utilization. They were aware of availability and information potential of diverse data, which could be used for business activities and, therefore, they had the need to utilize such quantity of diverse data. However, processing of large quantities of diverse data was very demanding in relation to the time of their processing, when the results from processed data were often no longer current, so their information value was low. This means that companies were insufficiently technologically equipped for processing and obtaining valuable information from diverse data. Capturing and storing large quantities of diverse data was also financially demanding. Thus, another need that led companies to the implementation of the Big Data solution was the need to reduce costs in relation to capturing and processing large quantities of diverse data. As the examined subjects represent large companies, they generate large quantities of data from various pieces of equipment and activities. Pieces of information from these data enter the process of decision-making on the performance of business

activities. Data from the analysis performed identified the need to eliminate downtimes, which were occurring especially in the case of transfer and evaluation of data between various information systems. Another reason for the implementation of the Big Data solution is the need to increase competitiveness. Companies were aware of information value of data, for instance, from mobile devices or production equipment, based on which it would be possible to understand buying behaviour of consumers more quickly and make decisions that would lead to the improvement of company processes and satisfaction of customer needs better than the competition. Due to the availability of ICT equipment, companies had large quantities of data on customers, using which they would be able to increase their competitiveness by improving product quality, i.e., by producing goods and services meeting the requirements of customers or quality standards. Another reason for the implementation of the Big Data solution was the need to improve company processes, especially in relation to decision-making. This means that decision-making processes used reports from information obtained by analysis and evaluation of structured data without the possibility to utilize unstructured data and their combinations (regarding time demands of processing as well as the costs). Other reasons that led companies to implement Big Data solutions included the absence of quick processing and access to data. Additionally, it was not possible to capture and process data in real time. Duplicity of data occurred, which affected the load on systems and speed of data transformation to information. The absence of possibility to perform analyses of all the data was caused by the fact that there was no single database available to be used in the decision-making.

Examination of data from individual cases identified reasons that led companies to implement the Big Data solution. Therefore, the second partial objective was fulfilled too. The third partial objective in the performed analysis was to identify benefits the companies achieved from the implementation of the Big Data solution regarding the support of sustainable decision-making. It was possible to identify and generalize the benefits from the implementation and utilization of the Big Data solution for the support of decision-making leading to sustainability of the companies.

In relation to the improvement of company processes, their sustainability was supported by the decision-making based on the Big Data solutions. Using the available information from diverse data (e.g., sensors in the production), bottlenecks in individual activities of the process can be detected and improvements can be made (e.g., elimination of duplicity, identification of the need to make reviews, etc.). The Big Data solution can be used as a source of relevant information for the support of sustainability via decision-making in relation to continuous improvement or reengineering of company processes. At the same time, it is possible to improve the communication within individual activities of the process, for instance, by automation of the data sent (e.g., sending information about a tested product). The responsible worker in the process or a manager can make quicker decisions about the performance of other process activities and continuously evaluate the effectiveness of individual activities and the whole process. This means that the Big Data solution can be used to support the sustainability via decision-making within the whole company.

Advanced analytical tools are available in Big Data solutions to obtain information value from diverse large data volumes. With these tools, companies can obtain information according to their needs and the nature of the issue the manager is deciding on. Advanced analytical tools of Big Data solutions allow companies to visualize data in various graphical reports, from which managers can quickly identify the problem or the factors that affect the decision-making. At the same time, it is possible to obtain information for the needs of decision-making as the result of processing all the historical data from information systems and currently generated data in the company and its environment. Current data, usually of unstructured nature (from sensors, social media, videos etc.), allow managers to obtain necessary information for decision-making, e.g., for making decisions about the company shop layout based on the data about the position of customers within the shop. The implementation of Big Data solutions allows companies to make sustainable decisions via better understanding of consumers' buying behaviour or company processes and impacts affecting their effectiveness (e.g., shipment delivery based on the evaluation of data about traffic situation; improvement of health care for the patient using the records from the

doctor, fitness equipment, biometric data etc.). In addition to information about buying behaviour, Big Data solutions enable companies to make decisions in relation to the extension of product portfolio and decisions that impact the improvement of product quality. These decisions can include the decision about the expansion of production, marketing of new product, changes of shop layout, increase of stock or transfer of stock between company branches, etc. Expansion of product portfolio can be made on the grounds of evaluation of data from customers, e.g., from social media or mobile devices in real time. Improvement of product quality can be approached in two ways – by making products according to needs and requirements of customers, or by improving processes for achieving conformity of product parameters during their production. This means that using Big Data solutions, companies can identify needs and requirements of customers more accurately and produce goods and services up to the level of individual customer connection (e.g., individual treatment program for a patient). From the perspective of product quality, in the sense of product conformity with the production procedure and with production parameters, improvement can be achieved by streamlining the production process via elimination of time losses. Saved sources can be used for funding research and development of production procedures or functions of produced goods and services.

Implementation and utilization of Big Data solutions also positively affects the increase of company sales. Making decisions aimed at ensuring the increase of sales or elimination of impacts of events in the future is supported by Big Data solutions via the possibility to create advanced predictive analyses. The companies can utilize diverse data from internal and external sources, for instance in relation to predictions of demand or predictions of risks. With predictive analyses, it is possible to increase sales via decisions related to the management of the supply chain (Kampf, et al., 2018; Pečený, et al., 2020; Zraková, et al., 2019). Utilization of Big Data solutions in the company can also result in the reduction of costs.

The fulfilment of the last partial objective of the analysis can be confirmed similarly to the previous two. The findings from the analysis of cases of implementation and utilization of Big Data solutions in companies describe their benefits as well.

Based on the evidence obtained via an in-depth analysis of the included cases from the business practice, the validity of the hypothesis stated for the research was confirmed. Thus, there are significant reasons that justify the application of Big Data in managerial decision-making to support the achievement of economic sustainability. By confirming the hypothesis's validity in combination with the partial results described above, the answers to the research questions defined were found as well.

Following eight categories resulting from the content analysis of the selected cases describing the application of the Big Data technology in the business practice, the process of implementing this technology in the managerial decision-making was designed as it is depicted below (Fig. 1).
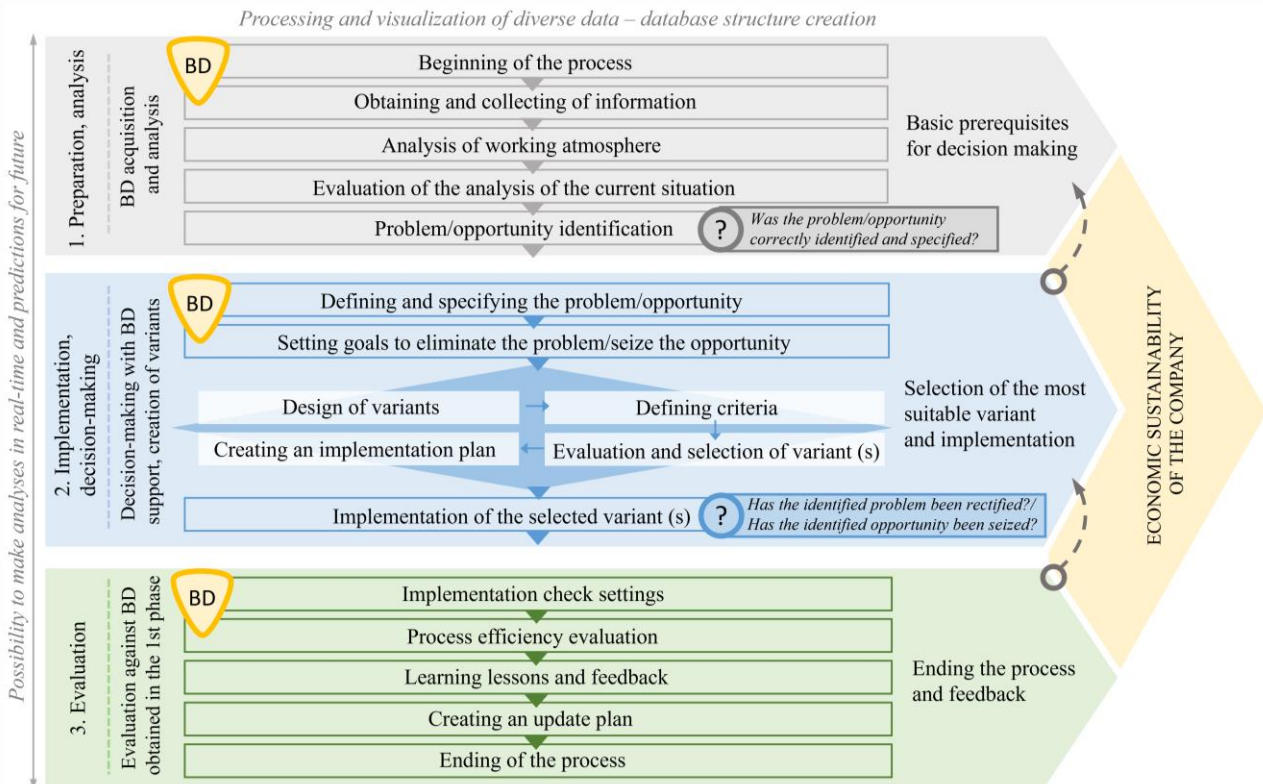
Figure 1. The complex process of utilizing Big Data for the support of decision-making in the company
Source: own elaboration

The model has three layers that are separate but interconnected. The first one is the division of the whole process into three phases – labelled by numbers. In the core of the model there is a description of activities connected to the decision on the implementation of the Big Data (BD) solution itself. The last layer is created by the impact of the whole logical structure on the support of economic sustainability of a company (direction from left to right in the model).

4.7. Discussion

By the implementation of the Big Data solution, companies gained the platform for processing and visualization of diverse data. They also gained a solution that integrates all available data from various sources (company information systems, social networks, Internet, mobile devices, sensors, software applications, etc.) into a single database structure, which is available within the whole company. (Mayer-Schönberg, Cukier 2013) Utilization of a Big Data solution results in automation of processes of data collection and transfer (e.g., from several branches, departments, etc.) into one database for obtaining information from all the data whenever the managerial decision-making occurs. (Romero et al., 2017; Cheng et al., 2018)

Based on the information obtained via the analysis, we can conclude that the introduction and use of the Big Data solution help companies with sustainability via enhanced managerial decision making, mainly due to (Wu et al., 2018; Sulich et al., 2021; Aghaali et al., 2022):
- the possibility to make analyses from all the data (structured and unstructured) in real time,
- predictive analyses,

- the possibility of capturing and processing diverse data from internal and external environment of the company.

From the perspective of decision-making processes within the whole company, these are supported as decisions are made based on information obtained from various sources, especially external, unstructured data. This way, the company can make decisions not only on the grounds of available company data, the information value of which can be limited due to the nature of the processes or possibilities of current information systems. (Kamble et al., 2021; Haili et al., 2021)

Visualization of available data helps in the decision-making process in the case of making quick decisions, reacting to current situation on the market or in the company. It is also possible to intuitively estimate necessary decisions of the company, branches, or individual departments using graphic reports or dashboards displaying monitored data and their changes immediately, in real time. Analysis of data in real time represents another benefit for companies after the implementation of the Big Data solution. (Deverell et al., 2019; Diaz et al., 2021)

Implementation of solution for processing large quantities of diverse data (Big Data) for the support of decision-making in the company represents a complex process. This complexity is enhanced also by the demanding nature of the Big Data platform itself regarding hardware, software, personnel, processes, and information flows. The company must be prepared for the implementation and utilization of the Big Data solution to achieve the support of decision-making because of the occurrence of possible problems, both in designing the model of decision-making with the support of Big Data and in the implementation of the solution. (Ikram et al., 2020; Andronie et al., 2021)

There are several problems that can be identified regarding the implementation of the Big Data solution in the company, which affect the significance of the designed solution for the support of sustainable decision-making: (Ďuricová, 2011; Donato, 2014; Jia et al., 2015; Samuels, 2017; Muntean, 2018; Steinberg, 2018; Sousa, Rocha, 2020; Sahoo, 2021; Mishra et al., 2021; Meiyou, Ye, 2022)

1. Incorrect identification of the need to implement certain technological solution for the support of decision-making can be caused by initial enthusiasm from possibilities of new technology, but the company might not need such solution regarding its business activity, processes, etc. It is important for the company to realize whether this technological solution will bring the required benefit for it and whether it will be utilizable in the company also in the future regarding financial and time demands of the solution's implementation.
2. Incorrect understanding of data can lead to erroneous identification of data sources, i.e., the company will obtain data with information value that will not be suitable for the support of decision-making in particular areas or processes of the company.
3. Implementation of the Big Data solution with unsuitable software equipment has significant impact on the usability of the solution for the support of decision-making. Software equipment means analytical and reporting tools using which the manager will obtain and visualize information from available data. If incorrect tools are implemented or some tools are missing, we can speak about ineffective investment as the Big Data solution will not be usable for the support of decision-making.
4. Lack of qualified personnel the company can assign to the work and support of the Big Data solution. There can also be a problem that employees do not have sufficient abilities and skills to use the designed solution for the support of decision-making.
5. There can be an issue in utilizing the Big Data platform in the company for the support of decision-making when the decisions made using the obtained information will not lead to the solution of the defined problem. This issue is related to the feedback within individual parts of the decision-making process. In this case, the company must focus on the suitability of the algorithms used, credibility of data sources, and analytical tools used in the decision-making process.

Identified basic problems are meant to serve as an aid for companies in decision-making and implementation of the designed Big Data solution. Regarding the extent and complexity of the Big Data technology and the diversity of business activities of individual companies, it cannot be excluded that other problems may occur, which were not included in this paper. Thorough preparation of the company for these issues can result in mitigation of their impacts in the implementation of the Big Data solution (Wu et al., 2017; Batista, Francisco, 2018).

On the other hand, well managed implementation of the Big Data solution enables using data in real time to support sustainable decisions especially in the field of: improvement of company processes, elimination of wastage, acceleration of development of new products, and making communication more effective. (Ranjan, 2019; Hariri et al., 2019; Meiyou, 2022)

Therefore, it can be established that Big Data solutions have a significant impact on sustainability not only via the decision-making, but also in the sense defined by Muntean who says that sustainability of a company can be understood as business approach that creates long-term value for stakeholders by the means of utilizing opportunities and managing risks arising from the economic, environmental, and social development (2018; Ferenc, et al., 2017; Soviar, et al., 2018).

Conclusions

At the time when IT dominates not only the private but especially the commercial sphere, information has crucial importance for companies, of which managers are aware. Business sustainability can be ensured only if correct decisions are made systematically. One of the criteria on which the quality of such decisions depends is the collection, processing, and, especially, correct evaluation of the pieces of information available. Application of the Big Data technology is one of the possibilities how to ensure economic sustainability of companies via the utilization of information.

Novelty of the research presented in this article lies in *the categorization of the factors* crucial for the implementation of the Big Data solution. This solution then supports the decision-making process in a company via which its economic sustainability can be positively affected.

Another element of the article's novelty is *the proposed model* (Fig. 1). Its originality is based on the complex approach to the utilization of Big Data for the support of decision-making in the company. The complexity is achieved by the three layers included in the model's description that can be found in the text.

Research limitations are listed in the following points. The main sources of research data were documents, case studies, and research publications available via the Internet. Due to the characteristics of the research, criteria were chosen to limit the selection of documents that were reviewed and analysed. Documents acceptable for analysis had to meet the following criteria:

- focus on Big Data and decision-making support,
- published by a Big Data vendor or specialist, manager, or an IT professional,
- Big Data solutions implemented in the company identical to the solution's vendor or manufacturer,
- the Big Data vendor's solution meets the basic general characteristics of Big Data (volume, variety, velocity).

Additionally, the limiting factor of the research conducted is its focus on large companies in the following sectors: *industrial production; wholesale, retail, and repair of motor vehicles; transport and storage; health and social work; telecommunications and IT.*

The reason for selecting large companies in the above-mentioned industries is mainly the demanding nature of Big Data solutions in terms of finance, technological infrastructure, and the educational level of the company's staff. The theoretical background of this article includes these points as well.

In this article, the authors have demonstrated the benefits of using this technology in various, seemingly unrelated sectors. The benefits are obvious, regardless of whether the company operates in the automotive industry, retail, technology, insurance, logistics or other industries. Specific benefits may vary, ranging from cost reduction to the understanding of consumer behaviour and optimization of business processes. However, they share a common element, which is the understanding of the information available and its utilization to predict the future. A correct prediction of the future is directly proportional to the sustainability of a company in the long run achieved via managerial decision-making.

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