SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2023
ORGANIZATION AND MANAGEMENT SERIES NO. 175

THE CONCEPT OF DIAGNOSTIC ANALYTICS

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Purpose: The goal of the paper is to analyze the main features, benefits and problems with the diagnostic analytics usage.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.
Findings: The paper discusses the concept of diagnostic analytics, which is a powerful tool for organizations to understand the underlying factors and reasons behind specific outcomes or events. By analyzing historical data and applying statistical techniques, organizations can identify root causes, patterns, and correlations that explain past events. This understanding enables informed decision-making, performance improvement, risk mitigation, enhanced customer insights, process optimization, resource allocation, and continuous improvement.
Nevertheless, there are several challenges associated with diagnostic analytics. Firstly, the analysis process can be time-consuming due to the need for thorough examination and interpretation of data. Additionally, real-time insights may be limited as diagnostic analytics primarily focuses on historical data. Issues related to data quality and availability may also arise, impacting the accuracy and reliability of the analysis. Furthermore, diagnostic analytics lacks predictive capabilities, making it more challenging to anticipate future outcomes. The complexity of analysis, data privacy and security concerns, risks of bias and misinterpretation, and difficulties in identifying causal relationships further add to the challenges organizations face.
Originality/value: Detailed analysis of all subjects related to the problems connected with the diagnostic analytics.

Keywords: Industry 4.0; diagnostic analytics, business analytics, data analysis, real-time analytics.

Category of the paper: literature review.

1. Introduction

Diagnostic analytics is a branch of data analytics that focuses on examining historical data and identifying the root causes of various outcomes, events, or trends. It involves a thorough investigation and analysis of data to uncover patterns, relationships, and anomalies that can provide insights into why certain events occurred or certain outcomes were achieved.

Diagnostic analytics is a powerful approach to analyze historical data and understand the underlying causes of specific events or outcomes. By leveraging statistical and analytical techniques, organizations can gain valuable insights that drive informed decision-making and help improve future performance.

The goal of the paper is to analyze the main features, benefits and problems with the diagnostic analytics usage.

2. Diagnostic analytics - definitions

The primary objective of diagnostic analytics is to answer the question "Why did it happen?" It aims to go beyond simply describing what happened and delves into the underlying factors and reasons that led to a particular outcome. By understanding the causes and drivers behind past events, organizations can gain valuable insights and make informed decisions to improve future performance.

Diagnostic analytics relies on various statistical and analytical techniques to analyze historical data (Sułkowski, Wolniak, 2015, 2016, 2018; Wolniak, Skotnicka-Zasadzień, 2008, 2010, 2014, 2018, 2019, 2022; Wolniak, 2011, 2013, 2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022; Gajdzik, Wolniak, 2023). These techniques include data mining, correlation analysis, regression analysis, hypothesis testing, and root cause analysis. By applying these methods, analysts can identify relationships between variables, detect trends and patterns, and uncover potential factors that influenced specific outcomes (Hurwitz et al., 2015).

The term diagnostic analytics can be defined as a branch of data analytics that focuses on the examination and analysis of historical data to understand the reasons behind specific outcomes or events. It involves the use of statistical analysis, data mining techniques, and other analytical tools to uncover patterns, correlations, and causal relationships within the data (Wolniak, Sułkowski, 2015, 2016; Wolniak, Grebski, 2018; Wolniak et al., 2019, 2020; Wolniak, Habek, 2015, 2016; Wolniak, Skotnicka, 2011; Wolniak, Jonek-Kowalska, 2021; 2022). The primary goal of diagnostic analytics is to identify the root causes of past events or trends, enabling organizations to gain insights into what happened and why it happened (Hwang et al., 2017).

One common application of diagnostic analytics is in the field of business intelligence, where organizations analyze operational data to gain insights into the performance of different departments, products, or processes (Wolniak, 2016; Czerwińska-Lubszczyk et al., 2022; Drozd, Wolniak, 2021; Gajdzik, Wolniak, 2021, 2022; Gębczyńska, Wolniak, 2018, 2023; Grabowska et al., 2019, 2020, 2021). For example, a retail company may use diagnostic analytics to understand why sales declined in a particular region or why a specific product line experienced low customer satisfaction. By examining data related to factors such as pricing, marketing campaigns, customer demographics, and competitor activity, the company can identify the key drivers behind the decline and take corrective actions (Patanjali, 2018; Nourani, 2021, Sharma et al., 2020).

Another area where diagnostic analytics plays a crucial role is in healthcare. Medical professionals and researchers often analyze patient data to understand the factors contributing to disease outbreaks, treatment effectiveness, or patient outcomes (Cam et al., 2021). By examining patient demographics, medical history, lifestyle factors, and treatment protocols, healthcare providers can identify patterns and risk factors that help in diagnosing diseases, improving treatment plans, and enhancing patient care (Greasley, 2019).

In addition to business and healthcare, diagnostic analytics finds applications in various other fields, including finance, marketing, manufacturing, and logistics. It enables organizations to uncover hidden insights, optimize processes, identify inefficiencies, and make data-driven decisions processes (Jonek-Kowalska, Wolniak, 2021, 2022; Jonek-Kowalska et al., 2022; Kordel, Wolniak, 2021, 2023; Rosak-Szyrocka et al., 2023; Gajdzik et al., 2023, Orzeł, Wolniak, 2021, 2022; Ponomarenko et al., 2016; Stawiarska et al., 2020, 2021; Stecuła, Wolniak, 2022; Olkiewicz et al., 2021).

While diagnostic analytics provides valuable insights into past events, it should be noted that it does not offer predictive capabilities. Its focus is on understanding what has already happened rather than forecasting future outcomes. For predictive analytics, organizations turn to other branches of data analytics, such as predictive modeling and forecasting (Hurwitz et al., 2015; Lawton, 2019; Charles et al., 2023; Scappini, 2016; Peter et al., 2023).

Real-time analytics and diagnostic analytics are two distinct approaches to data analysis, each serving different purposes and timeframes. In the table 1 there is a comparison between those concepts.

Table 1.
Comparison of real-time analytics and diagnostic analytics

Aspect	Real-Time Analytics	Diagnostic Analytics
Focus	Immediate and up-to-the-minute data analysis. Real-time analytics is primarily focused on monitoring and detecting events as they happen. It is used to track ongoing processes, identify anomalies, and trigger immediate actions or alerts. Real-time analytics is particularly valuable for time-sensitive situations that require quick response or intervention.	Examination of historical data to identify root causes. Diagnostic analytics focuses on understanding the reasons and factors behind specific outcomes or events that have already occurred. It aims to uncover the root causes and patterns in historical data, enabling organizations to gain insights into what happened and why. Diagnostic analytics is commonly used for retrospective analysis, performance evaluation, and process improvement.
Time Frame	Real-time or near real-time data processing. Real-time analytics focuses on analyzing data as it is generated or shortly after. It provides immediate insights and analysis of data in real-time or near real-time, allowing for quick decision-making and immediate actions.	Analysis of past data to understand what happened. Diagnostic analytics, on the other hand, looks at historical data to understand past events and identify the underlying causes. It analyzes data that has already been collected and processed, usually covering a longer time frame.
Purpose	Monitoring, detecting, and reacting quickly.	Understanding the reasons and factors behind specific outcomes.
Data Sources	Streaming data, sensors, IoT devices, etc. Real-time analytics relies on streaming data sources such as sensors, IoT devices, social media feeds, or live transactional data. It requires continuous data ingestion and processing to deliver up-to-the-minute insights.	Historical data from databases, data warehouses, or systems. Diagnostic analytics typically utilizes historical data from databases, data warehouses, or other data repositories. It involves examining data that has already been collected and stored over a period of time.
Analysis Techniques	Data streaming, complex event processing. Real-time analytics employs techniques like data streaming, complex event processing, and real-time data visualization. It often involves applying algorithms and rules to analyze data in motion and make instantaneous decisions or trigger automated responses.	Statistical analysis, root cause analysis, hypothesis testing. Diagnostic analytics utilizes techniques such as statistical analysis, root cause analysis, hypothesis testing, and data mining. It focuses on exploring historical data, identifying correlations, patterns, and causal relationships to explain past events or outcomes.
Decision-Making	Immediate actions or responses based on data. Real-time analytics supports immediate decision-making based on real-time insights. It enables organizations to take instant actions, such as adjusting pricing, optimizing inventory, or responding to emerging trends or threats.	Informed decision-making for future improvements. Diagnostic analytics informs decision-making for future improvements. It helps organizations understand the factors that contributed to past outcomes and enables them to make data-driven decisions to optimize processes, enhance performance, and avoid similar issues in the future.
Application Examples	Fraud detection, real-time dashboards.	Identifying sales decline causes, patient outcome analysis.
Predictive Capabilities	Limited.	Focuses on explaining what happened rather than predicting.
Data Volume	Handles high volume and velocity of data.	Analyzes large volumes of historical data.
Importance of Time	Critical importance on real-time insights.	Less emphasis on real-time insights, focuses on historical.
System Requirements	Real-time data processing and analytics.	Access to historical data, data storage.

Source: Authors own work on the basis of: (Hurwitz et al., 2015; Lawton, 2019; Charles et al., 2023, Scappini, 2016, Peter et al., 2023).

3. Benefits and problems of diagnostic analytics usage

The usage of diagnostic analytics empowers organizations with valuable insights into the root causes of outcomes, informs decision-making, drives performance improvement, mitigates risks, enhances customer understanding, optimizes processes, and enables continuous improvement. By leveraging historical data and analytical techniques, organizations can gain a competitive edge, increase operational efficiency, and make data-driven decisions to achieve their goals.

On the basis of literature analysis following benefits of diagnostic analytics can be formulated (Hwang et al., 2017; Hurwitz et al., 2015; Lawton, 2019; Charles et al., 2023; Scappini, 2016; Peter et al., 2023):

- Root Cause Identification: Diagnostic analytics enables organizations to identify the root causes behind specific outcomes or events. By analyzing historical data and applying statistical techniques, organizations can gain insights into the factors that led to certain results. This understanding helps in addressing issues at their source and implementing targeted solutions.
- Informed Decision-Making: This type of analytics analytics provides organizations with a solid foundation for making informed decisions. By uncovering the underlying causes and relationships between variables, decision-makers can better understand the impact of various factors on outcomes. This knowledge allows them to develop effective strategies, optimize processes, and allocate resources more efficiently.
- Performance Improvement: By analyzing past data, diagnostic analytics helps organizations improve their performance. It reveals inefficiencies, bottlenecks, and areas for improvement. Organizations can identify patterns, trends, and correlations that impact performance, enabling them to make data-driven adjustments to enhance productivity, quality, and overall operational effectiveness.
- Risk Mitigation: Described method plays a crucial role in risk management. By understanding the root causes of risks and analyzing historical data, organizations can proactively identify potential risks and take preventive measures. They can assess the impact of various factors on risk occurrence and develop mitigation strategies to minimize negative outcomes.
- Enhanced Customer Insights: Diagnostic analytics helps organizations gain deeper insights into customer behavior, preferences, and satisfaction. By analyzing historical data, organizations can understand the factors that influence customer actions and make data-backed decisions to improve customer experiences, tailor marketing campaigns, and optimize product offerings.

- Process Optimization: By examining historical data, diagnostic analytics enables organizations to identify process inefficiencies, bottlenecks, and areas of improvement. By understanding the factors that contribute to delays, errors, or resource constraints, organizations can streamline processes, eliminate waste, and enhance operational efficiency.
- Resource Allocation: This type of analytics aids in optimizing resource allocation. By analyzing past performance and identifying the key drivers of success or failure, organizations can allocate resources effectively. This includes optimizing budget allocation, personnel deployment, inventory management, and capacity planning based on data-driven insights.
- Continuous Improvement: The usage of diagnostic analytics facilitates a culture of continuous improvement within organizations. By regularly analyzing historical data, organizations can track progress, evaluate the effectiveness of implemented changes, and identify new areas for improvement. It helps organizations measure the impact of interventions and make iterative adjustments to achieve ongoing enhancements.

While there are several benefits to the use of diagnostic analytics, there are also some potential disadvantages and problems that businesses and organizations should be aware of. Despite these challenges, organizations that address these limitations and effectively leverage diagnostic analytics can gain valuable insights into past events, optimize their operations, and make informed decisions based on historical data (Sharma et al., 2020; Wolniak, 2013, 2016; Hys, Wolniak, 2018). It is important to recognize the limitations and supplement diagnostic analytics with other analytical approaches to achieve a comprehensive understanding of data and drive future success.

Below are some of the key disadvantages and problems associated with the usage of diagnostic analytics (Hwang et al., 2017; Hurwitz et al., 2015; Lawton, 2019; Charles et al., 2023, Scappini, 2016; Peter et al., 2023):

- Time-Intensive Analysis: Diagnostic analytics involves analyzing large volumes of historical data, which can be a time-consuming process. Extracting, cleaning, and preparing the data for analysis can require substantial effort and resources. Additionally, the analysis itself may involve complex statistical techniques and interpretation, further adding to the time required.
- Limited Real-Time Insights: This type of analytics focuses on analyzing past data to understand what happened, rather than providing real-time insights. This means that organizations may miss opportunities to respond immediately to emerging trends, events, or anomalies. Real-time decision-making requires the integration of real-time analytics or other approaches to complement diagnostic analytics.

- Data Quality and Availability: The accuracy and reliability of diagnostic analytics heavily depend on the quality of the underlying data. Issues such as incomplete or inaccurate data, data inconsistencies, and data silos can hinder the effectiveness of the analysis. Ensuring data quality and establishing data governance practices are critical for obtaining accurate insights.
- Lack of Predictive Capabilities: Method of analytics described in the paper primarily focuses on explaining past events and outcomes, rather than predicting future events. While it helps identify root causes, it may not provide proactive insights or predictive capabilities to anticipate future outcomes. For organizations seeking forward-looking insights, other branches of analytics such as predictive analytics or prescriptive analytics may be necessary.
- Complexity of Analysis: Analyzing historical data and identifying root causes can be a complex task. It requires expertise in statistical analysis, data mining, and domain knowledge. Organizations may need skilled analysts or data scientists with a deep understanding of the data and the ability to apply appropriate analytical techniques to derive meaningful insights.
- Data Privacy and Security Concerns: This method of analytics involves accessing and analyzing historical data, which can contain sensitive information. Organizations need to ensure data privacy and comply with relevant data protection regulations. Inappropriate data handling or unauthorized access to data can lead to breaches, privacy violations, and legal consequences.
- Bias and Misinterpretation: Like any data analysis, diagnostic analytics is susceptible to biases and misinterpretation of results. Biases in data collection, sampling, or analysis can lead to inaccurate or misleading insights. It requires careful consideration of the data context, understanding potential biases, and applying robust analytical methods to mitigate these risks.
- Difficulty in Identifying Causal Relationships: While diagnostic analytics can identify correlations and associations between variables, establishing true causal relationships can be challenging. Different factors may be interrelated, and identifying the true cause-effect relationships may require additional research, experimentation, or advanced techniques such as experimental design.

4. Example of descriptive analytics usage in business

Diagnostic analytics finds extensive applications in various business domains. Organizations use diagnostic analytics to understand the factors influencing sales performance. By analyzing historical sales data alongside marketing campaigns, pricing strategies, customer

demographics, and competitor activities, businesses can identify the root causes of sales fluctuations, customer churn, or low conversion rates. This analysis helps in optimizing sales strategies, improving customer targeting, and enhancing overall sales effectiveness (Hwang et al., 2017; Hurwitz et al., 2015; Lawton, 2019; Charles et al., 2023, Scappini, 2016; Peter et al., 2023).

Diagnostic analytics enables businesses to delve into customer feedback and satisfaction data to identify key drivers of customer satisfaction or dissatisfaction. By analyzing customer interactions, surveys, social media sentiment, and historical data, organizations can pinpoint areas where customer expectations are not met, address pain points, and make improvements to enhance overall customer satisfaction and loyalty (Cam et al., 2021).

This type of analytics plays a vital role in optimizing operational processes. Organizations analyze historical operational data, including production metrics, supply chain data, and quality control records, to identify bottlenecks, inefficiencies, and process variations. By understanding the root causes of these issues, organizations can streamline workflows, eliminate waste, reduce costs, and improve overall operational efficiency.

Diagnostic analytics is employed to analyze historical data for identifying patterns and anomalies associated with fraud, financial irregularities, or security breaches. By examining transactional data, access logs, and historical behavior patterns, organizations can identify potential fraud instances, mitigate risks, and enhance security measures to protect their assets and maintain regulatory compliance. Organizations leverage diagnostic analytics to assess employee performance and identify factors impacting productivity and engagement. By analyzing historical employee data, including performance metrics, training records, and employee feedback, organizations can identify patterns and factors contributing to high or low performance. This analysis helps in identifying training needs, optimizing workforce allocation, and implementing strategies to enhance employee engagement and productivity (Peter et al., 2023).

Also diagnostic analytics is utilized to optimize supply chain management. Organizations analyze historical data related to procurement, inventory levels, supplier performance, transportation logistics, and customer demand patterns. By understanding the historical trends and root causes of supply chain inefficiencies, organizations can optimize inventory levels, improve demand forecasting, enhance supplier relationships, and reduce costs (Hurwitz et al., 2015).

Describe method of analytics helps organizations evaluate the effectiveness of marketing campaigns. By analyzing historical marketing data, including customer responses, campaign metrics, and customer segmentation, organizations can identify the most successful campaigns, target audience segments with the highest response rates, and determine the factors that lead to campaign success or failure. This analysis guides future marketing strategies and resource allocation for optimal outcomes.

Diagnostic analytics plays a crucial role in quality management by helping organizations identify the root causes of quality issues, optimize processes, and enhance product or service quality. Diagnostic analytics in quality management helps organizations identify the root causes of quality issues, optimize processes, evaluate supplier performance, analyze customer complaints, perform root cause analysis, and implement statistical process control. By leveraging historical data and applying analytical techniques, organizations can improve product or service quality, enhance customer satisfaction, and drive continuous quality improvement initiatives.

Below are some of examples of usage of descriptive analytics in quality management (Hwang et al., 2017; Hurwitz et al., 2015; Lawton, 2019; Charles et al., 2023, Scappini, 2016; Peter et al., 2023):

- Diagnostic analytics can be used to analyze historical data on product defects or service failures. By examining data related to defect types, production or service parameters, equipment performance, and customer complaints, organizations can identify patterns and underlying causes of defects. For example, a manufacturing company might analyze defect data to identify common manufacturing process errors or equipment malfunctions causing defects. This analysis helps in implementing corrective actions to improve product quality and reduce defects.
- Organizations can use diagnostic analytics to evaluate the performance of their suppliers and vendors. By analyzing data related to delivery times, product quality, compliance issues, and customer feedback, organizations can identify suppliers that consistently meet quality standards and those that require improvement. This analysis helps in supplier selection, contract negotiations, and establishing quality improvement initiatives with suppliers.
- Diagnostic analytics helps optimize processes to enhance quality. Organizations can analyze historical process data, including process parameters, inputs, and outputs, to identify variations and inefficiencies that affect quality. For instance, a service organization might analyze process data to identify process steps that result in delays or errors, leading to customer complaints. By understanding the root causes, organizations can streamline processes, eliminate non-value-added steps, and reduce errors to improve quality.
- The method of analytics described in the paper enables organizations to analyze customer complaint data to identify recurring quality issues. By examining complaint data, organizations can identify the root causes of complaints and the associated process or product areas that need improvement. For example, a telecommunications company might analyze complaint data to identify common issues related to network outages, billing errors, or customer service interactions. This analysis helps in prioritizing improvement initiatives and addressing customer concerns to enhance overall quality.

- Diagnostic analytics facilitates root cause analysis to identify the underlying factors contributing to quality issues. By analyzing historical data, organizations can identify correlations, trends, and relationships between variables that impact quality. For example, a healthcare organization might analyze patient data to identify factors leading to medical errors or adverse events. This analysis helps in identifying system failures, training needs, or process gaps that need to be addressed to improve quality and patient safety.
- Also diagnostic analytics involves the application of statistical techniques like control charts to monitor and analyze process variations. SPC enables organizations to identify process deviations that may impact quality. By analyzing historical process data against control limits, organizations can detect trends, out-of-control points, or shifts in process performance. This analysis helps in taking timely corrective actions and maintaining consistent quality levels.

5. Conclusion

In conclusion it can be stated that diagnostic analytics is a powerful tool for organizations to understand the underlying factors and reasons behind specific outcomes or events. By analyzing historical data and applying statistical techniques, organizations can identify root causes, patterns, and correlations that explain past events. This understanding enables informed decision-making, performance improvement, risk mitigation, enhanced customer insights, process optimization, resource allocation, and continuous improvement.

Nevertheless, there are several challenges associated with diagnostic analytics. Firstly, the analysis process can be time-consuming due to the need for thorough examination and interpretation of data. Additionally, real-time insights may be limited as diagnostic analytics primarily focuses on historical data. Issues related to data quality and availability may also arise, impacting the accuracy and reliability of the analysis. Furthermore, diagnostic analytics lacks predictive capabilities, making it more challenging to anticipate future outcomes. The complexity of analysis, data privacy and security concerns, risks of bias and misinterpretation, and difficulties in identifying causal relationships further add to the challenges organizations face.

To overcome these limitations, organizations should complement diagnostic analytics with other analytical approaches. By doing so, they can achieve a comprehensive understanding of their data and drive future success. It is crucial to address these challenges and ensure that diagnostic analytics is supplemented with predictive and prescriptive analytics, enabling organizations to anticipate future events and make proactive decisions. Furthermore,

organizations must address data quality issues, enhance data privacy and security measures, and implement measures to mitigate bias and misinterpretation risks.

Despite these challenges, diagnostic analytics finds widespread applications across various domains, including business intelligence, healthcare, finance, marketing, manufacturing, and logistics. It empowers organizations to extract valuable insights from historical data, optimize operations, and make informed, data-driven decisions. By harnessing the benefits of diagnostic analytics and addressing its challenges, organizations can unlock the full potential of their data, drive performance improvements, and remain competitive in today's data-driven landscape.

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