SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 196

RISK MITIGATION – THE BUSINESS ANALYTICS USAGE IN INDUSTRY 4.0 CONDITIONS

Radosław WOLNIAK

Silesian University of Technology, Organization and Management Department, Economics and Informatics Institute; rwolniak@polsl.pl, ORCID: 0000-0003-0317-9811

Purpose: The purpose of this publication is to present the applications of usage of business analytics in risk mitigation.
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 incorporation of business analytics into risk mitigation strategies amid the landscape of Industry 4.0 signifies a pivotal paradigm shift in response to the multifaceted challenges posed by technological disruptions, supply chain vulnerabilities, regulatory changes, and cybersecurity threats. As industries undergo unprecedented digital transformations, traditional risk management approaches are rendered obsolete, prompting the integration of more data-driven and analytical methodologies. Business analytics plays a crucial role in this transformative shift, leveraging vast volumes of data generated in Industry 4.0 environments. Through advanced analytics techniques, organizations can proactively anticipate and respond to potential risks in real-time, with predictive analytics enabling the forecast of disruptions and the implementation of preemptive measures. Beyond immediate operational concerns, the applications of business analytics extend to supply chain optimization, cybersecurity monitoring, and regulatory compliance. The symbiotic relationship between business analytics and risk mitigation emerges as a cornerstone for sustainable and resilient business practices in the evolving landscape of Industry 4.0, emphasizing the necessity of addressing associated challenges and leveraging a diverse array of software applications for comprehensive risk management.
Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of business analytics in the case of risk mitigation.
Keywords: business analytics, Industry 4.0, digitalization, artificial intelligence, real-time monitoring; risk mitigation.
Category of the paper: literature review.

1. Introduction

Risk mitigation in the context of Industry 4.0 is a multifaceted challenge, encompassing a wide array of factors such as technological disruptions, supply chain vulnerabilities, regulatory changes, and cybersecurity threats. As industries undergo unprecedented digital transformations, the traditional risk management approaches are rendered obsolete, necessitating a paradigm shift towards more data-driven and analytical methodologies.

Business analytics plays a pivotal role in this shift by harnessing the vast volumes of data generated in Industry 4.0 environments. Through advanced analytics techniques, businesses can gain valuable insights into their operations, enabling them to anticipate and respond to potential risks in real-time. Predictive analytics, for instance, empowers organizations to forecast potential disruptions, enabling proactive measures to be implemented before issues escalate (Zeng et al., 2022; Pech, Vrchota, 2022).

The purpose of this publication is to present the applications of usage of business analytics in risk mitigation.

2. The selected aspects of business analytics usage in risk mitigation

The integration of business analytics in risk mitigation extends beyond the immediate operational realm. It extends to supply chain management, where analytics can be applied to assess and optimize the entire supply chain ecosystem (Akundi et al., 2022). Real-time monitoring of suppliers, demand forecasting, and inventory management are just a few areas where analytics can enhance visibility and resilience, reducing the impact of disruptions (Ghibakholl et al., 2022).

In the realm of cybersecurity, another critical facet of risk management, business analytics proves instrumental in identifying and mitigating potential threats. By analyzing patterns and anomalies in network data, businesses can detect cybersecurity breaches at an early stage, preventing significant data breaches and financial losses. This proactive approach to cybersecurity aligns with the agile nature of Industry 4.0, where the speed of response is paramount (Bakir, Dahlan, 2022).

Furthermore, regulatory compliance is a perennial concern for businesses, and Industry 4.0 brings forth a host of new regulations and standards (Jonek-Kowalska, Wolniak, 2021). Business analytics, with its ability to interpret and analyze regulatory requirements, facilitates adherence to compliance standards, mitigating legal and reputational risks (Scappini, 2016).

The incorporation of business analytics in the risk mitigation strategies of businesses operating in Industry 4.0 conditions is not just a choice but a necessity. The ability to harness the power of data for predictive and prescriptive insights empowers organizations to navigate the complexities of the modern industrial landscape (Gajdzik, Wolniak, 2022; Gajdzik et al., 2023). As Industry 4.0 continues to evolve, the symbiotic relationship between business analytics and risk mitigation will undoubtedly be a cornerstone for sustainable and resilient business practices (Cillo et al., 2022).

Table 1 contains descriptions of how business analytics is used in the case risk mitigation.

Table 1.
The usage of business analytics in risk mitigation

Application	Description
Predictive Analytics	Utilizes historical data and statistical algorithms to forecast potential risks and disruptions, enabling proactive mitigation measures.
Supply Chain Optimization	Applies analytics to enhance visibility and efficiency in supply chain management, reducing vulnerabilities and improving responsiveness to disruptions.
Cybersecurity Monitoring	Leverages data analytics to monitor network activities, detect anomalies, and identify potential cybersecurity threats, enabling early intervention and prevention.
Regulatory Compliance	Utilizes analytics to interpret and analyze regulatory requirements, ensuring businesses adhere to compliance standards and mitigate legal and reputational risks.
Operational Risk Analysis	Analyzes operational data to identify and assess risks associated with internal processes, systems, and human factors, allowing organizations to implement targeted risk mitigation strategies.
Customer Behavior Analysis	Examines customer data to identify patterns and trends that may pose risks to customer satisfaction or loyalty, enabling businesses to proactively address issues and enhance customer relationships.
Financial Risk Management	Applies analytics to assess financial data and market trends, helping organizations identify and manage financial risks such as market fluctuations, credit risks, and liquidity challenges.
Strategic Decision Support	Provides insights for strategic decision-making by analyzing various data sources, helping businesses make informed choices that align with their risk tolerance and long-term objectives.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020; Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

3. Software used in risk mitigation in Industry 4.0 conditions

In the contemporary business landscape, the integration of business analytics software has become instrumental in addressing the complexities of risk mitigation. Businesses, operating in an environment characterized by rapid technological advancements and dynamic market conditions, are increasingly turning to sophisticated analytics tools to fortify their risk management strategies. Among the array of business analytics software available, IBM Watson Analytics stands out, providing organizations with a comprehensive platform for exploring and

analyzing data to identify and mitigate risks. Its features encompass predictive modeling, data visualization, and cognitive capabilities, enabling a proactive approach to risk management.

SAS Enterprise Miner is another powerful tool specifically designed for data mining and predictive modeling. By leveraging this software, businesses can identify patterns and trends that may pose risks in various operational domains. Automated modeling, data mining, and statistical analysis are key features that contribute to effective risk mitigation strategies. Tableau, renowned for its robust data visualization capabilities, empowers organizations to gain insights into potential risks through interactive and intuitive dashboards. Its user-friendly interface facilitates quick and efficient analysis, fostering a deeper understanding of risk factors (Adel, 2022).

Microsoft Power BI, a business analytics tool by Microsoft, is widely adopted for risk management purposes. Offering interactive reports and dashboards, Power BI allows organizations to visualize and analyze data, supporting informed decision-making in risk mitigation strategies. Oracle Analytics Cloud, a cloud-based platform by Oracle, provides advanced analytics and machine learning tools for risk mitigation. With self-service analytics and collaboration features, it enables organizations to proactively address potential risks in their operations (Nourani, 2021).

SAP BusinessObjects is another comprehensive suite of business intelligence tools that includes capabilities for risk management. Businesses utilize this software for risk reporting, predictive analytics, and dashboards, contributing to a holistic approach to risk mitigation. Qlik Sense, with its associative data modeling and visualization capabilities, supports organizations in exploring data relationships and making informed decisions. Its interactive visualizations and real-time data exploration features contribute to a dynamic risk analysis process.

Palantir Gotham, designed for data integration and analysis, is particularly valuable for organizations dealing with complex and interconnected data sources. Its capabilities in link analysis, visualization, and collaboration contribute to effective risk mitigation in intricate operational landscapes. Alteryx, as a data blending and analytics platform, empowers users to prepare, blend, and analyze data from various sources. With features such as predictive analytics and workflow automation, Alteryx enhances the efficiency of risk mitigation.

The integration of business analytics software has become a cornerstone in modern risk mitigation strategies. These tools offer diverse features, from data exploration and visualization to predictive modeling and machine learning, providing organizations with the means to proactively identify, assess, and address potential risks in their operational environments (Du et al., 2023; Fjellström, Osarenkhoe, 2023; Castro et al., 2014; Wang et al., 2023).

Table 2 highlighting examples of software and applications used in risk mitigation, along with descriptions of their usage.

Table 2.
The usage of business analytics software in risk mitigation

Software/Application	Description	Key Features
IBM Watson Analytics	Empowers businesses to explore and analyze data for risk identification and mitigation. Provides predictive analytics, data visualization, and cognitive capabilities.	Predictive modeling, data visualization, natural language processing, machine learning algorithms.
SAS Enterprise Miner	A comprehensive tool for data mining and predictive modeling, SAS Enterprise Miner aids in identifying patterns and trends for risk mitigation in various business domains.	Data mining, predictive modeling, machine learning, automated modeling, statistical analysis.
Tableau	Known for its powerful data visualization capabilities, Tableau enables businesses to gain insights into potential risks through interactive and intuitive dashboards.	Interactive dashboards, real-time data connectivity, drag-and-drop analytics, collaborative features.
Microsoft Power BI	A business analytics tool by Microsoft, Power BI allows organizations to visualize and analyze data for risk management. It offers interactive reports and dashboards.	Data visualization, interactive dashboards, self-service analytics, integration with Microsoft products.
Oracle Analytics Cloud	Oracle's cloud-based analytics platform facilitates risk mitigation by providing tools for data visualization, advanced analytics, and machine learning.	Self-service analytics, machine learning algorithms, data preparation, collaboration tools.
SAP BusinessObjects	SAP's suite of business intelligence tools includes risk management capabilities, allowing organizations to analyze and monitor risks in their business operations.	Risk reporting, dashboards, predictive analytics, integration with SAP applications.
Qlik Sense	Qlik Sense offers associative data modeling and visualization for risk analysis. It enables users to explore data relationships and make informed decisions.	Associative data modeling, interactive visualizations, data storytelling, real-time data exploration.
Palantir Gotham	Designed for data integration and analysis, Palantir Gotham is used for risk mitigation by organizations dealing with complex and interconnected data sources.	Data integration, link analysis, visualization, collaboration tools, scalable architecture.
Alteryx	Alteryx is a data blending and analytics platform that facilitates risk mitigation by enabling users to prepare, blend, and analyze data from various sources.	Data blending, predictive analytics, spatial analytics, workflow automation, data preparation.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020; Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

4. Advantages and problems of business analytics usage in risk mitigation

The incorporation of business analytics offers a multitude of advantages, reshaping the traditional approaches to risk management. One key advantage lies in the ability of analytics to enable organizations to adopt a proactive stance in identifying potential risks. By delving into historical data, patterns, and trends, businesses can anticipate and recognize emerging risks before they materialize, allowing for the implementation of timely and targeted mitigation strategies (Greasley, 2019).

Real-time monitoring and response form another critical advantage of leveraging business analytics in risk mitigation. Through the continuous analysis of data streams, organizations gain the capacity to respond swiftly to evolving risks, addressing them in their nascent stages and preventing potential escalation. This real-time responsiveness is pivotal in an environment where the landscape can change rapidly. Moreover, the data-driven nature of business analytics transforms decision-making processes. By providing decision-makers with insights derived from comprehensive data analysis, analytics facilitates informed and strategic decision-making aligned with an organization's risk tolerance and overarching objectives. This shift towards data-driven decision-making enhances the overall resilience and adaptability of the organization.

Enhanced visibility and transparency are inherent benefits of employing analytics tools in risk mitigation. These tools provide intuitive data visualizations, offering stakeholders a clearer understanding of various facets of the business. This heightened visibility promotes transparency within the organization, ensuring that potential risks are not only identified but also well-understood by key stakeholders. In the realm of supply chain management, analytics plays a pivotal role in improving resilience. Organizations can optimize their supply chains by identifying vulnerabilities and disruptions in real time. This optimization not only reduces the impact of supply chain risks but also ensures a more agile and responsive approach to challenges that may arise (Nourani, 2021).

The application of predictive modeling through analytics is particularly valuable for risk forecasting. By leveraging predictive analytics models, organizations can forecast future risks based on historical data, allowing for the formulation of proactive measures and the development of effective risk mitigation strategies. On the cybersecurity front, business analytics contributes to threat detection. Through the continuous monitoring of network activities and the identification of anomalies, analytics tools bolster cybersecurity measures, creating a more secure and resilient business environment in the face of evolving digital threats.

Furthermore, analytics supports organizations in navigating the complex landscape of regulatory compliance. By interpreting and analyzing regulatory requirements, businesses can ensure adherence to compliance standards, mitigating legal and reputational risks associated with non-compliance (Charles et al., 2023).

Lastly, the cost-effective allocation of resources is facilitated by the insights derived from data analysis. Organizations can prioritize resource allocation based on areas with higher risk, optimizing budget allocation for risk mitigation strategies and ensuring a more efficient use of available resources. In essence, the advantages of incorporating business analytics in risk mitigation extend beyond mere risk identification, fostering a holistic and adaptive risk management approach.

Table 3 contains the advantages of using business analytics in risk mitigation within Industry 4.0 conditions, along with descriptions for each advantage.

Table 3.
The advantages of using business analytics in risk mitigation

Advantage	Description
Proactive Risk Identification	Business analytics enables organizations to proactively identify potential risks by analyzing historical data, patterns, and trends, allowing for timely and targeted risk mitigation strategies.
Real-time Monitoring and Response	The use of analytics facilitates real-time monitoring of data, allowing organizations to respond swiftly to emerging risks and mitigate their impact before they escalate.
Data-driven Decision Making	Analytics empowers decision-makers with data-driven insights, enabling informed and strategic decisions that align with an organization's risk tolerance and long-term objectives.
Enhanced Visibility and Transparency	By providing comprehensive data visualization, analytics tools enhance visibility into various aspects of the business, promoting transparency and a clearer understanding of potential risks.
Improved Supply Chain Resilience	Businesses can optimize supply chain management through analytics, identifying vulnerabilities and disruptions in real time, thereby enhancing resilience and reducing supply chain risks.
Predictive Modeling for Risk Forecasting	Predictive analytics models enable organizations to forecast future risks based on historical data, allowing for proactive measures and the development of effective risk mitigation strategies.
Cybersecurity Threat Detection	Business analytics aids in monitoring network activities, identifying anomalies, and detecting potential cybersecurity threats, contributing to a more secure and resilient business environment.
Compliance Management and Regulatory Adherence	Analytics tools assist in interpreting and analyzing regulatory requirements, ensuring organizations adhere to compliance standards and mitigate legal and reputational risks.
Cost-effective Resource Allocation	Through the analysis of data, organizations can allocate resources more effectively, focusing on areas with higher risk and optimizing budget allocation for risk mitigation strategies.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020; Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

Table 4 contains the problems of using business analytics in risk mitigation within Industry 4.0 conditions, along with descriptions for each advantage. These problems underscore the importance of addressing data quality, integration, skill development, and change management to successfully harness the benefits of business analytics in global supply chain coordination.

Table 4.

The problems of using business analytics in risk mitigation

Problem	Description
Data Quality Issues	Businesses may encounter challenges related to the quality of data used in analytics, including inaccuracies, incomplete information, and inconsistencies, leading to unreliable risk assessments.
Lack of Skilled Personnel	The effective use of business analytics demands a skilled workforce with expertise in data analysis, statistics, and domain knowledge. A shortage of such personnel can hinder successful implementation.
Integration Challenges	Integrating analytics tools with existing systems and processes can pose challenges, resulting in compatibility issues and disruptions that may impede the seamless flow of information for risk mitigation.
Overemphasis on Historical Data	Relying solely on historical data for risk mitigation may overlook emerging or unprecedented risks, as analytics models might not account for novel situations that deviate from past patterns.

Cont. table 2.

Inadequate Understanding of Analytics	Organizations may face issues if there is a lack of understanding about how to interpret and utilize analytics insights for risk mitigation, leading to suboptimal decision-making and risk management strategies.
Cost and Budget Constraints	The implementation and maintenance of robust analytics solutions require significant financial investments. Budget constraints may limit access to advanced analytics tools, hindering effective risk mitigation.
Ethical and Privacy Concerns	The use of business analytics raises ethical concerns related to data privacy and consent. Mishandling sensitive information may lead to legal repercussions, damaging an organization's reputation.
Lack of Real-time Analytics Capabilities	Delayed or lagging analytics processes can be problematic in fast-paced environments, where real-time insights are crucial for identifying and responding to emerging risks promptly.
Unforeseen Technical Challenges	Technical issues, such as software glitches, server downtimes, or data breaches, may disrupt the functionality of analytics systems, potentially compromising the effectiveness of risk mitigation efforts.

Source: (Adel, 2022; Akundi et al., 2022; Olsen, 2023; Aslam et al., 2020; Bakir, Dahlan, 2022; Cillo et al., 2022; Ghibakholl et al., 2022, Javaid, Haleem, 2020; Javaid et al., 2020; Cam et al., 2021; Charles et al., 2023; Greasley, 2019; Hurwitz et al., 2015; Nourani, 2021; Peter et al., 2023).

5. Conclusion

The adoption of business analytics in the realm of risk mitigation within the context of Industry 4.0 represents a crucial paradigm shift in response to the multifaceted challenges posed by technological disruptions, supply chain vulnerabilities, regulatory changes, and cybersecurity threats. As industries undergo unprecedented digital transformations, traditional risk management approaches become obsolete, necessitating the integration of more data-driven and analytical methodologies. The pivotal role played by business analytics in this transformative shift is evident in its ability to harness the vast volumes of data generated in Industry 4.0 environments. Through advanced analytics techniques, businesses gain valuable insights that enable them to anticipate and respond to potential risks in real-time. Predictive analytics, for instance, empowers organizations to forecast disruptions, allowing for proactive measures to be implemented before issues escalate.

The applications of business analytics in risk mitigation extend beyond immediate operational concerns. In supply chain management, analytics is applied to assess and optimize the entire supply chain ecosystem, enhancing visibility and resilience. In cybersecurity, analytics proves instrumental in identifying and mitigating potential threats by analyzing patterns and anomalies in network data. Additionally, analytics aids in regulatory compliance by interpreting and analyzing regulatory requirements, mitigating legal and reputational risks.

The publication further emphasizes the necessity of incorporating business analytics into the risk mitigation strategies of businesses operating in Industry 4.0 conditions. The ability to harness the power of data for predictive and prescriptive insights empowers organizations to navigate the complexities of the modern industrial landscape. The symbiotic relationship

between business analytics and risk mitigation emerges as a cornerstone for sustainable and resilient business practices in the evolving landscape of Industry 4.0.

The advantages of using business analytics in risk mitigation are highlighted, encompassing proactive risk identification, real-time monitoring and response, data-driven decision-making, enhanced visibility and transparency, improved supply chain resilience, predictive modeling for risk forecasting, cybersecurity threat detection, compliance management, and cost-effective resource allocation. However, it is essential to acknowledge the challenges and problems associated with the utilization of business analytics in risk mitigation. These include data quality issues, a lack of skilled personnel, integration challenges, overemphasis on historical data, inadequate understanding of analytics, cost and budget constraints, ethical and privacy concerns, lack of real-time analytics capabilities, and unforeseen technical challenges. Addressing these challenges is crucial to realizing the full potential of business analytics in effective risk mitigation.

In the realm of software applications, a diverse array of tools, such as IBM Watson Analytics, SAS Enterprise Miner, Tableau, Microsoft Power BI, Oracle Analytics Cloud, SAP BusinessObjects, Qlik Sense, Palantir Gotham, and Alteryx, is presented as integral components of risk mitigation strategies in Industry 4.0 conditions. These tools offer features ranging from predictive modeling and data visualization to machine learning and workflow automation, providing organizations with the means to proactively identify, assess, and address potential risks.

The integration of business analytics in risk mitigation strategies, accompanied by the utilization of advanced software applications, emerges as a necessity for organizations navigating the challenges of Industry 4.0. The advantages in terms of proactive risk management, real-time responsiveness, and informed decision-making are considerable. However, the associated challenges underline the importance of addressing data quality, skill development, integration, and ethical considerations to ensure the successful implementation and sustained effectiveness of business analytics in risk mitigation.

References

1. Adel, A. (2022). Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas. *Journal of Cloud Computing, 11(1),* 40.
2. Akundi, A., Euresti, D., Luna, S., Ankobiah, W., Lopes, A., Edinbarough, I. (2022). State of Industry 5.0-Analysis and Identification of Current Research Trends. *Applied System Innovation, 5(1),* DOI: 10.3390/asi5010027.

3. Aslam, F., Wang, A.M., Li, M.Z., Rehman, K.U. (2020). Innovation in the Era of IoT and Industry 5.0: Absolute Innovation Management (AIM) Framework. *Information, 11(2),* doi:10.3390/info11020124
4. Bakir, A., Dahlan, M. (2022). Higher education leadership and curricular design in industry 5.0 environment: a cursory glance. *Development and Learning in Organizations*.
5. Cam, J.D. Cochran, J.J., Ohlmann, M.J.F. (2021). *Business analytics: descriptive, predictive, prescriptive.* Boston: Cengage.
6. Charles, V., Garg, P., Gupta, N., Agrawal, M. (2023). *Data Analytics and Business Intelligence: Computational Frameworks, Practices, and Applications*. New York: CRS Press.
7. Cillo, V., Gregori, G.L., Daniele, L.M., Caputo, F., Bitbol-Saba, N. (2022). Rethinking companies' culture through knowledge management lens during Industry 5.0 transition. *Journal of Knowledge Management, 26(10),* 2485-2498.
8. Dameri, R.P. (2016). Smart City and ICT. Shaping Urban Space for Better Quality of Life. In: *Information and Communication Technologies in Organizations and Society*. Cham, Switzerland: Springer International Publishing.
9. Di Marino, C., Rega, A., Vitolo, F., Patalano, S. (2023). Enhancing Human-Robot Collaboration in the Industry 5.0 Context: Workplace Layout Prototyping. *Lecture Notes in Mechanical Engineering*, 454-465.
10. Dutta, J., Roy, S., Chowdhury, C. (2019). Unified framework for IoT and smartphone based different smart city related applications. *Microsystem Technologies, 25(1),* 83-96.
11. Gajdzik, B., Wolniak, R. (2021a). Digitalisation and innovation in the steel industry in Poland - selected tools of ICT in an analysis of statistical data and a case study. *Energies, 14(11),* 1-25.
12. Gajdzik, B., Wolniak, R. (2021b). Influence of the COVID-19 crisis on steel production in Poland compared to the financial crisis of 2009 and to boom periods in the market. *Resources, 10(1),* 1-17.
13. Gajdzik, B., Wolniak, R. (2021c). Transitioning of steel producers to the steelworks 4.0 - literature review with case studies. *Energies, 14(14),* 1-22.
14. Gajdzik, B., Wolniak, R. (2022). Smart Production Workers in Terms of Creativity and Innovation: The Implication for Open Innovation. *Journal of Open Innovations: Technology, Market and Complexity, 8(1),* 68.
15. Gajdzik, B., Wolniak, R. (2022a). Framework for R&D&I Activities in the Steel Industry in Popularizing the Idea of Industry 4.0. *Journal of Open Innovation: Technology, Market, and Complexity, 8(3),* 133.
16. Gajdzik, B., Wolniak, R. (2022b). Influence of Industry 4.0 Projects on Business Operations: literature and empirical pilot studies based on case studies in Poland. *Journal of Open Innovation: Technology, Market, and Complexity, 8(1),* 1-20.

17. Gajdzik, B., Wolniak, R. (2022c). Smart Production Workers in Terms of Creativity and Innovation: The Implication for Open Innovation. *Journal of Open Innovations: Technology, Market and Complexity, 8(1),* 68.
18. Gajdzik, B., Wolniak, R., Grebski, W. (2023a). Process of Transformation to Net Zero Steelmaking: Decarbonisation Scenarios Based on the Analysis of the Polish Steel Industry. *Energies, 16(8), 3384*, https://doi.org/10.3390/en16083384.
19. Gajdzik, B., Wolniak, R., Grebski, W. (2023b). Electricity and heat demand in steel industry technological processes in Industry 4.0 conditions. *Energies*, *16(2),* 1-29.
20. Gajdzik, B., Wolniak, R., Grebski, W.(2022). An econometric model of the operation of the steel industry in Poland in the context of process heat and energy consumption. *Energies, 15(21),* 1-26, 7909.
21. Gajdzik, B., Wolniak, R., Nagaj, R., Grebski, W., Romanyshyn, T. (2023). Barriers to Renewable Energy Source (RES) Installations as Determinants of Energy Consumption in EU Countries. *Energies, 16(21),* 7364.
22. Gajdzik, B., Wolniak, R., Nagaj, R., Grebski, W., Romanyshyn, T. (2023). Barriers to Renewable Energy Source (RES) Installations as Determinants of Energy Consumption in EU Countries. *Energies, 16(21),* 7364.
23. Gębczyńska, A., Wolniak, R. (2018). *Process management level in local government.* Philadelphia: CreativeSpace.
24. Ghibakholl, M., Iranmanesh, M., Mubarak, M.F., Mubarik, M., Rejeb, A., Nilashi, M. (2022). Identifying industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values. *Sustainable Production and Consumption*, *33,* 716-737.
25. Grabowska, S., Saniuk, S., Gajdzik, B. (2022). Industry 5.0: improving humanization and sustainability of Industry 4.0. *Scientometrics, 127(6)*, 3117-3144, https://doi.org/10.1007/s11192-022-04370-1.
26. Grabowska, S., Grebski, M., Grebski, W., Saniuk, S., Wolniak, R. (2021). *Inżynier w gospodarce 4.0.* Toruń: Towarzystwo Naukowe Organizacji i Kierownictwa – Stowarzyszenie Wyższej Użyteczności "Dom Organizatora".
27. Grabowska, S., Grebski, M., Grebski, W., Wolniak, R. (2019). *Introduction to engineering concepts from a creativity and innovativeness perspective.* New York: KDP Publishing.
28. Grabowska, S., Grebski, M., Grebski, W., Wolniak, R. (2020). *Inżynier – zawód przyszłości. Umiejętności i kompetencje inżynierskie w erze Przemysłu 4.0.* Warszawa: CeDeWu.
29. Greasley, A. (2019). *Simulating Business Processes for Descriptive, Predictive, and Prescriptive Analytics.* Boston: deGruyter.
30. Hąbek, P., Wolniak, R. (2013). Analysis of approaches to CSR reporting in selected European Union countries. *International Journal of Economics and Research*, *4(6)*, 79-95.

31. Hąbek, P., Wolniak, R. (2016). Assessing the quality of corporate social responsibility reports: the case of reporting practices in selected European Union member states. *Quality & Quantity, 50(1),* 339-420.
32. Hąbek, P., Wolniak, R. (2016). Factors influencing the development of CSR reporting practices: experts' versus preparers' points of view. *Engineering Economy, 26(5),* 560-570.
33. Hąbek, P., Wolniak, R. (2016). Relationship between management practices and quality of CSR reports. *Procedia – Social and Behavioral Sciences, 220,* 115-123.
34. Herdiansyah, H. (2023). Smart city based on community empowerment, social capital, and public trust in urban areas. *Glob. J. Environ. Sci. Manag., 9,* 113-128.
35. Hurwitz, J., Kaufman, M., Bowles, A. (2015). *Cognitive Computing and Big Data Analytics.* New York: Wiley.
36. Hys, K., Wolniak, R. (2018). Praktyki przedsiębiorstw przemysłu chemicznego w Polsce w zakresie CSR. *Przemysł Chemiczny, 9,* 1000-1002.
37. Javaid, M., Haleem, A. (2020). Critical Components of Industry 5.0 Towards a Successful Adoption in the Field of Manufacturing, *Journal of Industrial Integration and Management-Innovation and Entrepreneurship, 5(2),* 327-348, doi: 10.1142/S2424862220500141.
38. Javaid, M., Haleem, A., Singh, R.P., Haq, M.I.U., Raina, A., Suman, R. (2020). Industry 5.0: Potential Applications in COVID-19. *Journal of Industrial Integration and Management-Innovation and Entrepreneurship, 5(4),* 507-530, doi: 10.1142/S2424862220500220.
39. Jonek-Kowalska, I., Wolniak, R. (2021a). Economic opportunities for creating smart cities in Poland. Does wealth matter? *Cities, 114,* 1-6.
40. Jonek-Kowalska, I., Wolniak, R. (2021b). The influence of local economic conditions on start-ups and local open innovation system. *Journal of Open Innovations: Technology, Market and Complexity, 7(2),* 1-19.
41. Jonek-Kowalska, I., Wolniak, R. (2022). Sharing economies' initiatives in municipal authorities' perspective: research evidence from Poland in the context of smart cities' development. *Sustainability, 14(4),* 1-23.
42. Jonek-Kowalska, I., Wolniak, R. (2023). *Towards sustainability and a better quality of life?* London: Routledge.
43. Kordel, P., Wolniak, R. (2021). Technology entrepreneurship and the performance of enterprises in the conditions of Covid-19 pandemic: the fuzzy set analysis of waste to energy enterprises in Poland. *Energies, 14(13),* 1-22.
44. Kwiotkowska, A., Gajdzik, B., Wolniak, R., Vveinhardt, J., Gębczyńska, M. (2021). Leadership competencies in making Industry 4.0 effective: the case of Polish heat and power industry. *Energies, 14(14),* 1-22.

45. Kwiotkowska, A., Wolniak, R., Gajdzik, B., Gębczyńska, M. (2022). Configurational paths of leadership competency shortages and 4.0 leadership effectiveness: an fs/QCA study. *Sustainability, 14(5),* 1-21.
46. Michalak, A., Wolniak, R. (2023). The innovativeness of the country and the renewables and non-renewables in the energy mix on the example of European Union. *Journal of Open Innovation: Technology, Market, and Complexity, 9(2),* https://doi.org/10.1016/j.joitmc. 2023.100061.
47. Nourani, C.F. (2021). *Artificial Intelligence and Computing Logic: Cognitive Technology for AI Business Analytics (Innovation Management and Computing).* New York: CRC Press.
48. Olkiewicz, M., Olkiewicz, A., Wolniak, R., Wyszomirski, A. (2021). Effects of pro-ecological investments on an example of the heating industry - case study. *Energies, 14(18),* 1-24, 5959.
49. Olsen, C. (2023). Toward a Digital Sustainability Reporting Framework in Organizations in the Industry 5.0 Era: An Accounting Perspective. *Lecture Notes in Networks and Systems, 557,* 463-473.
50. Orzeł, B., Wolniak, R. (2021). Clusters of elements for quality assurance of health worker protection measures in times of COVID-19 pandemic. *Administrative Science, 11(2),* 1-14, 46.
51. Orzeł, B., Wolniak, R. (2022). Digitization in the design and construction industry - remote work in the context of sustainability: a study from Poland. *Sustainability, 14(3),* 1-25.
52. Peter, G.S., Amit, C.B., Deokar, V., Patel, N.R. (2023). *Machine Learning for Business Analytics: Concepts, Techniques and Applications in RapidMiner.* New York: Wiley.
53. Ponomarenko, T.V., Wolniak, R., Marinina, O.A. (2016). Corporate Social responsibility in coal industry (Practices of russian and european companies). *Journal of Mining Institute, 222,* 882-891.
54. Rosak-Szyrocka, J., Żywiołek J., Wolniak, R. (2023). Main reasons for religious tourism - from a quantitative analysis to a model. *International Journal for Quality Research, 1(17),* 109-120.
55. Scappini, A. (2016). *80 Fundamental Models for Business Analysts: Descriptive, Predictive, and Prescriptive Analytics Models with Ready-to-Use Excel Templates.* New York: Create Space.
56. Stawiarska, E., Szwajca, D., Matusek, M., Wolniak, R. (2020). *Wdrażanie rozwiązań przemysłu 4.0 w wybranych funkcjonalnych obszarach zarządzania przedsiębiorstw branży motoryzacyjnej: próba diagnozy.* Warszawa: CeDeWu.
57. Stawiarska, E., Szwajca, D., Matusek, M., Wolniak, R. (2021). Diagnosis of the maturity level of implementing Industry 4.0 solutions in selected functional areas of management of automotive companies in Poland. *Sustainability, 13(9),* 1-38.

58. Steculа, K., Wolniak, R. (2022). Advantages and Disadvantages of E-Learning Innovations during COVID-19 Pandemic in Higher Education in Poland. *Journal of Open Innovation: Technology, Market, and Complexity*, *8(3),* 159.
59. Steculа, K., Wolniak, R. (2022). Influence of COVID-19 Pandemic on Dissemination of Innovative E-Learning Tools in Higher Education in Poland. *Journal of Open Innovations: Technology, Market and Complexity*, *8(1),* 89.
60. Wolniak, R, Skotnicka-Zasadzień, B. (2014). The use of value stream mapping to introduction of organizational innovation in industry. *Metalurgija*, *53(4),* 709-713.
61. Wolniak, R. (2011). *Parametryzacja kryteriów oceny poziomu dojrzałości systemu zarządzania jakością.* Gliwice: Wydawnictwo Politechniki Śląskiej.
62. Wolniak, R. (2013). Projakościowa typologia kultur organizacyjnych. *Przegląd Organizacji*, *3,* 13-17.
63. Wolniak, R. (2014). Korzyści doskonalenia systemów zarządzania jakością opartych o wymagania normy ISO 9001:2009. *Problemy Jakości*, *3,* 20-25.
64. Wolniak, R. (2016a). Kulturowe aspekty zarządzania jakością. *Etyka biznesu i zrównoważony rozwój. Interdyscyplinarne studia teoretyczno-empiryczne*, *1*, 109-122.
65. Wolniak, R. (2016b). *Metoda QFD w zarządzaniu jakością. Teoria i praktyka*. Gliwice: Wydawnictwo Politechniki Śląskiej.
66. Wolniak, R. (2016c). Relations between corporate social responsibility reporting and the concept of greenwashing. *Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacji i Zarządzanie, 87,* 443-453.
67. Wolniak, R. (2016d). The role of QFD method in creating innovation. *Systemy Wspomagania Inżynierii Produkcji, 3*, 127-134.
68. Wolniak, R. (2017a). Analiza relacji pomiędzy wskaźnikiem innowacyjności a nasyceniem kraju certyfikatami ISO 9001, ISO 14001 oraz ISO/TS 16949. *Kwartalnik Organizacja i Kierowanie*, *2,* 139-150.
69. Wolniak, R. (2017b). Analiza wskaźników nasycenia certyfikatami ISO 9001, ISO 14001 oraz ISO/TS 16949 oraz zależności pomiędzy nimi. *Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacji i Zarządzanie, 108*, 421-430.
70. Wolniak, R. (2017c). The Corporate Social Responsibility practices in mining sector in Spain and in Poland – similarities and differences. *Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacji i Zarządzanie*, *111*, 111-120.
71. Wolniak, R. (2017d). The Design Thinking method and its stages. *Systemy Wspomagania Inżynierii Produkcji, 6*, 247-255.
72. Wolniak, R. (2021). Performance evaluation in ISO 9001:2015. *Silesian University of Technology Scientific Papers. Organization and Management Series*, *151,* 725-734.
73. Wolniak, R. (2022a). Innovations in Industry 4.0 conditions. *Silesian University of Technology Scientific Papers. Organization and Management Series*, *169,* 725-741.

74. Wolniak, R. (2022b). Functioning of real-time analytics in business. *Silesian University of Technology Scientific Papers. Organization and Management Series*, *172,* 659-677.
75. Wolniak, R., Jonek-Kowalska, I. (2021a). The level of the quality of life in the city and its monitoring. *Innovation (Abingdon*), *34(3),* 376-398.
76. Wolniak, R., Jonek-Kowalska, I. (2021c). The quality of service to residents by public administration on the example of municipal offices in Poland. *Administration Management Public*, *37,* 132-150.
77. Wolniak, R., Jonek-Kowalska, I. (2022). The creative services sector in Polish cities. *Journal of Open Innovation: Technology, Market, and Complexity*, *8(1),* 1-23.
78. Wolniak, R., Saniuk, S., Grabowska, S., Gajdzik, B. (2020). Identification of energy efficiency trends in the context of the development of industry 4.0 using the Polish steel sector as an example. *Energies*, *13(11),* 1-16.
79. Wolniak, R., Skotnicka, B. (2011).: *Metody i narzędzia zarządzania jakością – Teoria i praktyka, cz. 1*. Gliwice: Wydawnictwo Naukowe Politechniki Śląskiej.
80. Wolniak, R., Skotnicka-Zasadzień, B. (2008). *Wybrane metody badania satysfakcji klienta i oceny dostawców w organizacjach.* Gliwice: Wydawnictwo Politechniki Śląskiej.
81. Wolniak, R., Skotnicka-Zasadzień, B. (2010). *Zarządzanie jakością dla inżynierów.* Gliwice: Wydawnictwo Politechniki Śląskiej.
82. Wolniak, R., Skotnicka-Zasadzień, B. (2018). Developing a model of factors influencing the quality of service for disabled customers in the condition s of sustainable development, illustrated by an example of the Silesian Voivodeship public administration. *Sustainability*, *7*, *1*-17.
83. Wolniak, R., Skotnicka-Zasadzień, B. (2022). Development of photovoltaic energy in EU countries as an alternative to fossil fuels. *Energies*, *15(2),* 1-23.
84. Wolniak, R., Skotnicka-Zasadzień, B. (2023). Development of Wind Energy in EU Countries as an Alternative Resource to Fossil Fuels in the Years 2016-2022. *Resources, 12(8),* 96.
85. Wolniak, R., Skotnicka-Zasadzień, B., Zasadzień, M. (2019). Problems of the functioning of e-administration in the Silesian region of Poland from the perspective of a person with disabilities. *Transylvanian Review of Public Administration*, *57E,* 137-155.
86. Wolniak, R., Sułkowski, M. (2015). Motywy wdrażanie certyfikowanych Systemów Zarządzania Jakością. *Problemy Jakości, 9,* 4-9.
87. Wolniak, R., Sułkowski, M. (2016). The reasons for the implementation of quality management systems in organizations. *Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacji i Zarządzanie*, *92,* 443-455.
88. Wolniak, R., Wyszomirski, A., Olkiewicz, M., Olkiewicz, A. (2021). Environmental corporate social responsibility activities in heating industry - case study. *Energies*, *14(7),* 1-19, 1930.