JITET (Jurnal Informatika dan Teknik Elektro Terapan)
Vol. 13 No. 2, pISSN: 2303-0577 eISSN: 2830-7062 http://dx.doi.org/10.23960/jitet.v13i2.6476

INFORMATION SYSTEMS EMPOWERED BY BIG DATA – A REVIEW OF APPLICATIONS IN SMES' RESILIENCE AND PERFORMANCE

Adi Dadan Ramdana[1*], Mia Sumiarsih[2], Awit Marwati Sakinah[3], Lisna Yulianti[4], Azis Mutholib[5]

[1,2,4,5]Management Program, Faculty of Economics and Business, Mayasari Bakti University
[3]Departemen Informatics Engineering, STMIK DCI

Received: 9 Maret 2025
Accepted: 29 Maret 2025
Published: 14 April 2025

Keywords:
Big Data Analytics; Business Performance; Business Resilience; SMEs; Strategic Decision-Making.

Corespondent Email:
adidadanr@gmail.com

Big Data Analytics (BDA) is increasingly helping Small and Medium-sized Enterprises (SMEs) improve resilience, efficiency, and decision-making. This Systematic Literature Review (SLR) explores the adoption of BDA in SMEs, highlighting its benefits, challenges, and key trends. Using the PRISMA framework, a structured search in Scopus identified 60 studies, with 42 meeting the inclusion criteria (2015–2025). The findings show that BDA supports SMEs in crisis management, supply chain optimization, and customer analytics, contributing to long-term business sustainability. However, several barriers limit its adoption, including high costs, technical complexity, and data security concerns. To understand its impact, this study applies Resource-Based View (RBV), Technology-Organization-Environment (TOE), and Dynamic Capabilities View (DCV) frameworks. To address adoption challenges, government support through financial incentives, improved digital infrastructure, and specialized training programs is recommended. SMEs should focus on cloud-based analytics, strategic collaborations, and building a data-driven culture to maximize BDA benefits. Although BDA has great potential, its adoption among SMEs remains uneven. Future research should explore its combination with Artificial Intelligence (AI) and Machine Learning (ML) to enhance competitiveness and drive innovation in a fast-changing business environment.

Abstrak. *Big Data Analytics (BDA) semakin berperan penting dalam membantu Small and Medium-sized Enterprises (SMEs) meningkatkan resiliensi, efisiensi operasional, dan pengambilan keputusan strategis. Studi ini merupakan Systematic Literature Review (SLR) yang mengeksplorasi adopsi BDA pada SMEs dengan menyoroti manfaat, tantangan, dan tren utama yang berkembang. Dengan menggunakan kerangka kerja PRISMA, pencarian sistematis pada basis data Scopus menghasilkan 60 studi, di mana 42 artikel memenuhi kriteria inklusi pada rentang tahun 2015–2025. Temuan menunjukkan bahwa BDA mendukung SMEs dalam manajemen krisis, optimalisasi rantai pasok, dan analitik pelanggan, yang secara keseluruhan berkontribusi terhadap keberlanjutan bisnis jangka panjang. Namun, adopsi BDA masih menghadapi sejumlah hambatan seperti biaya implementasi yang tinggi, kompleksitas teknis, dan kekhawatiran terhadap keamanan data. Untuk memahami dampaknya secara menyeluruh, studi ini mengadopsi kerangka teoritis Resource-Based View (RBV), Technology-Organization-Environment (TOE), dan Dynamic Capabilities View (DCV). Guna mengatasi tantangan adopsi, diperlukan dukungan pemerintah melalui insentif finansial, penguatan*

infrastruktur digital, dan program pelatihan khusus. Sementara itu, SMEs disarankan untuk fokus pada penggunaan cloud-based analytics, membangun kolaborasi strategis, serta membentuk budaya organisasi berbasis data. Meskipun BDA memiliki potensi besar, tingkat adopsinya di kalangan SMEs masih bervariasi. Penelitian selanjutnya sebaiknya mengeksplorasi integrasi BDA dengan Artificial Intelligence (AI) dan Machine Learning (ML) untuk meningkatkan daya saing dan mendorong inovasi dalam lingkungan bisnis yang terus berubah..

1. Introduction

Big Data Analytics (BDA) has emerged as a transformative force in the context of Small and Medium-sized Enterprises (SMEs), enabling these businesses to enhance their competitiveness in an increasingly data-centric market. Historically, the adoption of BDA was predominantly limited to large corporations due to the high costs and complexities associated with data management. However, advancements in technologies such as cloud computing, artificial intelligence, and machine learning have democratized access to BDA tools, empowering SMEs to leverage data-driven strategies to improve decision-making and operational efficiency [1], [2], [3]. The COVID-19 pandemic further underscored the critical need for BDA adoption, as SMEs faced unprecedented market volatility and uncertainty. Data-driven approaches became essential for navigating disruptions, managing resources efficiently, and maintaining business continuity during crises [4], [5].

Digital transformation has become a cornerstone for SMEs seeking to integrate BDA into their operations. Technological advancements, heightened market competition, and the growing demand for operational efficiency are driving this transformation. The integration of digital technologies allows SMEs to optimize processes, engage customers more effectively, and develop personalized experiences tailored to consumer preferences [6], [7]. The rapid expansion of e-commerce and digital marketing has further compelled SMEs to adopt BDA to analyze consumer behavior and refine their offerings. Organizational agility and strong leadership support play a pivotal role in fostering a culture of innovation and digital readiness, which are critical for successful BDA implementation [8], [9].

The impact of BDA on SME resilience and performance is profound. BDA equips SMEs with the ability to analyze vast datasets, enabling them to identify trends, forecast demand, and optimize supply chains. These capabilities are vital for maintaining competitiveness in dynamic markets [10], [11]. Additionally, BDA fosters innovation by providing actionable insights that inform product development and service enhancements, leading to improved financial performance and sustainability [6], [12], [13]. The effective utilization of BDA is mediated by organizational factors such as knowledge management practices and analytics culture, which enhance strategic decision-making and operational agility [14], [15].

Despite its potential, the adoption of BDA in SMEs is not without challenges. Existing research highlights gaps in understanding the specific mechanisms through which BDA influences SME performance and resilience. While many studies acknowledge the positive correlation between BDA and performance outcomes, the underlying processes and contextual factors that mediate these relationships remain underexplored [4], [13].

Furthermore, the distinction between resilience and performance in the context of BDA adoption lacks clarity. Resilience is often defined as the ability to adapt and recover from disruptions, whereas performance is typically associated with measurable outcomes such as profitability and growth [8]. However, the interplay between these constructs and the dual role of BDA in enhancing both resilience and performance are insufficiently addressed in the literature [5], [8].

Previous systematic literature reviews (SLR) on BDA in SMEs also exhibit notable limitations. Many reviews focus on broad trends without delving into the unique challenges SMEs face in adopting BDA

technologies [16], [17]. While some studies highlight technological barriers, they often overlook critical organizational and cultural factors that influence BDA adoption [11], [18]. Furthermore, existing reviews tend to offer static perspectives that do not adequately account for the evolving nature of BDA technologies and their practical applications within SMEs [17], [19]. Addressing these gaps is essential to developing a more nuanced understanding of how SMEs can effectively leverage BDA to enhance their operational capabilities and competitive advantage.

This study aims to address these research gaps by conducting a comprehensive SLR that synthesizes existing knowledge and identifies critical themes in the application of BDA in SMEs. By exploring how BDA contributes to resilience and performance, this review seeks to develop a cohesive framework that reflects the unique challenges and opportunities faced by SMEs in a data-driven economy. The findings of this SLR will not only advance academic discourse but also provide actionable insights for SMEs seeking to harness the potential of BDA for sustainable growth and innovation.

Moreover, this review will inform policymakers and industry stakeholders about the factors that facilitate or hinder BDA adoption in SMEs, guiding the development of targeted support mechanisms and best practices. By bridging the gap between theory and practice, this study contributes to the broader goal of empowering SMEs to thrive in an increasingly complex and competitive landscape.

2. Methods

Research Design

This study employs a SLR methodology to synthesize the current state of knowledge regarding the application of Big Data Analytics (BDA) in Small and Medium-sized Enterprises (SMEs). The SLR approach ensures methodological rigor, transparency, and reproducibility, aligning with established best practices and the PRISMA guidelines for systematic reviews. The PRISMA framework is central to the research design, providing a structured approach to identifying, screening, and selecting relevant studies. **Figure 1** illustrates the PRISMA flow diagram, detailing the step-by-step process of article identification, screening, eligibility assessment, and final inclusion. This design enables a comprehensive exploration of how BDA contributes to resilience and performance in SMEs while addressing gaps in the existing literature.

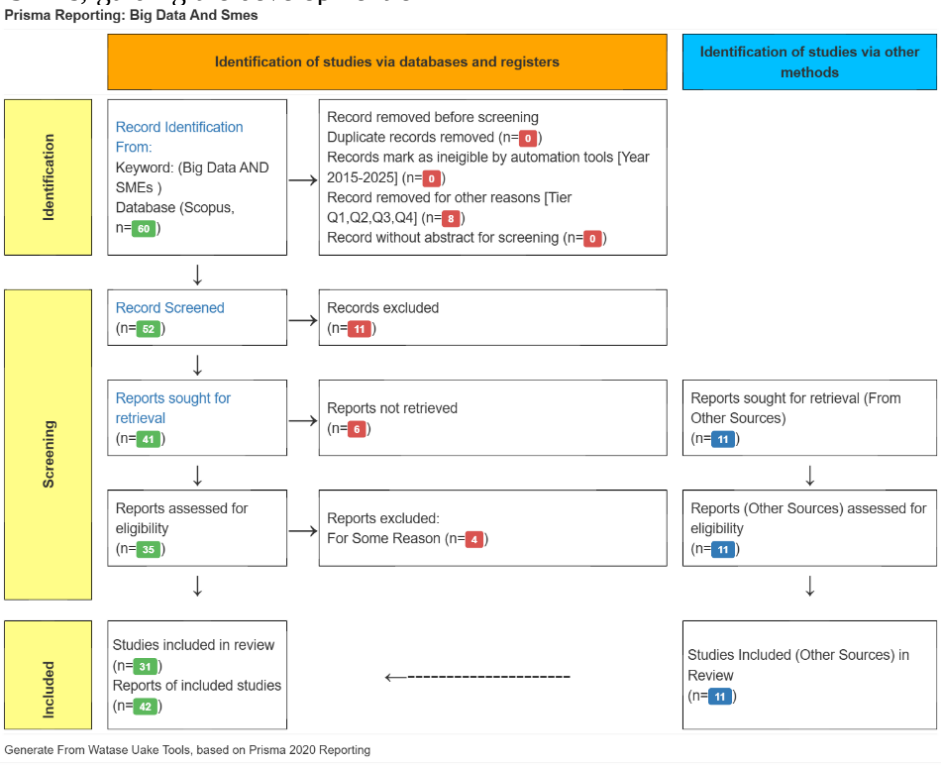

Figure. 1. PRISMA framework

Data Sources and Search Strategy

The literature search was conducted using the Scopus database, which is renowned for its extensive coverage of peer-reviewed articles across diverse disciplines. The primary query, "Big Data AND SMEs," was applied to titles, abstracts, and keywords to identify relevant studies. This search yielded 60 initial results, supplemented by 11 additional articles sourced through other methods, including citation tracking and manual searches. The search strategy was designed to ensure inclusivity while maintaining a focus on scholarly articles that directly address the role of BDA in enhancing SME capabilities. By utilizing Scopus as the primary database, the study captures a wide array of perspectives, encompassing technological, organizational, and environmental factors relevant to BDA adoption.

Inclusion and Exclusion Criteria

To ensure the relevance and quality of the included studies, strict inclusion and exclusion criteria were applied. Only articles published in scholarly journals between 2015 and 2025 were considered, reflecting the most recent advancements in BDA and its applications in SMEs. Studies were limited to those appearing in Scopus-indexed journals ranked Q1 to Q4, ensuring academic rigor and credibility. Open-access articles were prioritized to enhance the accessibility of findings. Exclusion criteria included studies outside the specified timeframe, those not published in scholarly journals, and articles lacking relevance to BDA or SME contexts. This rigorous filtering process ensured that the final selection represented high-quality research aligned with the study's objectives.

Screening and Selection

The screening and selection process utilized the Watase Uake Research Collaboration Tools, which streamlined the identification and assessment of relevant articles. Automation tools were employed to exclude records marked as ineligible based on the specified criteria, such as publication year or journal tier. From the initial 60 Scopus articles, eight were removed due to irrelevance or non-compliance with journal ranking requirements, leaving 52 articles for screening. Eleven articles sourced from other methods underwent the same rigorous assessment. After the screening process, 41 articles were retrieved for detailed evaluation, with six excluded due to retrieval issues and four deemed ineligible during the final eligibility assessment. Ultimately, 42 articles were included for detailed analysis, surpassing the minimum requirement of 40 studies for an SLR as outlined by Paul et al. [20]. This systematic approach ensured a robust dataset for subsequent analysis and synthesis.

Data Extraction and Categorization

The selected studies were analyzed and categorized based on their contributions to two primary themes: resilience and performance. Resilience-focused articles examined how BDA supports SMEs in adapting to disruptions, managing risks, and ensuring business continuity. For instance, studies highlighted the role of BDA in mitigating risks during crises such as the COVID-19 pandemic [4], enhancing adaptability to market changes [5], and supporting sustainability planning post-pandemic [13]. These articles provided insights into how BDA enables SMEs to anticipate challenges, reconfigure resources, and maintain operational stability.

Performance-focused articles explored how BDA improves operational efficiency, strategic decision-making, customer engagement, and innovation within SMEs. Examples include research on optimizing supply chain management [21], leveraging customer analytics for personalized experiences [7], and fostering innovation through data-driven insights [22]. By categorizing studies into these themes, the review identified patterns and gaps in how BDA drives SME growth and competitiveness.

The categorization process was guided by predefined criteria to ensure consistency and relevance. Each article was examined for its focus on resilience or performance, with additional attention to cross-cutting themes such as technological readiness, organizational culture, and external influences. This systematic approach provided a nuanced understanding of the diverse ways in which

BDA enhances SME capabilities, laying the groundwork for a comprehensive synthesis of findings.

3. Findings

The transformative potential of Big Data Analytics (BDA) has garnered significant attention in recent years, especially in the context of Small and Medium-sized Enterprises (SMEs). The review of the existing literature highlights three major themes that define the relationship between BDA and SMEs: resilience, performance, and geographical and sectoral trends. These themes collectively illustrate how SMEs utilize BDA to navigate uncertainties, optimize their operations, and innovate within their respective industries. This chapter synthesizes these key findings, using visual representations such as Figures 2 through 6 and Tables 1 through 8, to provide a comprehensive analysis of the current state of BDA research in SMEs. Each subsection delves into a specific theme, supported by evidence from the reviewed literature, figures, and tables.

Big Data and SMEs' Resilience

Big Data Analytics (BDA) is crucial for enhancing the resilience of SMEs, enabling them to effectively respond to uncertainties and disruptions. As demonstrated in **Figure 2**, the volume of publications focusing on BDA and SMEs has grown significantly, particularly after 2020, a trend driven by the global disruptions caused by the COVID-19 pandemic. This surge in interest underscores the importance of data-driven strategies in crisis management and adaptation, as noted in the Literature Statement [4].

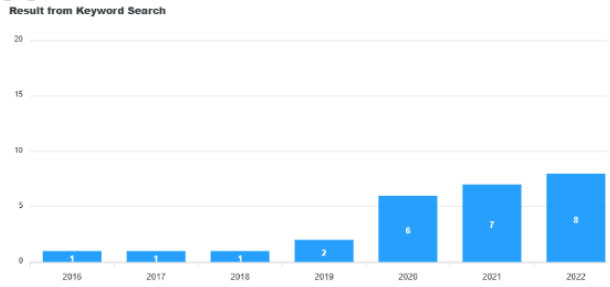

Figure 2. Trends in The Volume of Publications on Big Data and SMEs

In crisis management, BDA equips SMEs with real-time insights into market trends and consumer behaviors, allowing them to pivot their strategies swiftly. **Figure 3** shows that "Adaptability and Flexibility" is the most explored aspect of resilience, with 23 studies highlighting its importance. For instance, SMEs leveraged BDA during the pandemic to analyze consumer demand shifts, enabling them to adjust their product offerings and marketing efforts accordingly [23]. The use of predictive analytics for financial risk management also played a pivotal role, allowing SMEs to forecast cash flow challenges and develop contingency plans to ensure liquidity [2].

Risk mitigation is another dimension where BDA demonstrates its value. Predictive analytics enables SMEs to anticipate potential disruptions, particularly in supply chain operations. Real-time data monitoring helps firms identify bottlenecks and adjust procurement strategies. **Table 1** emphasizes how BDA has been instrumental in mitigating risks, particularly in manufacturing SMEs. Furthermore, **Table 2** highlights that regions like China and Europe are at the forefront of resilience-focused research, benefitting from advanced technological ecosystems [12].

Figure 3. Category I Classification SMEs' Resilience in Articles Focusing

BDA also supports business continuity planning by integrating data insights into strategic decision-making frameworks. According to the Literature Statement, this integration fosters resilience by aligning data initiatives with broader organizational goals [10]. SMEs that adopted BDA-driven continuity models during the pandemic showed higher survival rates and faster recovery, as they were better equipped to adapt to resource constraints and market changes [24]. ensures methodological rigor, transparency, and reproducibility, aligning with established best practices and the PRISMA guidelines for systematic reviews. The PRISMA framework is central to the research design, providing a structured approach to identifying, screening, and selecting relevant studies. **Figure 1** illustrates the PRISMA flow diagram, detailing the step-by-step process of article identification,

screening, eligibility assessment, and final inclusion. This design enables a comprehensive exploration of how BDA contributes to resilience and performance in SMEs while addressing gaps in the existing literature.

Table 1.
Categorization of Big Data and SMEs Research by Focus Area and Author Contributions Resilience Category

Resilience Category	Count	Authors
Adaptability And Flexibility	23	Bertello et al., 2020[25]; Limpeeticharoenchot et al., 2020[26]; Liu et al., 2020[27]; [28] et al., 2020; Nasrollahi et al., 2021[14]; Song et al., 2022[13]; Wided, 2022[8]; Giang and Liaw, 2022[29]; Zhang and Wang, 2022[7]; , 2022; Maroufkhani et al., 2022[18]; Cadden et al., 2023[30]; Soluk et al., 2023[31]; Lacam and Salvetat, 2023[32]; Lutfi, 2023[33]; Hongyun et al., 2023[34]; Ciacci and Penco, 2023[35]; , 2023; Mathani et al., 2024[36]; Al-Shanableh, 2024[37]; Asiri et al., 2024[6]; Ferrigno et al., 2024[38]; Mehmood et al., 2024[12]
Risk Mitigation	9	Iranmanesh et al., 2022[10]; Chuah and Thurusamry, 2022[39]; Jalali et al., 2023[11]; Anwar et al., 2024[40]; Alshuaibi et al., 2024[41]; Xie, 2024[42]; Ardito et al., 2024[43]; Ebhota et al., 2024[44]; Shaik et al., 2024[24]
Crisis Management	6	Lutfi et al., 2022[33]; Chatterjee et al., 2022[23]; Baig et al., 2023[45]; Khan et al., 2024[46]; Msechu et al., 2024[47]; Shi et al., 2024[48]
Business Continuity Planning	3	Ciasullo et al., 2022[4]; Singagerda et al., 2024[49]; Rumman et al., 2024[50]

Table 2.
Geographical Distribution of Big Data and SMEs Research by Resilience Category

Resilience Category	Count	Authors
Adaptability And Flexibility	23	China, France, India, Iran, Italy, Jordan, Pakistan, Saudi Arabia, Thailand, UK, Vietnam
Risk Mitigation	9	China, Europa, Malaysia, Nigeria, Oman, Saudi Arabia, USA
Crisis Management	6	China, India, Jordan, Malaysia, Pakistan, Tanzania
Business Continuity Planning	3	Europe, Indonesia, Jordan

Big Data and SMEs' Performance

BDA significantly enhances SME performance by improving operational efficiency, strategic decision-making, customer analytics, and innovation capabilities. **Figure 4** illustrates that "Strategic Decision-Making" is the most discussed category in performance-focused research, with 24 studies emphasizing its importance. Frameworks such as the Technology-Organization-Environment (TOE) model provide a foundation for assessing SMEs' readiness to adopt BDA, as highlighted in the Literature Statement [34].

Operational efficiency is a primary outcome of BDA adoption, as SMEs can streamline their supply chains and optimize resource allocation. Predictive analytics allows firms to forecast demand, manage inventory, and enhance supplier performance. **Figure 4** shows that 7 studies specifically focus on operational efficiency, underscoring its critical role in cost reduction and customer satisfaction. **Table 3** supports these findings by illustrating how manufacturing SMEs use BDA to improve production planning and reduce inefficiencies [4].

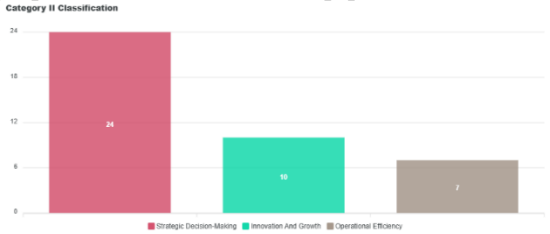

Figure 4. Category II Classification SMEs' Performance Trends in Articles Focusing

Customer analytics is another area where BDA provides substantial benefits. Advanced data analysis enables SMEs to segment customers effectively, personalize marketing efforts, and enhance customer loyalty. As noted in the Literature Statement, customer segmentation and personalization drive both satisfaction and retention [51]. **Table 4** demonstrates the geographical distribution of customer analytics research, with a strong focus on Europe and Asia. Retail SMEs, in particular, utilize BDA to analyze purchasing patterns and deliver tailored promotions, contributing to increased sales and improved brand loyalty [13].

Vol. 13 No. 2, pISSN: 2303-0577 eISSN: 2830-7062 http://dx.doi.org/10.23960/jitet.v13i2.6476

Table 3.
Categorization of Big Data and SMEs Research by Focus Area and Author Contributions Performance Category

Performance Category	Count	Authors
Strategic Decision-Making	24	Bertello et al., 2020[25]; Limpeeticharoenchot et al., 2020[26]; Nasrollahi et al., 2021[14]; Maroufkhani et al., 2022[18]; Chatterjee et al., 2022[23]; Wided, 2022[51]; Song et al., 2022[13]; Iranmanesh et al., 2022[10]; Zhang and Wang, 2022[7]; Giang and Liaw, 2022[29]; Lutfi et al., 2022[52]; Ciasullo et al., 2022[4]; Hongyun et al., 2023[34]; Lutfi, 2023[33]; Lacam and Salvetat, 2023[32]; Shi et al., 2024[48]; Ardito et al., 2024[43]; Shaik et al., 2024[24]; Ebhota et al., 2024[44]; Alshuaibi et al., 2024[41]; Khan et al., 2024[46]; Mathani et al., 2024[36]; Asiri et al., 2024[6]; Al-Shanableh, 2024[37]
Innovation And Growth	10	Liu et al., 2020[27]; Saleem et al., 2020[28]; , 2022; Cadden et al., 2023[30]; Soluk et al., 2023[31]; , 2023; Ciacci and Penco, 2023[35]; Rumman et al., 2024[50]; Mehmood et al., 2024[12]; Ferrigno et al., 2024[38]
Operational Efficiency	7	Chuah and Thurusamry, 2022[39]; Jalali et al., 2023[11]; Baig et al., 2023[45]; Anwar et al., 2024[40]; Msechu et al., 2024[47]; Xie, 2024[42]; Singagerda et al., 2024[49]

Table 4.
Categorization of Big Data and SMEs Research by Focus Area and Author Contributions Performance Category

Performance Category	Count	Authors
Strategic Decision-Making	24	China, Europa, Europe, France, India, Iran, Italy, Jordan, Malaysia, Nigeria, Pakistan, Saudi Arabia, Thailand, USA, Vietnam
Innovation And Growth	10	China, India, Italy, Jordan, Pakistan, UK
Operational Efficiency	7	China, Indonesia, Malaysia, Oman, Tanzania

BDA Adoption has become a key driver of innovation and growth for SMEs. **Figure 5** highlights important themes such as "Digital Transformation," "Innovation Performance," and "Process Innovation," showing how SMEs use BDA to improve efficiency and develop new products. BDA also plays a crucial role in enhancing "Economic Performance" and "Financial Performance," helping businesses remain competitive and sustainable. Additionally, SMEs are leveraging BDA for better supply chain management, smarter decision-making, and stronger stakeholder relationships. However, challenges such as "Technological Complexity" and "Compliance" continue to hinder full-scale adoption, requiring strategic solutions for successful implementation.

Table 5 highlights the theoretical frameworks underpinning these innovations, with the Dynamic Capabilities View (DCV) emphasizing the agility and adaptability needed to sustain growth through BDA [46].

Figure 5. Word Clouds Based on Variables

Table 5.
Theoretical Frameworks in Big Data and SMEs Research by Performance Category

Performance Category	Count	Theory
Strategic Decision-Making	24	Ability-Motivation-Opportunity (AMO), Behavioral Agency Theory, Corporate Sustainability Theory, Diffusion Of Innovation (DOI), Dynamic Capabilities View, Dynamic Capability Theory (DCT), Relates To Rough Set Theory (RST), Resource-Based View (RBV), Technology Acceptance Model (TAM), Technology Organization Environment.

Innovation And Growth	10	Dynamic Capabilities View, Dynamic Capability Theory (DCT) Knowledge-Based View (KBV), Natural Resource-Based View (Natural RBV), Resource-Based View (RBV).
Operational Efficiency	7	Agency Theory, Resource-Based View (RBV), Technology Organization Environment

Geographical and Sectoral Trends

The adoption of BDA among SMEs varies significantly across regions and sectors, influenced by factors such as technological infrastructure and industry concentration. **Figure 6** illustrates that China leads in BDA research, followed by Europe and Jordan, reflecting their advanced technological ecosystems and supportive policies. **Table 6** further emphasizes the popularity of these regions in BDA studies, while **Table 7** highlights the citation patterns that reinforce their leadership [18]. In developing regions, SMEs face challenges such as limited access to technology and skilled labor, as noted in the Literature Statement [11]. However, the emergence of cloud-based analytics tools offers a potential solution, enabling resource-constrained SMEs to adopt BDA at lower costs [2].

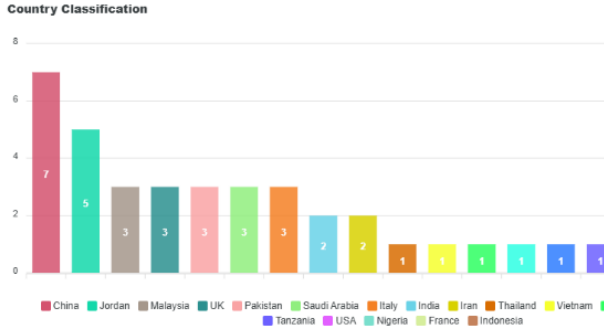

Figure 6. Countries Study

Sectoral variations in BDA adoption are also evident, as shown in **Figure 3**. Manufacturing SMEs lead in BDA applications, utilizing predictive analytics for supply chain optimization and quality control. **Table 8** supports this by showcasing the theoretical frameworks applied in manufacturing-focused research. Retail SMEs also benefit significantly from BDA, particularly in customer analytics and inventory management. **Table 2** illustrates the concentration of retail-focused studies in Europe and Asia, where real-time data analysis has revolutionized stock management and customer engagement [34]. The finance sector leverages BDA for risk assessment, fraud detection, and personalized services, as highlighted in the Literature Statement [14]. Meanwhile, healthcare SMEs are beginning to explore BDA for patient analytics and operational efficiency, reflecting the sectoral diversity in BDA applications.

Table 6.
Popular Country

Country	Count	Authors
China	7	Saleem et al., 2020; Song et al., 2022; Zhang and Wang, 2022; , 2022; Xie, 2024; Anwar et al., 2024; Shi et al., 2024
Jordan	4	Lutfi et al., 2022; Rumman et al., 2024; Al-Shanableh, 2024; Mathani et al., 2024
Malaysia	3	Chuah and Thurusamry, 2022; Baig et al., 2023; Iranmanesh et al., 2022
Pakistan	3	, 2023; Hongyun et al., 2023; Khan et al., 2024
Iran	2	Nasrollahi et al., 2021; Maroufkhani et al., 2022
Saudi Arabia	2	Wided, 2022; Asiri et al., 2024
UK	2	Liu et al., 2020; Cadden et al., 2023
Europa	1	Ardito et al., 2024
Europe	1	Ciasullo et al., 2022
India	1	Mehmood et al., 2024

Table 7.
Citation Country

Country	Count	Authors
Jordan	176	Lutfi et al., 2022; Rumman et al., 2024; Al-Shanableh, 2024; Mathani et al., 2024
UK	136	Liu et al., 2020; Cadden et al., 2023
Iran	110	Nasrollahi et al., 2021; Maroufkhani et al., 2022
China	94	Saleem et al., 2020; Song et al., 2022; Zhang and Wang, 2022; , 2022; Xie, 2024; Anwar et al., 2024; Shi et al., 2024

Malaysia	50	Chuah and Thurusamry, 2022; Baig et al., 2023; Iranmanesh et al., 2022
Europe	42	Ciasullo et al., 2022
Saudi Arabia	31	Wided, 2022; Asiri et al., 2024
Pakistan	28	, 2023; Hongyun et al., 2023; Khan et al., 2024
India	8	Mehmood et al., 2024
Thailand	8	Limpeeticharoenchot et al., 2020

Table 8.
Theoretical Frameworks in Big Data and SMEs Research by Resilience Category

Resilience Category	Count	Theory
Adaptability And Flexibility	23	Diffusion Of Innovation (DOI), Dynamic Capabilities View, Dynamic Capability Theory (DCT), Knowledge-Based View (KBV), Natural Resource-Based View (Natural RBV), Resource-Based View (RBV), Technology Acceptance Model (TAM), Technology Organization Environment.
Risk Mitigation	9	Ability-Motivation-Opportunity (AMO), Corporate Sustainability Theory, Dynamic Capability Theory (DCT), Resource-Based View (RBV), Technology Organization Environment.
Crisis Management	6	Agency Theory, Behavioral Agency Theory, Relates To Rough Set Theory (RST) Resource-Based View (RBV), Technology Organization Environment.
Business Continuity Planning	3	Dynamic Capability Theory (DCT), Resource-Based View (RBV)

4. Discussion

This section critically analyzes the findings of the SLR, comparing them with existing literature, discussing theoretical and practical contributions, and addressing the barriers and challenges to BDA adoption. It also highlights actionable policy implications to enhance BDA adoption and offers directions for future research.

Comparison with Existing Literature

The findings of this SLR align closely with existing literature on Big Data Analytics (BDA) and Small and Medium-sized Enterprises (SMEs), particularly in emphasizing BDA's role in enhancing operational efficiency and decision-making. Previous research consistently highlights how BDA equips SMEs with critical insights for improving supply chain management, adapting to market changes, and maintaining competitive advantages [4], [18]. This study reinforces these observations by identifying predictive analytics as a key enabler of operational agility and resilience, as supported by **Figures 5** and **6**. However, this review extends the academic discourse by exploring dimensions that have received less attention in prior studies. While earlier works often focus on technological barriers, this research underscores the importance of organizational culture and leadership in facilitating BDA adoption [10]. A supportive organizational culture, coupled with strong management commitment, has emerged as a critical factor in overcoming resistance to change, a challenge noted but underexplored in earlier studies [11], [13].

This study also diverges from existing literature by integrating resilience and sustainability as core dimensions of BDA adoption. While much of the previous research emphasizes immediate operational benefits, this review reveals that aligning BDA initiatives with strategic planning fosters long-term sustainability. As depicted in **Table 8**, SMEs that incorporate BDA into their continuity models demonstrate greater adaptability to disruptions, contributing to improved resilience [24]. This novel perspective highlights the strategic value of BDA beyond its immediate applications. In terms of theoretical contributions, this study integrates the Resource-Based View (RBV) and the Technology-Organization-Environment (TOE) framework, providing a comprehensive understanding of BDA adoption. The emphasis on resilience and adaptability reflects elements of the Dynamic Capabilities View (DCV), particularly in sectors like manufacturing and retail, where agility is critical [53], [54]. **Table 5** reinforces this finding by showcasing the prevalence of DCV in BDA research across these industries.

Barriers and Challenges to BDA Adoption

Despite the potential benefits of BDA, SMEs face numerous barriers to its adoption. Technological constraints are among the most significant challenges, particularly the lack of in-house expertise and the complexity of BDA tools [11], [18]. Many SMEs perceive these technologies as difficult to implement and

operate, which creates resistance among employees and decision-makers. This resistance is often exacerbated by inadequate training programs, as SMEs fail to invest in developing the technical skills necessary for BDA utilization [12].

Financial constraints further impede BDA adoption. The high initial investment required for acquiring BDA technologies, coupled with ongoing maintenance and operational costs, limits SMEs' ability to fully leverage these tools [29], [34]. Moreover, the lack of access to funding and financial support mechanisms makes it challenging for resource-constrained SMEs to prioritize BDA initiatives over other operational needs. This issue is particularly pronounced in developing regions, where limited infrastructure and technological capabilities hinder progress, as shown in **Table 2**.

Organizational and cultural challenges also present significant obstacles. Resistance to change within SMEs, driven by fears of job displacement or a lack of understanding of BDA benefits, is a recurring issue [13]. Fragmented data management practices compound this challenge, as SMEs struggle to integrate data silos across departments, limiting their ability to perform comprehensive analyses [50].

Data privacy and security concerns add another layer of complexity. The fear of data breaches and compliance risks discourages SMEs from adopting advanced analytics tools, particularly in industries handling sensitive customer data [6], [23]. While these barriers are well-documented, the findings of this study emphasize the need for integrated strategies that address both technological and organizational challenges holistically.

Policy and Practical Implications

The findings of this SLR have several implications for policymakers, practitioners, and SME managers. Governments play a pivotal role in facilitating BDA adoption by addressing the financial, technological, and organizational barriers that SMEs face. Policies offering financial incentives, such as grants, subsidies, and low-interest loans, can alleviate the cost burdens associated with BDA implementation [4]. As noted in **Table 6**, regions with strong government support, such as Europe and China, lead in BDA adoption, highlighting the effectiveness of these initiatives [18].

Investment in digital infrastructure is another critical area for policy intervention. Improved access to high-speed internet, cloud computing services, and affordable analytics tools can bridge the technological gap, particularly in underserved regions [34]. Public-private partnerships could also facilitate the development of innovative BDA solutions tailored to the unique needs of SMEs [42].

Training and capacity-building programs are essential for addressing skill gaps in SME workforces. Policymakers should collaborate with academic institutions and industry experts to design programs focused on data literacy, analytics techniques, and technology management [18], [55]. These efforts would empower SME employees to utilize BDA effectively, fostering a culture of data-driven decision-making.

From a practical perspective, SMEs can adopt cost-effective strategies to implement BDA. Starting with pilot projects and scaling gradually allows firms to test and refine their analytics initiatives before full-scale adoption. Leveraging cloud-based solutions can further reduce costs while providing access to advanced analytics tools without the need for extensive hardware investments [23].

SMEs should also prioritize data quality and integration to maximize the benefits of BDA. Ensuring accurate and reliable data through robust cleaning and management processes enhances the effectiveness of analytics efforts [2]. Collaboration with technology providers and consultants can help SMEs navigate the complexities of BDA adoption, providing access to expertise and resources that may otherwise be unavailable [14].

Finally, fostering a data-driven culture within SMEs is crucial for sustaining BDA adoption. Management should actively promote the use of data insights in decision-making processes and invest in training programs to enhance employees' understanding of analytics tools [53]. By embedding data-driven practices into their organizational culture, SMEs can achieve long-term resilience and competitiveness.

5. Conclusion

This systematic literature review (SLR) has provided an in-depth exploration of how Big Data Analytics (BDA) contributes to enhancing the resilience and performance of Small and Medium-sized Enterprises (SMEs). By synthesizing findings from various empirical studies, the review offers theoretical, practical, and policy-related insights that are critical for both academic and business communities. The key takeaways are summarized as follows:

BDA Benefits for SMEs:

- Supports SMEs in navigating economic disruptions and uncertain environments.
- Enhances operational efficiency and strategic decision-making.
- Enables risk mitigation, supply chain optimization, and financial forecasting through predictive analytics.

Variability in Implementation:

- Adoption of BDA varies significantly across industries and regions.
- Influencing factors include technological readiness, organizational culture, and financial capacity.

Challenges to BDA Adoption:

- High implementation costs and limited technical expertise.
- Concerns related to data security and internal resistance to digital transformation.

Policy and Governmental Support:

Governments play a pivotal role through financial incentives, infrastructure development, and digital literacy initiatives.

Strategic Recommendations for SMEs:

- Foster a data-driven culture within the organization.
- Invest in cloud-based analytics platforms.
- Collaborate with external experts to strengthen analytical capabilities.

Theoretical Contributions:

The integration of Resource-Based View (RBV), Technology-Organization-Environment (TOE) model, and Dynamic Capabilities View (DCV) offers a holistic perspective on BDA-driven competitiveness.

Directions for Future Research:

- Examine the long-term impacts of BDA in resource-constrained environments.
- Investigate how Artificial Intelligence (AI) and Machine Learning (ML) can enhance BDA value.
- Explore the intersection of BDA, sustainability, and business resilience.

Acknowledgement

Thanks to Mayasari Bakti University for providing research opportunities through internal campus grant funds. The research results are expected to contribute to SME owners starting to plan BDA integration in their businesses and become a reference for further researchers.

References

[1] N. Omrani, N. Rejeb, A. Maalaoui, M. Dabic, and S. Kraus, "Drivers of Digital Transformation in SMEs," *IEEE Trans Eng Manage*, vol. 71, pp. 5030–5043, 2024, https://doi.org/10.1109/TEM.2022.3215727.

[2] C. Sanchez-Hughet, M. E. Aramendia-Muneta, and A. Erro-Garcés, "Seizing opportunities in Europe: a roadmap for efficient big data implementation in Spanish SMEs," *Digit. Poli. Regul. Govern.*, vol. 24, no. 5, pp. 463–478, 2022, https://doi.org/10.1108/DPRG-02-2022-0019.

[3] M. Sorger, B. J. Ralph, K. Hartl, M. Woschank, and M. Stockinger, "Big data in the metal processing value chain: A systematic digitalization approach under special consideration of standardization and smes," *Appl. Sci.*, vol. 11, no. 19, 2021, https://doi.org/10.3390/app11199021.

[4] M. V. Ciasullo, R. Montera, and A. Douglas, "Building SMEs' resilience in times of uncertainty: the role of big data analytics capability and co-innovation," *Trans. Gov. People Process Policy*, vol. 16, no. 2, pp. 203–217, 2022, https://doi.org/10.1108/TG-07-2021-0120.

[5] J. Zhang and H. Li, "The Impact of Big Data Management Capabilities on the Performance of Manufacturing Firms in Asian Economy During COVID-19: The Mediating Role of Organizational Agility and Moderating Role of Information Technology Capability," *Front. Psychol.*, vol. 13, 2022, https://doi.org/10.3389/fpsyg.2022.833026.

[6] A. M. Asiri, S. A. Al-Somali, and R. O. Maghrabi, "The Integration of Sustainable Technology and Big Data Analytics in Saudi Arabian SMEs: A Path to Improved Business Performance," *Sustainability*, vol. 16, no. 8, 2024, https://doi.org/10.3390/su16083209.

[7] G. Zhang and T. Wang, "Financial Budgets of Technology-Based SMEs From the Perspective of Sustainability and Big Data," *Front. Public Health*, vol. 10, 2022, https://doi.org/10.3389/fpubh.2022.861074.

[8] R. Wided, "IT Capabilities, Strategic Flexibility and Organizational Resilience in SMEs Post-COVID-19: A Mediating and Moderating Role of Big Data Analytics Capabilities," *Global J. Flexible Syst. Manage.*, vol. 24, no. 1, pp. 123–142, 2023, https://doi.org/10.1007/s40171-022-00327-8.

[9] M. Falahat, P. K. Cheah, J. Jayabalan, C. M. J. Lee, and S. B. Kai, "Big Data Analytics Capability Ecosystem Model for SMEs," *Sustainability*, vol. 15, no. 1, 2023, https://doi.org/10.3390/su15010360.

[10] M. Iranmanesh, K. H. Lim, B. Foroughi, M. C. Hong, and M. Ghobakhloo, "Determinants of intention to adopt big data and outsourcing among SMEs: organisational and technological factors as moderators," *MD*, vol. 61, no. 1, pp. 201–222, Jan. 2023, https://doi.org/10.1108/MD-08-2021-1059.

[11] A. Jalali, S. M. Al Riyami, M. R. Razzak, and H. Suleiman Alqam, "Linking extra-industry network and organization–stakeholder relationships to SMEs performance through absorptive capacity: interaction effect of outsourcing big data analytics," *BPMJ*, vol. 30, no. 2, pp. 411–434, Apr. 2024, https://doi.org/10.1108/BPMJ-05-2023-0347.

[12] K. Mehmood, F. Jabeen, M. Rashid, S. M. Alshibani, A. Lanteri, and G. Santoro, "Unraveling the transformation: the three-wave time-lagged study on big data analytics, green innovation and their impact on economic and environmental performance in manufacturing SMEs," *EJIM*, Feb. 2024, https://doi.org/10.1108/EJIM-10-2023-0903.

[13] J. Song *et al.*, "The Source of SMEs' Competitive Performance in COVID-19: Matching Big Data Analytics Capability to Business Models," *Inf. Syst. Front.*, vol. 24, no. 4, pp. 1167–1187, 2022, https://doi.org/10.1007/s10796-022-10287-0.

[14] M. Nasrollahi, J. Ramezani, and M. Sadraei, "The impact of big data adoption on smes' performance," *Big Data Cogn. Computing*, vol. 5, no. 4, 2021, https://doi.org/10.3390/bdcc5040068.

[15] A. Persaud and J. Zare, "Beyond Technological Capabilities: The Mediating Effects of Analytics Culture and Absorptive Capacity on Big Data Analytics Value Creation in Small- and Medium-Sized Enterprises," *IEEE Trans Eng Manage*, vol. 71, pp. 7147–7159, 2024, https://doi.org/10.1109/TEM.2023.3249415.

[16] S. Aldossari, U. A. Mokhtar, and A. T. Abdul Ghani, "Factor Influencing the Adoption of Big Data Analytics: A Systematic Literature and Experts Review," *SAGE Open*, vol. 13, no. 4, 2023, https://doi.org/10.1177/21582440231217902.

[17] S. Coleman, R. Göb, G. Manco, A. Pievatolo, X. Tort-Martorell, and M. S. Reis, "How Can SMEs Benefit from Big Data? Challenges and a Path Forward," *Qual Reliab Eng Int*, vol. 32, no. 6, pp. 2151–2164, 2016, https://doi.org/10.1002/qre.2008.

[18] P. Maroufkhani, M. Iranmanesh, and M. Ghobakhloo, "Determinants of big data analytics adoption in small and medium-sized enterprises (SMEs)," *IMDS*, vol. 123, no. 1, pp. 278–301, Feb. 2023, https://doi.org/10.1108/IMDS-11-2021-0695.

[19] M. H. Chuah and R. Thurusamry, "Challenges of big data adoption in Malaysia SMEs based on Lessig's modalities: A systematic review," *Cogent Bus. Manag.*, vol. 8, no. 1, 2021, https://doi.org/10.1080/23311975.2021.1968191.

[20] J. Paul, W. M. Lim, A. O'Cass, A. W. Hao, and S. Bresciani, "Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR)," *Int J Consumer Studies*, vol. 45, no. 4, Jul. 2021, https://doi.org/10.1111/ijcs.12695.

[21] F. Azevedo and J. L. Reis, "Big Data Analysis in Supply Chain Management in Portuguese SMEs 'Leader Excellence,'" *J. Inf. Syst. Eng. Manag.*, vol. 4, no. 3, 2019, https://doi.org/10.29333/jisem/5895.

[22] M. Orero-Blat, D. Palacios-Marqués, A. L. Leal-Rodríguez, and A. Ferraris, "Beyond digital transformation: a multi-mixed methods study on big data analytics capabilities and innovation in enhancing organizational performance," *Rev. Manage. Sci.*, 2024, https://doi.org/10.1007/s11846-024-00768-8.

[23] S. Chatterjee, R. Chaudhuri, M. Shah, and P. Maheshwari, "Big data driven innovation for sustaining SME supply chain operation in post COVID-19 scenario: Moderating role of SME technology leadership," *Comput Ind Eng*, vol. 168, 2022, https://doi.org/10.1016/j.cie.2022.108058.

[24] A. S. Shaik, A. Nazrul, S. M. Alshibani, V. Agarwal, and A. Papa, "Environmental and economical sustainability and stakeholder satisfaction in SMEs. Critical technological success factors of big data analytics," *Technological Forecasting and Social Change*, vol. 204, p. 123397, Jul. 2024, https://doi.org/10.1016/j.techfore.2024.123397.

[25] A. Bertello, A. Ferraris, S. Bresciani, and P. De Bernardi, "Big data analytics (BDA) and degree of internationalization: the interplay between governance of BDA infrastructure and BDA capabilities," *J. Manage. Gov.*, vol. 25, no. 4, pp. 1035–1055, 2021, https://doi.org/10.1007/s10997-020-09542-w.

[26] S. Limpeeticharoenchot, N. Cooharojananone, T. Chavarnakul, N. Tuaycharoen, and K. Atchariyachanvanich, "Innovative Mobile Application for Measuring Big Data Maturity: Case of SMEs in Thailand," *Int. J. Interact. Mob. Technol.*, vol. 14, no. 18, pp. 87–106, 2020, https://doi.org/10.3991/ijim.v14i18.16295.

[27] Y. Liu, A. Soroka, L. Han, J. Jian, and M. Tang, "Cloud-based big data analytics for customer insight-driven design innovation in SMEs," *International Journal of Information Management*, vol. 51, p. 102034, Apr. 2020, https://doi.org/10.1016/j.ijinfomgt.2019.11.002.

[28] H. Saleem, Y. Li, Z. Ali, A. Mehreen, and M. S. Mansoor, "An empirical investigation on how big data analytics influence China SMEs performance: do product and process innovation matter?," *Asia Pacific Business Review*, vol. 26, no. 5, pp. 537–562, Oct. 2020, https://doi.org/10.1080/13602381.2020.1759300.

[29] N. T. Giang and S.-Y. Liaw, "An application of data mining algorithms for predicting factors affecting Big Data Analysis adoption readiness in SMEs," *Math. Biosci. Eng.*, vol. 19, no. 8, pp. 8621–8647, 2022, https://doi.org/10.3934/mbe.2022400.

[30] T. Cadden, J. Weerawardena, G. Cao, Y. Duan, and R. McIvor, "Examining the role of big data and marketing analytics in SMEs innovation and competitive advantage: A knowledge integration perspective," *J. Bus. Res.*, vol. 168, 2023, https://doi.org/10.1016/j.jbusres.2023.114225.

[31] J. Soluk, C. Decker-Lange, and A. Hack, "Small steps for the big hit: A dynamic capabilities perspective on business networks and non-disruptive digital technologies in SMEs," *Technol. Forecast. Soc. Change*, vol. 191, 2023, https://doi.org/10.1016/j.techfore.2023.122490.

[32] J.-S. Lacam and D. Salvetat, "Influence of the CEO's personality traits of SME on the orchestration of big data," *J. High Technol. Manage. Res.*, vol. 34, no. 1, 2023, https://doi.org/10.1016/j.hitech.2023.100451.

[33] A. Lutfi *et al.*, "Factors Influencing the Adoption of Big Data Analytics in the Digital Transformation Era: Case Study of Jordanian SMEs," *Sustainability*, vol. 14, no. 3, 2022, https://doi.org/10.3390/su14031802.

[34] T. Hongyun *et al.*, "Navigating the digital landscape: examining the interdependencies of digital transformation and big data in driving SMEs' innovation performance," *K*, Dec. 2023, https://doi.org/10.1108/K-07-2023-1183.

[35] A. Ciacci and L. Penco, "Business model innovation: harnessing big data analytics and digital transformation in hostile environments," *J. Small Bus. Enterp. Dev.*, vol. 31, no. 8, pp. 22–46, 2023, https://doi.org/10.1108/JSBED-10-2022-0424.

[36] B. Mathani *et al.*, "Identifying variables influencing the adoption of artificial intelligence big data analytics among SMEs in Jordan," *10.5267/j.ijdns*, vol. 8, no. 4, pp. 2615–2626, 2024, https://doi.org/10.5267/j.ijdns.2024.4.016.

[37] N. Al-shanableh *et al.*, "The adoption of big data analytics in Jordanian SMEs: An extended technology organization environment framework with diffusion of innovation and perceived usefulness," *10.5267/j.ijdns*, vol. 8, no. 2, pp. 753–764, 2024, https://doi.org/10.5267/j.ijdns.2024.1.003.

[38] G. Ferrigno, S. Barabuffi, E. Marcazzan, and A. Piccaluga, "What 'V' of the big data influence SMEs' open innovation breadth and depth? An empirical analysis," *R D Manage.*, 2024, https://doi.org/10.1111/radm.12727.

[39] M.-H. Chuah and R. Thurusamry, "The relationship between architecture, social, law and market in determine challenges of big data analysis for Malaysia SMEs," *Cogent Bus. Manag.*, vol. 9, no. 1, 2022, https://doi.org/10.1080/23311975.2021.2021835.

[40] M. A. Anwar, Z. Zong, A. Mendiratta, and M. Z. Yaqub, "Antecedents of big data analytics adoption and its impact on decision quality and environmental performance of SMEs in recycling sector," *Technological Forecasting*

and Social Change, vol. 205, p. 123468, Aug. 2024, https://doi.org/10.1016/j.techfore.2024.123468.

[41] M. S. I. Alshuaibi, A. Alhebri, S. N. Khan, and A. A. Sheikh, "Big data analytics, GHRM practices, and green digital learning paving the way towards green innovation and sustainable firm performance," *J. Open Innov.: Technol. Mark. Complex.*, vol. 10, no. 4, 2024, https://doi.org/10.1016/j.joitmc.2024.100396.

[42] T. Xie, "An empirical analysis of the impact of Cross-border E-commerce on the competitiveness of SMEs based on the context of big data," *Appl. Math. Nonlinear Sci.*, vol. 9, no. 1, 2024, https://doi.org/10.2478/amns.2023.2.00503.

[43] L. Ardito, R. Filieri, E. Raguseo, and C. Vitari, "Artificial intelligence adoption and revenue growth in European SMEs: synergies with IoT and big data analytics," *INTR*, Dec. 2024, https://doi.org/10.1108/INTR-02-2024-0195.

[44] O. S. Ebhota, Y. Hongxing, and A. K. Sampene, "Investigating the influence of digital transformation, budgeting and budgetary control on the financial performance of SMEs," *Sci. African*, vol. 26, 2024, https://doi.org/10.1016/j.sciaf.2024.e02429.

[45] M. I. Baig, E. Yadegaridehkordi, and M. H. Nizam Bin Md Nasir, "Influence of big data adoption on sustainable marketing and operation of SMEs: a hybrid approach of SEM-ANN," *MD*, vol. 61, no. 7, pp. 2231–2253, Jul. 2023, https://doi.org/10.1108/MD-06-2022-0778.

[46] S. A. R. Khan, M. S. Tahir, and A. A. Sheikh, "Sustainable performance in SMEs using big data analytics for closed-loop supply chains and reverse omnichannel," *Heliyon*, vol. 10, no. 16, p. e36237, Aug. 2024, https://doi.org/10.1016/j.heliyon.2024.e36237.

[47] S. Z. Msechu, P. S. Kasoga, and E. F. Kipesha, "Firm characteristics and compliance with IFRSs for small and medium-sized entities in developing countries: evidence from Tanzania," *Cogent Bus. Manag.*, vol. 11, no. 1, 2024, https://doi.org/10.1080/23311975.2024.2399313.

[48] B. Shi, C. Bai, and Y. Dong, "A big data analytics method for assessing creditworthiness of SMEs: fuzzy equifinality relationships analysis," *Ann Oper Res*, May 2024, https://doi.org/10.1007/s10479-024-06054-w.

[49] F. S. Singagerda, L. Rahmawati, and A. Z. S. A. Sabri, "Linking supply chain management practices with supply chain performance and food and beverage: Evidence from SMEs' competitive advantage," *Uncertain Supply Chain Manag.*, vol. 12, no. 2, pp. 829–840, 2024, https://doi.org/10.5267/j.uscm.2024.1.004.

[50] A. A. Rumman, M. A. K. Alsmairat, R. Alshawabkeh, and L. Al-Abbadi, "Digital transformation in SMEs: Assessing the impact of big data capabilities on project success, business continuity, and sustainability," *10.5267/j.ijdns*, vol. 8, no. 4, pp. 2701–2712, 2024, https://doi.org/10.5267/j.ijdns.2024.4.009.

[51] R. Wided, "IT Capabilities, Strategic Flexibility and Organizational Resilience in SMEs Post-COVID-19: A Mediating and Moderating Role of Big Data Analytics Capabilities," *Glob J Flex Syst Manag*, vol. 24, no. 1, pp. 123–142, Mar. 2023, https://doi.org/10.1007/s40171-022-00327-8.

[52] A. Lutfi *et al.*, "Drivers and impact of big data analytic adoption in the retail industry: A quantitative investigation applying structural equation modeling," *Journal of Retailing and Consumer Services*, vol. 70, p. 103129, Jan. 2023, https://doi.org/10.1016/j.jretconser.2022.103129.

[53] E. S. Kim, Y. Choi, and J. Byun, "Big Data Analytics in Government: Improving Decision Making for R&D Investment in Korean SMEs," *Sustainability*, vol. 12, no. 1, p. 202, Dec. 2019, https://doi.org/10.3390/su12010202.

[54] S. A. R. Khan, M. S. Tahir, and A. A. Sheikh, "Sustainable performance in SMEs using big data analytics for closed-loop supply chains and reverse omnichannel," *Heliyon*, vol. 10, no. 16, 2024, https://doi.org/10.1016/j.heliyon.2024.e36237.

[55] X. Yu, "Big data-based digital management system for the whole process of financial reporting in SMEs," *Appl. Math. Nonlinear Sci.*, vol. 9, no. 1,2024, https://doi.org/10.2478/amns.2023.2.01224.