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Integrated Data Analytics, Business Intelligence, and Machine Learning Architecture for SMEs:
Framework for Small and Medium Enterprises

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ABSTRACT

Small and medium enterprises (SMEs) are pivotal drivers of employment, Gross Domestic Product (GDP) growth, and innovation globally, yet they continue to face persistent barriers to adopting data-driven technologies, and literature lacks actionable, resource-sensitive guidance for practitioners. The systematic review maps algorithm-specific applications across industries including XGBoost for credit risk, LightGBM for real-time BI automation, and Support Vector Machines for high-dimensional small datasets while identifying persistent gaps in methodological transparency, geographic diversity, and prescriptive guidance. Addressing these gaps, the paper makes three original contributions: (1) a critical synthesis distinguishing access gaps from outcome gaps in SME BI adoption; (2) an analysis of why cost-efficiency remains under-weighted relative to strategic growth as an adoption driver, despite resource constraints; and (3) a phased three-stage implementation roadmap guiding SMEs from frugal descriptive dashboards through predictive modeling to prescriptive decision automation.

KEYWORDS

Data Analytics, SMEs Performance, Big Data Analysis, Artificial Intelligence, Business Intelligence

INTRODUCTION

In today's socio-economic landscape, information technology enables businesses to exchange and leverage large volumes of data, transforming it into a strategic asset. Beyond storage, the analysis of data is critical for deriving actionable insights and supporting global economic advancement (Costa et al., 2023). For small and medium-sized enterprises (SMEs), effective data management facilitates the identification of patterns in operational performance, market trends, pricing strategies, and customer behavior, thereby enhancing competitiveness (Abonguie et al., 2025). SMEs play a vital role in sustaining employment, local supply chains, and innovation, contributing to economic resilience and inclusive growth. Despite their significance, many SMEs have faced severe challenges in recent years, including closures and job losses, with recovery efforts often insufficiently addressing their specific financial and operational needs (Hmaddi et al., 2025).

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The deployment of business intelligence (BI) tools and data analytics techniques is essential for SMEs to navigate operational challenges and align technological capabilities with strategic objectives. These analytical technologies enable firms to transform extensive datasets into actionable insights, supporting informed decision-making and enhancing competitive positioning in dynamic markets (Ain et al., 2019). Recent investigations demonstrate the substantial impact of BI and data analytics on organizational operations, including strategic customer relationship management strategies, supply chain efficiency improvement, and financial projection analysis (Phillips-Wren et al., 2021). Furthermore, emerging digital technologies—such as artificial intelligence (AI), machine learning (ML), and knowledge management—have significantly reshaped the acquisition, structuring, and application of customer data, driving both economic and social innovation (Almeida & Bernardino, 2016).

SMEs serve a critical role in driving international economic activity systems by providing substantial employment and exerting notable social and economic influence (Zare et al., 2025). The integration of data management and BI constitutes an advanced technological framework, incorporating rigorous methodologies, mathematical models, simulation tools, and both predictive and prescriptive analytics (Antoniadis et al., 2015). This integrated system enables the acquisition, manipulation, and interpretation of raw data streams to surface patterns and trends that guide organizational strategy, reduce decision latency, and strengthen market positioning (Hu et al., 2025).

The expansion of markets and the swift pace of technological innovation have exacerbated the competitive disadvantages faced by resource-constrained business entities relative to corporate-scale enterprises (Zare et al., 2025). This disparity emphasizes the necessity of utilizing knowledge-enhancing tools, such as BI, to bolster competitive advantage and ensure enduring organizational sustainability (Qi et al., 2023). This research offers an extensive examination of literature spanning the previous decade, concentrating on the adoption of advanced analytics techniques and BI platforms in the context of resource-constrained business entities. It examines the existing body of research to uncover gaps, particularly regarding the obstacles SMEs face when adopting BI and data analytics technologies, and explores strategies for effectively integrating these tools into routine operations. Through this in-depth critique of prior work, the review aims to discuss how SMEs can harness BI and data analytics solutions to bolster their operational capabilities and secure a competitive advantage not only within regional markets but also in the broader global economy.

BACKGROUND

Reimagining SME Business Operations With Cutting-Edge Data Analytics and BI

Recent years have witnessed a marked increase in relation to the uptake and perceived value of AI technologies across the business sector, with a substantial proportion of firms either implementing AI solutions or preparing to deploy them (Bahaw et al., 2025). AI's growing relevance, particularly its capacity to impact revenue outcomes, underscores its importance as a focal point for scholarly inquiry, especially for SMEs, which typically face resource scarcity yet possess noteworthy potential to leverage AI-enabled technologies (Hu et al., 2025).

Despite widespread adoption, SMEs commonly encounter implementation challenges due to limited financial resources, insufficient employee skill development, and underdeveloped technological infrastructures (Achmad & Wiratmadja, 2025). Integrating data analytics and BI offers a pathway to overcome these limitations, enabling SMEs to interpret large volumes of data and translate them into targeted operational and strategic improvements (Hu et al., 2025). Data analytics supports customer segmentation, demand forecasting, process optimization, and trend identification, driving measurable gains in efficiency and profitability (Brinch, 2018).

Effective data management, transformation, and analysis, coupled with BI deployment, are pivotal determinants of SME performance (Charles et al., 2025). Empirical evidence indicates that the integration of data mining methodologies and BI frameworks is reshaping industry practices, improving

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