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Article

Bright Harmony of Digitalised SMEs: Bridging Big Data Analytic Capabilities and Strategic Business Performance Through Digital Innovation

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Abstract

The current study examines the impact of big data on strategic business performance (SBP). The primary aim of this research is to identify the key antecedents of digital innovation and SBP. Furthermore, we highlight the role of big data analytic capabilities (BDACs) in enhancing digital innovation, which, in turn, enhances SBP. Additionally, we consider the moderating role of managers' digital competency. Small and medium-sized enterprises (SMEs) were selected as the unit of analysis. Using systematic sampling, data were collected from 524 owners/managers. The collected data were analysed using various statistical techniques, including partial least squares structural equation modelling, yielding several interesting results for the formulated hypotheses. The findings reveal that the BDACs of SMEs positively affect digital innovation, which, in turn, enhances SBP. The results confirm that BDACs are fundamental antecedents of SBP.

Keywords: big data analytic capabilities; digital innovation; manager digital competency; strategic business performance
JEL: D11, F12, M14

1. Introduction

Small and medium enterprises (SMEs) are the backbone of all economies and are important drivers of employment and innovation (Edobor and Sambo-Magaji, 2025). In the era of digitalisation, beyond the issue of limited resources—financial, human and technological—SMEs also face demands to leverage digital transformation to innovate efficiently and respond strategically (Mladenova, 2024). Having a large amount of data is insufficient to achieve strategic performance; there is a dire need for a firm's capacity to extract actionable insights from existing data (Khan et al., 2024). Although big data analytics (BDA) is regarded as an extraordinary achievement and a technological marvel in academic and business communities worldwide, debates persist regarding the necessary outcomes to gain the advantages of big data (Sabharwal and Miah, 2021; Su et al., 2022).

The increasing levels of digitisation of operational processes have significantly transformed SMEs in terms of competition in dynamic markets. Digitalisation in SMEs has elevated the strategic importance of BDA in competition. Innovative data-driven tools enable owners/managers of SMEs to derive valuable information, promoting the innovation of digital advances and improving strategic decision-making. The capacity of an organisation to successfully assemble talent, skills and technological capabilities to gather, store, process and analyse information to produce insights and enhance organisational knowledge is referred to as big data analytic capabilities (BDACs) (Sun and Huo, 2021). BDACs facilitate process redesign, product and service innovation, and firm responsiveness to customer demands (Qi et al., 2023). Therefore, the ability of companies to combine analytics and digital innovation is more likely to achieve high strategic business performance (SBP) and maintain a competitive advantage (Mikalef et al., 2019; Wamba et al., 2017). Hence, the purpose of the present research is to correlate the contribution of BDACs to digital innovation and SBP in SMEs.

In recent years, big data has become a strategic focus for both practitioners and researchers due to its pivotal

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role in facilitating the activities of its operators (Bothe et al., 2022; Lutfi et al., 2022). Companies are increasingly moving towards the faster implementation of BDA to create operational insights that improve competitive positioning and SBP (Cappa et al., 2021; Sazu and Akter Jahan, 2022). Previous research has also attributed BDA to productivity, innovation and competitive advantage, as it is an essential contributor to organisational performance (Capurro et al., 2022; Danielsen et al., 2021; Shahid and Sheikh, 2021). The recent development of data storage, processing and analysis technologies has further enabled firms to handle the increasing amount and complexity of data, leading to overall organisational improvement (Belhadi et al., 2019; Ikegwu et al., 2022). Nevertheless, empirical research on how BDACs realise SBP remains scarce, especially in SMEs, despite the rise in investments in big data (Adewusi et al., 2024; Ranjan and Foropon, 2021). This study addresses the underlying role that BDACs play in improving the SBP of SMEs.

In line with recent studies, the present research hypothesises that, although big data is a core organisational asset, it cannot alone lead to the attainment of SBP. To produce greater SBP by utilising big data, organisations must adopt a hybrid strategy that combines both online and non-physical assets, developing capabilities that are not easily replicated by competitors (Al-Khatib, 2023). While several organisations have begun to apply such inclusiveness to maximise the benefits of BDACs, there remains a limited understanding of the steps that can be taken regarding BDACs and how these steps can be used to exploit competitive advantages in the market (Fosso Wamba et al., 2024). Although academic interest in BDACs and their influence on firm performance has increased, previous research has predominantly focused on the direct performance of large-scale companies, providing inadequate insight into the mechanisms of transformation (Hongyun et al., 2025; Kiran and Sahin, 2024). The existing literature recognises that BDACs improve decision quality and operational efficiency, yet it inadequately explains how these capabilities are translated into SBP through digital innovation processes (Gupta and George, 2016; Wamba et al., 2017). Recent research indicates that BDACs influence a firm's performance indirectly and through changes in digital capabilities (Kiran and Sahin, 2024). The theoretical perspective employed in this study is the digital innovation perspective, as the systematic implementation of digital resources is often considered the foundation for creating organisational innovation capacity, thereby increasing developmental and transformational fitness, and consequently improving SBP.

Digital innovation, regarded as a strategic driver, is considered paramount; however, the mediating strength of digital innovation in the relationship between BDACs and SBP has received little research attention (Mikalef et al., 2019). This discrepancy is especially evident when it comes to SMEs, whose scope of resources and strategies differ significantly from those of large companies, thus limiting the overall applicability of current findings. To fill this gap, the current research examines how digital innovation mediates the impact of BDACs on SBP in SMEs. Moreover, the concept of BDACs is defined and explained in terms of its impact on a firm's performance through digital innovation. This study further argues that the benefits of BDACs can be effectively leveraged when combined with managers' digital competencies. Specifically, the moderating role of managers' digital competency is proposed to strengthen the impact of BDACs on digital innovation. It is hypothesised that managers' digital competencies moderate the connection between BDACs and digital innovation, thereby enhancing the firm's transformative ability to reconstruct, reshape and innovate operational activities in alignment with market needs and trends (Ranjan and Foropon, 2021).

Managers with higher competencies in digitalisation are better equipped to translate complex analytics that support the adoption of innovative practices (Aghazadeh et al., 2024). Furthermore, research indicates that managerial digital literacy and digital leadership not only enable the effective use of BDACs but also amplify their impact on innovation outcomes by fostering organisational learning, agility and adaptability (Khin and Ho, 2019).

2. Literature Review

2.1 Big Data Analytic Capabilities (BDACs)

Previous literature indicates that it is crucial to consider all fundamental factors when evaluating the strength and value of a business's investments in information systems (Nguyen et al., 2024). This enables information technology (IT) to serve as a differentiator and an effective and efficient factor for a firm's success (Affandi et al., 2024). IT and the concepts associated with it are used to evaluate a business's investments, thereby attaching value and importance to them. The capabilities of an organisation to use resources grounded in IT, in conjunction with other resources and capabilities, are referred to as IT capabilities (Abbas et al., 2024). The theoretical conventions and implementations of such studies based on IT capabilities are typically grounded in the Resource Based View (RBV) of the firm. RBV posits that a strategic performance edge emerges from the unique combination of economically rare, valuable and relevant resources that are also difficult to replicate (Hanafizadeh and Tavakoli, 2025). Organisations possess these resources throughout their structure, and their distinctive characteristics–such as vagueness, ingrained nature and dependence–allow them to outperform competitors, thus facilitating superior performance (Audretsch and Belitski, 2024). While resources can be easily copied, distinctive characteristics within a firm are challenging to imitate, serving as a constant and sustainable source of strategic performance (Willie, 2025). The primary differentiating factor among firms competing for superior performance

is their potential to assemble, organise and implement IT-based resources.

Competitive advantages in the business environment can be gained by effectively and efficiently utilising all resources dispersed across the organisation. These resources, with their inherent organisational attributes of embeddedness, ambiguity and path dependency, provide an edge to the organisation in terms of strategic performance (Yang et al., 2024). These firm-specific abilities and IT-related capabilities are difficult to copy and unique to the organisation, thereby providing a sustainable edge in terms of performance (Mikalef et al., 2021). Previous literature has clearly demonstrated that when these capabilities are properly implemented, they assist a firm in gaining an advantage in the competitive business environment (Hanafizadeh and Tavakoli, 2025).

The general definition of BDACs, as described in previous literature, can be summarised as "a new technological cohort and a group of frameworks developed to evoke value from a very large amount and variety of data speedily and by permitting discovery and analysis" (Mohamed et al., 2020). However, this definition does not encompass the influencing factors and resources within an organisation, such as technologies and data, which are necessary to ultimately achieve a competitive performance advantage (Osman, 2019). RBV is considered the most suitable and relevant framework, as the main objective of the current research study is to identify the resources that will assist a firm in developing BDACs. In light of the previous research conducted in this area, BDAC can be defined as the capability of an organisation to store, capture and analyse data to gain insights (Adewusi et al., 2024). The researcher has adopted the same approach as demonstrated consistently in previous studies, which use a categorisation concerned with the types of resources essential for developing IT capability (Al-Khatib, 2023). Resources are divided into physical or financial resources, human soft skills such as employees' knowledge and skill sets, and intangible resources like the culture and learning environment of the organisation (Willie, 2025).

As big data investments are known to take time to manifest results in measurable output, basic resources such as human and financial resources are necessary to support them (Sun, 2020). Literature in this field also suggests that to achieve the desired output from big data investments, human skills, especially technical and managerial skills, are required (Raguseo and Vitari, 2018). However, due to the ever-changing technological landscape and advancements, digital competencies are vital in organisations related to handling big data.

2.2 Big Data and Strategic Performance in SMEs

Despite the fact that most existing studies consider BDACs as a foundational source of SBP, research in SMEs remains rare (Aftab et al., 2025). Nonetheless, some studies have reported encouraging and promising positive outcomes in manufacturing contexts (Danielsen et al., 2021). Existing studies highlight that IT infrastructure provides a competitive edge by empowering organisational capabilities (Yang et al., 2024). The main viewpoint is that the IT capabilities of SMEs, which are extensions of BDACs, help to develop and promote strategic performance (Babalghaith and Aljarallah, 2024). The research knowledge in this regard is limited; therefore, empirical studies are required to follow the processes by which data-based insights are translated into action. BDACs enable firms to understand the necessary information about emerging business changes and accurately transmit it for well-coordinated innovation plans (Gravili et al., 2021). The decision-making processes and far-reaching strategies of SMEs increasingly depend on BDA, as most SMEs now rely on it (Kgakatsi et al., 2024). BDACs are a key differentiating factor for competitive performance in SMEs (Sen et al., 2016). Conversely, poor and inaccurate information can lead to product errors, dissatisfaction and the failure of SMEs (Asiri et al., 2024). Transforming operational processes becomes challenging for SMEs due to dynamic market changes (Anwar et al., 2024). BDACs have a positive effect on SBP (Majid et al., 2021). However, evidence shows that without BDACs, mere insights are insufficient for strategic performance in SMEs (Teng et al., 2022). Therefore, we consider BDACs and their effects on the SBP of SMEs.

BDACs assist organisations in identifying new opportunities through diverse data sources (Jung, 2022). Insights that were previously unavailable can be generated by amalgamating diverse data from different sources. The analytics extracted help organisations understand and cater to needs, providing optimal solutions. Drawing on RBV, BDACs represent a valuable, rare and difficult-to-imitate technological resource that enables firms to leverage data for superior performance. By enhancing market sensing, operational optimisation and insight generation, these capabilities allow firms to improve strategic alignment and performance outcomes. Empirical research has demonstrated that firms with strong BDACs tend to outperform competitors in terms of efficiency, responsiveness and strategic outcomes (Gupta and George, 2016; Wamba et al., 2017). In line with these assumptions, we formulated:

H1: BDACs positively predict the SBP of SMEs.

2.3 Mediating Role of Digital Innovation

Digital innovation enables the development of new business processes to improve products and services, responding to emerging market changes (Asiri et al., 2024). Organisations can increase their performance through digital innovation, which can also help them improve service performance and react more quickly to the market (Shah et al., 2025). Several studies, such as Tariq et al. (2024) and Wang and Zhang (2025), have documented that digital innovation is positively associated with organisational per-

formance. However, limited research has been conducted on how digital innovation affects the performance of SMEs. This study addresses this gap by examining the mediating impacts of digital innovation between BDACs and SBP in SMEs. The use of IT in the SME sector undoubtedly brings about a revolution in the business field (Karatas et al., 2022), as developing new processes, products or business models is often more effective than traditional methods of operation (Hongyun et al., 2025). BDACs are essential but not sufficient to produce strategic performance (Ebhota et al., 2024). In this context, digital innovation is viewed as a strategic choice that allows an organisation to reshape its current operations according to demand and need (Hermann et al., 2024). Digital innovation suggests the recombination of physical and digital resources to drive innovation that is essential for improving operational capabilities and, consequently, influencing SBP (Shah et al., 2024). Literature in the field of IT suggests that digital innovation may provide a competitive performance edge to organisations on its own; yet, it is one of the vital factors for transitioning traditional businesses into digitally-enabled models (Orero-Blat et al., 2025).

The ability of an organisation to develop IT infrastructure influences its capacity to handle complex conditions (Heredia et al., 2022) and allows for the improvement of operational activities (Li et al., 2025). Consequently, strategic performance in SMEs is promoted by BDACs, made easier through digital innovation (Majnaric et al., 2021). By evaluating how SMEs develop big data mechanisms for higher performance, these institutions can develop digital innovation (Kgakatsi et al., 2024).

SBP is based on knowledge and information created with the help of BDACs (Asiri et al., 2024). Digital innovation enables the amalgamation of information and necessary data from various sources to enrich decision-making with new ideas and disrupt core processes and methods (Ardolino et al., 2025; Lin et al., 2025). Effective communication facilitates the harnessing of diverse knowledge and information from different internal and external sources to improve performance (White, 2025). Some knowledge and information that assist in enhancing SMEs' performance are primarily based on collaboration among professionals, supported by technological resources. Since effective IT infrastructure allows for the exchange of knowledge and information to promote innovation activities (Haleem et al., 2022), the owner/managers of SMEs can unlock new operational designs to meet customer and market demands (Teng et al., 2022). In line with these arguments, we formulated that:

H2: There is a positive mediation of digital innovation between BDACs and SBP.

2.4 Moderating Role of Digital Competency

Digital competency is defined as the ability of organisational members to effectively use technological tools and resources (Hammoda and Foli, 2024). The digital competency of owner/managers allows them to make the best use of big data for effective operational and innovative activities (Espina-Romero et al., 2024). In the era of digitalisation, the SME sector needs to be proactive and update its digital and IT resources used for business activities (White, 2025). Only in this way can it survive in this digital era. Digital competency is crucial for the use of AI tools (Abou Hashish and Alnajjar, 2024). Organisations with BDA can better assess and adapt to newly generated situations and reshape themselves accordingly (Bleijenbergh et al., 2023). Existing literature shows that digital competency empowers the use of emerging technologies (Hammoda and Foli, 2024). Similarly, insights generated through big data can assist in decision-making and provide a record of previously available decisions. Moreover, BDA swiftly and conveniently provides processing power to turn raw data into actionable measures within a short time, yielding effective response speed and improving efficiency and effectiveness concerning newly emerged technologies (Gravili et al., 2021). BDACs affect a firm's decision-making process; thus, it can be asserted that technology alone cannot be the determining factor in transforming existing modes of operation. Only those organisations that possess the digital competency of their members can effectively gain innovation advantages (Heredia et al., 2022; Li et al., 2025).

BDA is known to assist organisations in identifying new business opportunities through diverse data sources (Gravili et al., 2021). Insights that were previously unavailable can be generated by amalgamating diverse data from different sources, along with the ability to use that data to achieve digital innovation.

H3: There is a positive moderation of digital competency on the BDACs and digital innovation link.

2.5 Research Model

For the current study, we propose a research model illustrating that BDACs can be built through a combination of organisational capabilities, competencies and resources (Ikegwu et al., 2022; Majnaric et al., 2021). Existing literature on IT capabilities has long discussed the classification of resources into the aforementioned tangible and intangible resources, as well as human skills. Business organisations invest in these resources to promote their BDACs (Danielsen et al., 2021). In this study, we proposed that the mechanism of BDACs in an organisation originates from its capacity and willingness to promote technological capabilities. Moreover, BDACs help reinforce a firm's identifying, capturing and renovating capabilities, which in turn ensure SBP.

Considering RBV, the technological capabilities view, and the evolving literature on BDACs, the current study proposes that BDACs enable firms to reshape and reconstruct themselves in line with the ever-changing digital advancements (Hanafizadeh and Tavakoli, 2025). BDACs

help eliminate the risk of being outdated in terms of technological capabilities by promoting operational efficiency through digital innovation (Espina-Romero et al., 2024). The researcher argues that BDACs alone are insufficient to promote SBP; various factors exist that ensure a strong connection between this relationship. In line with existing studies, we considered the transformational role of digital innovation (Al-Khatib, 2023; Nguyen et al., 2024). The main notion discussed is that BDACs assist an organisation to recognise threats and opportunities, enabling it to take advantage of these opportunities before others in the market and subsequently adjust the organisational resource base accordingly. By implementing enhanced digital innovation, an edge in SBP can be achieved, with the role of BDACs being crucial throughout this process.

Although various researchers have investigated SBP in SMEs (Anwar et al., 2024; Kgakatsi et al., 2024), very few studies have considered BDACs as a predictor of such outcomes. This study explores the prediction of BDACs for SBP in SMEs and examines the mediating role of digital innovation. Fig. 1 shows the conceptual framework of the current study.

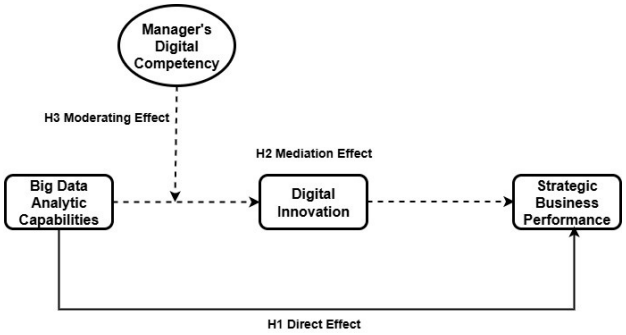


Fig. 1. Conceptual framework.

3. Methodology

The research design of the study explains the procedure for data collection, how the collected data are measured and what statistical procedures were adopted for analysis. The current study is descriptive in nature and employs a cross-sectional design to relate the characteristics of the proposed phenomenon. The objective of the current study is to explain the prediction of BDACs for SBP via digital innovation and digital competency. To achieve the study objectives, we applied a quantitative approach to assess the impact of BDACs on SBP. This study employed a systematic random sampling technique to select SMEs operating in Saudi Arabia, specifically focusing on SMEs located in Riyadh, Jeddah, Dammam and Al-Khobar, where initiatives for SME digitalisation are most pronounced. Initially, we approached the Saudi SMEs general authority to obtain official SMEs directories to develop the sampling frame for the current study. In the first phase, 3000 owner/managers were selected for data collection. In the next phase, only 2155 SMEs were finalised, as they were directly involved and used automated data systems and technological tools for their operations. Subsequently, owner/managers working in the selected SMEs were approached to collect detailed information. A total of 612 responses were received; after screening, 88 responses were excluded, leaving 524 valid responses for analysis.

3.1 Measurement

Different items were modified from earlier studies to determine the study variables, including BDACs (the independent factor), digital innovation (the mediator), digital competency (the moderator) and SBP (the dependent variable). Using a five-point scale that ranged from 1 = highly disagree to 5 = highly agree, each item's strength was assessed. Table 1 presents the measurement items of the study constructs.

3.1.1 Big Data Analytic Capabilities (BDACs) Measurement

Although BDACs were initially conceptualised and examined in large-scale enterprises with specialised analytical resources and extensive data infrastructures, the current study suggests that BDACs can also be applied within SMEs when appropriately contextualised. Drawing on RBV and dynamic capability theory, BDACs in SMEs can be understood as adaptive, resource-light capabilities that allow them to enhance operational effectiveness, improve decision-making and sense opportunities despite resource restrictions. By conceptualising BDACs in this manner, this study extends the applicability of the construct beyond large firms and provides a theoretically grounded and contextually relevant framework for examining data-driven capabilities in SMEs.

In the current study, we measure BDACs using a measurement scale with three dimensions from the work of Mikalef and Krogstie (2018). Most existing studies evaluate BDACs as first-order constructs with varying numbers of items modified based on the study requirements. In line with these researchers, we assessed BDACs with the help of 10 items adapted from the research of Binsaeed et al. (2023), Kim et al. (2012) and Karimi et al. (2001).

3.1.2 Digital Innovation

Digital innovation reflects the SMEs' capacity to use emerging technologies to convert inputs into outputs (Afuah, 2002). The digital innovation of an organisation concerns the use of digital and advanced technologies to create market offerings, business models and processes. With the help of digital technology, organisations can develop new platforms, products and services (Khin and Ho, 2019). The current study adopted measures of digital innovation from the research work of Khin and Ho (2019)

Table 1. First-order constructs with factor loadings.

First-order constructs	Codes	Items	Loadings
BDACs	BDAC1	Our firm can collect data from multiple internal and external sources (e.g., customers, operations, suppliers)	0.932
	BDAC2	Our firm is able to integrate data from various sources	0.849
	BDAC3	Our firm uses analytical tools to analyse and process operational data efficiently	0.903
	BDAC4	Our employees are capable of analysing data to support managerial decision-making	0.820
	BDAC5	Our firm can transform data analytics results into actionable business insights	0.920
	BDAC6	We identify customer needs and market trends using data analytics	0.941
	BDAC7	We improve operational processes and efficiency through data analytics	0.897
	BDAC8	Our operational and strategic decisions are based on data-driven insights	0.936
	BDAC9	Our firm continuously updates its analytics capabilities in response to changing business needs	0.910
	BDAC10	We respond quickly to market changes using data analytics	0.898
Digital innovation	DI1	Our firm uses digital tools to develop new services or products	0.887
	DI2	We frequently improve existing products through digital solutions	0.893
	DI3	Digital technologies enable us to introduce innovative business processes	0.859
	DI4	Our firm experiments with new digital tools to improve operations	0.911
	DI5	Digital innovation helps us respond to emerging customer needs	0.847
	DI6	Our firm adopts digital solutions faster than competitors	0.914
	DI7	Digital innovation contributes to creating new revenue opportunities	0.891
	DI8	Our firm continuously explores new digital ideas	0.942
SBP	SBP1	Our firm has achieved sustained growth in revenue over the past three years	0.970
	SBP2	Our profitability has increased consistently	0.962
	SBP3	Our firm has improved its market share	0.980
	SBP4	Our firm controls its operational costs effectively	0.972
	SBP5	Our firm has gained a competitive advantage over competitors	0.809
	SBP6	Our firm achieves high customer satisfaction levels	0.843
	SBP7	We are able to respond quickly to market changes	0.923
	SBP8	Our firm has enhanced its brand reputation over time	0.868
	SBP9	Our firm achieves growth in the number of customers	0.923
	SBP10	Our firm successfully develops new products	0.884
	SBP11	Our firm introduces process improvements	0.934
	SBP12	Our firm achieves sustainable long-term performance	0.897
	SBP13	Our firm has expanded into new segments or markets	0.869
	SBP14	Our firm effectively utilises digital technology to enhance performance	0.916
	SBP15	Our firm maintains relationships with partners and suppliers	0.942
	SBP16	Our employees significantly contribute to business goals	0.909
	SBP17	Our firm is positioned to remain competitive in the future	0.932
Digital competency	DC1	Our employees possess the necessary digital skills to perform their jobs effectively	0.843
	DC2	Our firm initiates digital training for employees when needed	0.892
	DC3	Our employees are confident in using digital technologies	0.887
	DC4	Our firm effectively uses digital records and information systems	0.839
	DC5	We use digital tools to support operational and managerial decisions	0.940
	DC6	Employees use digital platforms to communicate effectively with each other	0.859
	DC7	Digital technologies are used to enhance the quality of products or services	0.832
	DC8	Employees are willing and comfortable learning new digital technologies	0.889

Note: BDACs, big data analytic capabilities; SBP, strategic business performance.

and Nambisan et al. (2017). Respondents recorded their responses regarding several aspects related to digital innovation on an 8-item scale using a 5-point Likert scale.

3.1.3 Digital Competency

Digital competency reflects the technological ability of owner/managers of SMEs to efficiently and effectively use digital tools and AI technologies (Mikalef and Krogstie, 2018). The digital competency of the owner/managers of SMEs was assessed using an 8-item scale formulated and validated by Schwarz et al. (2024).

3.1.4 Strategic Business Performance (SBP)

SBP is conceptually developed as the extent to which SMEs perform better than their competitors (Yousaf and Majid, 2018). To measure SBP in SMEs, respondents were asked to assess the relative performance of their SMEs in terms of financial, innovation and operational performance. The outcome variable, SBP, is measured using 17 items adopted from the work of Yousaf and Majid (2018).

4. Results

To evaluate the reliability and validity of the research model, we applied partial least squares-based structural equation modelling (PLS-SEM) analysis. For the current study, all analyses were conducted using the Smart PLS 3 software package (Hair et al., 2011). PLS-SEM allows for the estimation of simultaneous, complex and multiple associations of one or more dependent and one or more independent variables. It is a variance-based and soft modelling statistical technique for analysis. Moreover, it enables testing of the total and indirect effects among study constructs. Therefore, PLS-SEM is an appropriate methodology for testing the research model proposed for the current study.

4.1 Assessment of Common Method Bias (CMB)

For the current study, we use three methods to check for CMB problems. First, we established that there were no prearranged incorrect responses to guide the respondents and they were assured that their privacy and confidentiality would be strictly maintained, encouraging unbiased responses (Cooper et al., 2020). Second, we assessed the presence of CMB with post hoc diagnostic tests. The findings of Harman's single factor test confirmed that the explanatory power of a single factor is 36.0% according to principal component analysis, which is below the threshold of 50% (Henseler et al., 2015; Podsakoff et al., 2003). With these methods, it is confirmed that CMB is not a serious concern in this study.

4.2 Assessment of Measurement Model

Table 2 presents the outcomes of the measurement model and construct validity. The results established the internal consistency reliability, as the values of Cronbach's alpha for all study constructs ranged from 0.798 to 0.874, which is higher than the recommended threshold of 0.70. Second, the coefficients of factor loadings and weights of all constructs were significant and met the acceptance criteria. Third, convergent validity was assessed with Average Variance Extracted (AVE) values, and the coefficients of all configurations ranged from 0.741 to 0.884. Finally, discriminant validity was established using the Fornell-Larcker criterion, as the square root of the AVE estimates for each construct exceeded its correlations with other constructs (Henseler et al., 2015). In line with the guidelines established by Fornell and Larcker (1981) and Hair et al. (2011), we examined discriminant and convergent validity to evaluate construct validity. The coefficients presented in Table 2 confirm that convergent validity is at a satisfactory level, as the standard factor loading (>0.70) and AVE (>0.50) of study constructs are both greater than the threshold (Fornell and Larcker, 1981).

4.3 Confirmatory Factor Analysis (CFA)

CFA was conducted to estimate the construct validity of the study measurement model. The current study conducted CFA using AMOS 26.0 (IBM Corp., Armonk, NY, USA) software with PLS-SEM (Smart PLS, version 3, Smart PLS GmbH, Bonningstedt, Germany) to evaluate construct validity. CFA enables researchers to examine whether the latent constructs theorised based on existing studies and theory are appropriately determined by their observed variables (Brown, 2015). To verify the adequacy of the model, CFA enables the researcher to evaluate model fit indices, factor loadings and modification indices. Table 3 presents the model fit indices for the hypothesised model, which shows acceptable fit, with χ^2 = 1378.54, df = 654, χ^2/df = 2.11, CFI = 0.95, GFI = 0.96, RMSEA = 0.05 (CFI, Comparative-Fit Index; GFI, Goodness-of-Fit Index; RMSEA, Root Mean Square Error of Approximation). All values were significant and met the threshold levels.

4.4 Hypothesis Testing

PLS-SEM was utilised to examine the direct, indirect and moderating effects and test the study hypotheses. First, we validate the direct effect of BDACs on SBP. Table 4 presents the outcomes of the path (BDAC → SBP), showing the direct relationship between BDACs and SBP (β = 0.254, $p < 0.001$). Therefore, we accept study H1.

Second, we analysed the mediating role of digital innovation (DI) in the direct impact of BDACs on SBP. The results presented in Table 4 confirm the indirect impacts of DI between BDACs and SBP (Beta = 0.157, L = 0.019 to U = 0.168); hence, we accept H2. The findings of confidence interval verification confirmed the significant indirect effect at the 5% level, as the bias-corrected confidence interval (BCCI) did not contain zero. To test for partial and full mediation, we calculate the total effect (0.254 + 0.157 = 0.411) and variance accounted for (VAF) (38%), confirm-

Table 2. Reliability and validity results.

Construct	Age	Education	Experience	01	02	03	04
Age	**1.000**						
Education	0.022	**1.000**					
Experience	0.034	0.030	**1.000**				
01. BDACs	0.042	0.031	0.011	**0.860**			
02. DI	0.023	0.019	–0.026	0.653**	**0.940**		
03. DC	0.047	0.052	0.033	0.704**	0.732**	**0.917**	
04. SBP	0.011	0.072	0.016	0.668**	0.697**	0.677**	**0.930**
Cronbach's alpha				0.798	0.851	0.832	0.874
rho_a				0.899	0.923	0.883	0.876
AVE				0.741	0.884	0.841	0.866
R^2					0.432	0.578	0.495
Q^2				0.473	0.558	0.513	0.458
HTMT <0.85				Yes	Yes	Yes	Yes

Note: Values in bold font on the diagonals show the square root of AVE, non-diagonal values are the correlations of latent variables. ** $p < 0.01$, rho_a (composite reliability), HTMT (Heterotrait-Monotrait) ratio of correlations, BDACs, big data analytic capabilities; DI, digital innovation; DC, digital competency; SBP, strategic business performance; AVE, Average Variance Extracted.

Table 3. Confirmatory factor analysis.

Model detail	χ^2	Df	χ^2/df	RMSEA	GFI	CFI
Four-factor model	1378.54	654	2.11	0.05	0.96	0.95
Three-factor model	1265.76	431	2.94	0.07	0.83	0.88
Two-factor model	1456.76	381	3.84	0.08	0.79	0.78
One-factor model	1489.21	360	4.14	0.06	0.65	0.66

Note: RMSEA, Root Mean Square Error of Approximation; GFI, Goodness-of-Fit Index; CFI, Comparative-Fit Index.

Table 4. Significance testing of path effects with bootstrap.

Path	B	S.E	t-statistic	*p*-value	BCCI
BDAC → SBP	0.254	0.059	4.305	***	
BDAC→DI→SBP	0.157	0.048	3.208	**	0.019, 0.168
BDAC×DC→DI	0.194	0.046	4.217	***	

Note: Indirect effects are partially mediated, 5000 iterations for bootstrapping, 95% confidence level, S.E, standard error; BCCI, bias-corrected confidence interval; BDACs, big data analytic capabilities; DI, digital innovation; SBP, strategic business performance. ** $p <$ 0.01 *** $p < 0.001$, two tailed; n = 524.

ing the partial mediation effect.

Finally, the moderating effect of digital competency between BDACs and DI was positively significant in (BDAC×DC → DI) path. The moderating effect of digital competency was (0.194***) between BDACs and digital innovation, which was significant at the 1% level. These findings support H3 and suggest that SME owner/managers with higher levels of digital competency can utilise digital and technological resources to enhance strategic performance.

Moreover, the moderating effect of digital competency on BDACs and digital innovation in SMEs was also presented using slope analysis for the BDACs × digital competency interaction term (Fig. 2). It is concluded that the digital competency of owner/managers, along with BDACs, is higher than digital innovation in SMEs, which increased.

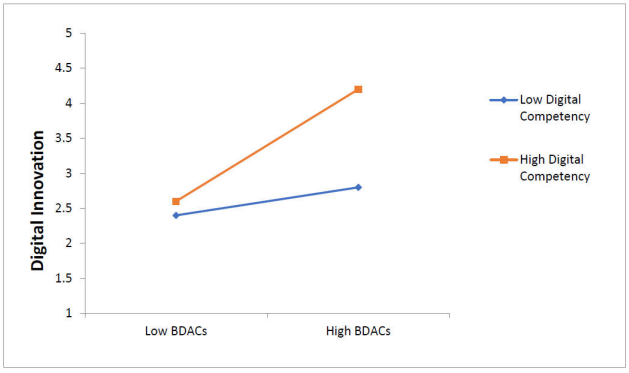


Fig. 2. Slope analysis.

5. Discussion

The adoption and relevance of big data continue to increase, yet the mechanisms by which BDACs are transformed into concrete results have not been thoroughly researched. Existing empirical studies indicate that only a few corporations have maximised the benefits of BDACs; thus, there remains a gap in the literature regarding how BDACs can enhance firm performance. The paper contributes significantly to this discussion by analysing the transformative process of BDACs in small business organisations, specifically via digital innovation.

In line with H1, the findings reveal that BDACs have a significant and positive impact on SBP, building on previous research (Majid et al., 2021; Sen et al., 2016). The results highlight that analytics capabilities are not only technological resources but also strategic enablers that assist SMEs in optimising their operations, enhancing decision-making and forecasting of market trends. BDACs can also enhance sustainable innovation practices in line with new literature on sustainability in innovation (e.g., Adiguzel et al., 2025; Ranjan and Foropon, 2021), by helping firms make data-driven decisions to maximise resource utilisation, minimise operational costs and enhance long-term competitiveness.

H2 was formulated to examine the mediation of digital innovation in the connection between BDACs and SBP of SMEs. The outcomes of H2 confirmed the mediation of digital innovation between BDACs and SBP. The SBP is largely based on a digital innovation mechanism. The findings reveal that BDACs generate value through a structured innovation process (Asiri et al., 2024). SMEs leverage insights from big data to enhance processes, reshape and refine their products and respond effectively to customer demands (Kgakatsi et al., 2024).

Furthermore, managerial-level digital competencies were shown to moderate the link between BDACs and digital innovation (H3). Lower digital literacy and capabilities among owner-managers of SMEs hinder their ability to comprehend and interpret analytics outputs effectively, align them with strategic goals and utilise innovative solutions in response to emergent market and sustainability opportunities (Adiguzel et al., 2025; Kgakatsi et al., 2024). This highlights the necessity of human potential to optimise the transformational power of BDACs. The strengthening effect of digital competency demonstrates that it plays a critical role in the big data procedure that enhances the digital innovation of SMEs. The digital competency of owner/managers provides awareness regarding market changes crucial for product innovation.

5.1 Implications for Research

The primary objective of this research study is to identify mechanisms that can yield workable and measurable outputs that give value to businesses. A concept is developed here that BDAC is essential for SMEs to extract significant results from big data. The study establishes that BDAC is a technological capability that also requires various other competencies for its development. Furthermore, limited studies are available to verify the business value BDAC attaches to businesses, apart from a few exceptions. Therefore, empirical evidence is provided for the theoretical framework of BDAC by addressing gaps in the existing literature. The current study explored this with the help of research on 524 owner/managers of SMEs, investigating the relevance of BDACs concerning technological capabilities and digital competency. This study is significant as it provides empirical evidence on the BDACs of SMEs and also proves the positive effects of BDAC on SMEs' digital innovation, which ultimately becomes vital for achieving SBP.

The notion is that BDAC is distinct from IT capabilities in that it helps to gain new comprehension and insights, which further assist a firm in restructuring and transforming its operations. The findings support this notion as proposed by the researcher and clearly show the positive effect of BDACs on the SBP of SMEs by developing and influencing digital innovation. SMEs' transition to technological planning can help in developing strong BDACs and the use of big data mechanisms in its operations, strategies and informing decisions made for SBP. It posits that BDACs do not work merely as a secondary aspect of a business strategy but help existing strategies synthesise technology and business. The knowledge generated by BDA aids in comprehending threats and opportunities while also providing guidance in the process of digital innovation. More powerful and effective decisions can be made by managers to sense and transform their business operations according to demands. It concludes that stronger BDACs enhance the maturity and quality of decisions.

A limited number of empirical studies have considered the role of BDACs in the context of SMEs to verify the assertion of the renewing role played by BDACs in SME operations. More ambiguity exists in explaining the relevance of digital innovation as an intervening factor between BDACs and SBP. Finally, the current study facilitates understanding and uncovers the network of connections through which BDACs can assist SMEs in achieving SBP. Previous literature has shown the direct effects of BDACs on firm performance, whereas the current study explores the indirect effect of the usefulness of digital innovation. The findings of this study can have real-life applications, particularly regarding the speed and pathways through which SMEs can utilise BDA to understand the value extracted from such large datasets. To achieve significant outcomes, BDACs are considered essential as a prerequisite; however, their effects on SBP can be assessed through the actions they prompt. Therefore, it is crucial to keep in consideration the level of insights utilised by owner/managers, as these can sometimes be overlooked or neglected by the managers.

5.2 Implications for Practice

The findings of the current research study can be applied to practical operations. Firstly, the study clarifies that big data is not merely an investment in technology, involving the collection of vast amounts of random data and passing it to the IT department for experimentation and analysis. Organisations can only derive value when experts with advanced levels of expertise are hired, possessing mature technological and managerial understanding of big data, while fostering a culture of continuous learning and implementing data-driven decisions within the organisation. The overall effect of these resources and effective development will assist all kinds of organisations in developing BDACs. This is a lengthy process with various subprocesses that require long-term commitment from top-level executives and managers, as well as a comprehensive plan for the adoption of BDA. Many research studies have already begun to merge and provide guidelines to top-level management of large-scale entities on how they can develop and benefit from mature and developed BDACs.

The findings of this research study can aid in developing evaluation tools to assess the strengths and weaknesses of SMEs. Similarly, it can highlight areas that are poorly developed or poorly funded. More specifically, owner/-managers can gain insights into intangible aspects where the strength of organisational learning can be assessed, allowing management to incorporate these aspects or strategies throughout their organisation. Most of the organisations, particularly SMEs, are still at the initial stages of big data; therefore, it is imperative to have a thorough understanding of all areas that should be prioritised for extracting value, as well as an awareness of the associated costs and benefits. Some capabilities and competencies, such as technological and digital competencies, can be easily acquired from the market. Consequently, SME management should recognise that some skills and strategies require time to develop, necessitating proactive efforts before expecting outcomes.

Finally, the current study demonstrates that business value is not directly achieved solely by developing BDACs; effective actions must also be taken based on the knowledge and understanding gained. This understanding is merely a part of the firm's ability to sense, capture and re-construct during the process, whereas success can only be realised when SMEs are positioned to respond to the insights provided by BDACs. This requires flexibility, the reshaping of operational and digital innovation, and termination of any impediments that can cause a delay in the transformation of these insights into actions. In conclusion, it can be asserted that big data insights are just one component and are futile unless they are put in action with the assistance of digital innovation and digital competencies.

5.3 Limitations and Future Research

The current research study faced several constraints and limitations. Firstly, self-reported responses were analysed, which can result in self-prioritisation or bias, despite considerable precautions taken to prevent partiality. The reliance on a single informant and the nature of the data collected, which is perceptual, may indicate that the data are biased and may not align with factual data.

Remedial measures were adopted by instructing different respondents to consult other employees who were in a better position to answer the questions. The study primarily concentrates on the owner/managers of SMEs; however, input from various informants from the same SMEs could enhance authenticity and validity. As the current study considers the value of BDACs for SMEs through the intervening effect of digital innovation, it did not account for contextual or environmental conditions. It is highly probable that big data initiatives may be more beneficial in some contexts than in others. This gap is left for future researchers to address, which could be of immense value and importance, especially considering the costs incurred on big data initiatives.

The main proposition is that BDAC plays an important role, but it is neither the only nor a sufficient condition to produce SBP, as multiple external and internal factors can also contribute. These may be explored in a future research study.

6. Conclusions

The current research study encompasses BDACs and is influenced by the work of researchers and experts in the field of BDACs. The researcher has provided a comprehensive view of the discussions regarding the essential elements needed for the adoption of big data; however, organisational aspects of big data remain ambiguous, and thus limited empirical evidence exists in this respect. Therefore, the researcher must focus on particular aspects or a few random individual cases of big data advantages, yet there is still a need to explore the wide range and scope of resources that are crucial for developing BDACs and the value they can impart to businesses. The current study examined the role of BDACs in achieving SBP via digital innovation. It has focused on RBV, dynamic capabilities and the existing body of research on BDA. The findings suggest that BDACs support the digital innovation mechanism, which in turn promotes SBP. This process assists firms in developing an understanding initiated by BDACs and helps them to revolutionise their operations. Moreover, BDACs promote digital innovation, which ultimately supports SBP.

It is concluded that big data is not merely data; it involves intricate processes and subprocesses during its operations. To acquire capability and capacity, multiple resources need to be utilised. Insights obtained from BDACs are just one component of a long process of theoretical and practical implementation, where actions and reconstructions are also vital parts of this extended process. To achieve SBP, it is essential to effectively and efficiently

highlight and recognise the mechanisms and impediments for better results.

Availability of Data and Materials

All data reported in this paper will be shared by the corresponding author upon reasonable request.

Author Contributions

Conceptualization: GA, AG, and ZY; Methodology: AA, NI, and EC; Software: NI, and ZY; validation: GA, AG, and EC; formal analysis: AA, and EC; investigation: GA, and ZY; resources: AA, and NI; data curation: NI, and AA; writing—original draft preparation: GA, AG, and ZY; writing—review and editing: AA, NI, and EC; visualization: ZY; supervision: AG, and GA; project administration: AG; funding acquisition: EC. All authors have been involved in revising it critically for important intellectual content. All authors have read and agreed to the published version of the manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT-3.5 to check spelling and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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