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Linking business analytics capability and sustainability performance: the mediating role of circular economy implementation

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Abstract

Purpose – Though business analytics capability continues to attract considerable industrial and scholarly attention, its holistic performance implications, especially in the post-COVID-19 period, have not been fully understood. Thus, there have been calls for a full understanding of the implications of BAC for achieving holistic, sustainable outcomes among firms. This study therefore examines the influence of BAC on the three dimensions of sustainable performance. We also proposed the mediating role of circular economy implementation.

Design/methodology/approach – We tested the proposed model using survey data from 246 managers of manufacturing firms in Ghana. Partial least squares structural equation modelling was employed to validate the model.

Findings – Our findings showed that BAC significantly enhances both sustainable performance and circular economy implementation. We also found a significant association between CEI and sustainable performance. We further found significant partial mediation of CEI in the BAC sustainable performance nexus.

Practical implications – Our study offers thoughtful insights for managers, policymakers and the academic community that firms should simultaneously implement circular models alongside building analytics competencies in the quest to achieve balanced performance outcomes.

Originality/value – To the best of our knowledge, our study is among the very few attempts to understand the mechanism that channels the benefits of BAC for a holistic, sustainable outcome.

Keywords Business analytics capability, Sustainable performance, Circular economy implementation

Paper type Research paper

Introduction

In a world increasingly defined by complex and interconnected challenges, the pursuit of sustainability has emerged as a paramount global priority. As the effects of climate change,

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resource depletion and social inequities become ever more pronounced, businesses find themselves at the crossroads of economic success and environmental responsibility (Haley and Arrigo, 2022; Owusu Kwateng *et al.*, 2022). In this critical juncture, the integration of business analytics has proven to be a transformative force, offering a dynamic and data-driven approach to simultaneously enhance profitability and sustainability performance (Mbima and Tetteh, 2023). The convergence of business analytics and sustainability is not only a response to societal demands for responsible corporate practices, but also it aligns with the essential goals of businesses to thrive in a rapidly evolving marketplace. Organisations that harness the power of data analytics are better positioned to make informed decisions, optimize resource allocation and identify opportunities to reduce environmental impacts. Consequently, this synergy between data-driven insights and sustainable practices has the potential to reshape the corporate landscape by promoting responsible growth, risk mitigation and innovation. While previous studies (Wamba *et al.*, 2017; Raut *et al.*, 2019; Singh and El-Kassar, 2019; Bag *et al.*, 2020; Kamble *et al.*, 2020; Kristoffersen *et al.*, 2021; Agrawal *et al.*, 2022; Edwin Cheng *et al.*, 2022; Cheng *et al.*, 2023; Alyahya *et al.*, 2023) have shown the critical role of data analytic capability in the success of sustainable practices, the role of business analytics capability is less understood.

Data analytics capability is a component of business analytics capability, such that business analytics capability encompasses a broader set of capabilities that includes data analytics (Mbima and Tetteh, 2023). It represents an organization's overall ability to use data and analytics to drive business value. For the purposes of this paper, business analytics (BA) capability is defined as IT-enabled business capabilities that enhance proficiency in two key areas: information management and analytical expertise (Ashrafi *et al.*, 2019). BA capability represents a technologically enabled skill set that enables the processing of large volumes of high-velocity data and various types of data insights (Wamba *et al.*, 2017). From the industry perspective, firms like Amazon use business analytics extensively to personalize recommendations for customers based on their browsing and purchasing history. This has helped Amazon increase customer engagement and drive sales. Similarly, Netflix uses business analytics to analyse viewer data and recommend content to users. By analysing viewing patterns and preferences, Netflix is able to suggest content that is likely to be of interest to each user, leading to higher viewer engagement and retention. Walmart also uses business analytics to optimize its supply chain operations. By analysing sales data and inventory levels, Walmart is able to forecast demand more accurately, reduce stockouts and improve overall efficiency in its supply chain. Uber uses business analytics to optimize its pricing strategy. By analysing demand patterns and traffic conditions, Uber is able to adjust its prices dynamically to match supply with demand, maximizing revenue.

Even though Kristoffersen *et al.* (2021) showed that business analytics capability remains a crucial antecedent to firm performance and circular economy implementation, it is still unclear how business analytics capability may influence sustainable performance. Meanwhile, there have been calls on the need to empirically holistically understand the performance implications of business analytics capability (Kamble *et al.*, 2020; Agrawal *et al.*, 2022). This study attempts to fill the gap by employing the dynamic capability theory to examine how business analytics capability may influence sustainable performance. Additionally, while the sustainable performance of firms may not only be affected by business analytics capability but also it is essential to recognise and examine the relevant conditions necessary for the anticipated impact of business analytics capability on sustainable performance to occur. This study therefore investigates the mediating role of circular economy implementation. The emergence of the circular economy paradigm, a system that prioritises resource efficiency, waste reduction and the reuse of materials, has garnered attention as a potent mechanism for achieving sustainable business models (Geissdoerfer *et al.*, 2017). It revolves around the idea of "reduce, reuse, and recycle", intending to replace the traditional linear "take-make-waste" model with a more regenerative and sustainable system (Rashid and Malik, 2023). The implementation of circular economy principles encompasses various strategies and practices, including but not limited to product redesign for longevity and recyclability, remanufacturing, waste reduction, extended product lifecycles and creating closed-loop systems that promote the reutilization of materials (Diaz *et al.*, 2022). This approach significantly influences how business analytics capability impacts sustainable performance by optimising resource use, reducing waste and enhancing the overall environmental and social impact of a business (Abdallah and Al-Ghwayeen, 2020). Domenech and Bahn-Walkowiak (2019) embracing circular economy practices, businesses could transition towards more resource-efficient and environmentally responsible operations, which align with the broader goals of sustainability. Therefore, understanding the interconnectedness between business analytics, circular economy implementation and sustainable performance is essential for organisations aiming to improve their sustainable performance. This understanding provides insights into how leveraging business analytics capabilities can support the adoption and efficacy of circular economy practices, leading to more robust, environmentally conscious and socially responsible business models.

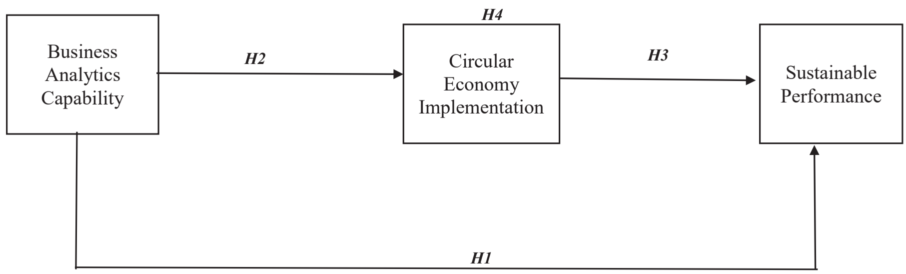
The outcome of this study makes a twofold contribution. First, this study is the first to empirically validate how sustainable performance could be achieved through BAC. Hence, shed light on the transformative potential of BAC, providing insights and inspiration for organisations seeking to navigate the ever-changing landscape of sustainability and secure their position as industry leaders. Second, our study pushes the boundaries of knowledge by demonstrating that the intermediary role played by the circular economy on the effect of BAC on sustainable performance could be enhanced. The remaining parts of the paper are organised as follows: A literature review is provided in Section 2; Section 3 provides the methodology and data analysis presented and discussed in Section 4. The last section presents a conclusion, limitations and suggestions for further study.

Theoretical review and hypotheses development

The dynamic capability theory was chosen as the theoretical underpinning for the study. This is because in today's extremely dynamic and unpredictable business environment, a firm's resources and other organisational competencies can only be optimised through dynamic capabilities (Teece *et al.*, 1997). One of such capabilities that has received massive attention in the existing literature is business analytics capability (BAC) (Ashrafi *et al.*, 2019; Kristoffersen *et al.*, 2021). BAC has been recognised as a key capability that can direct a firm's course to success (Wang *et al.*, 2016). However, it is important to note that although dynamic capabilities are significant conditions for achieving a competitive edge over others in a changing environment, they are still insufficient. Success can only be achieved when these capabilities facilitate the creation of resources and competencies that can ensure competitive advantage (Teece *et al.*, 1997). Knowledge obtained through analytics capabilities can help firms modify and improve their strategic direction, business processes, and communication networks, thereby stimulating growth in organisational capabilities (Bahrami and Shokouhyar, 2022), which opens up avenues for innovative performance (Khan and Tao, 2022). Similarly, previous studies (Kamewor, 2022; Mbima and Tetteh, 2023; Garmaki *et al.*, 2023) have also shown that analytics capabilities innovate the entire architecture of a business system, from the process stage to the final product development and from the infrastructural system to the segmental one. Therefore, in a firm's attempt to achieve performance, insights gained through analytics capabilities have been considered crucial. Again, dynamic capability theory posits that organizations can develop and refine their capabilities over time in response to changing external conditions. Business analytics capability represents one such dynamic capability, as it involves the capacity to collect, analyse and act upon data for improved decision-making. By investing in business analytics capabilities, organizations can enhance their ability to understand and respond to market dynamics and sustainability challenges. In this study, dynamic capability theory suggests that business analytics capability is a dynamic resource that allows organizations to adapt to environmental turbulence, including sustainability challenges. The circular economy serves as a mediating mechanism through which business analytics capability can influence sustainable performance by guiding organizations towards more sustainable and resource-efficient practices. By continuously adapting and learning, firms can achieve better sustainable performance outcomes in the context of the circular economy, as shown in Figure 1.

Hypotheses development

Business analytics capability and sustainable performance. Sustainable performance pertains to an organisation's capacity to attain its goals and accomplish its mission while mitigating adverse effects on the environment, society and the economy in the long run (Cheng *et al.*, 2023). The impact of business analytics capability (BAC) on sustainable performance is significant and encompasses several dimensions (Khan *et al.*, 2022). The utilisation of BAC enables businesses to leverage insights derived from data analysis, resulting in improved operational efficiency, cost optimisation and informed strategic decision-making (Wang and Byrd, 2017). Through the utilisation of analytics, companies have the ability to identify and exploit potential avenues for diminishing their environmental footprints, enhancing the efficiency of their resource utilisation and mitigating the creation of waste (Adabere *et al.*, 2021). This approach allows enterprises to align their practices with principles of environmental and social responsibility (Khan *et al.*, 2021a, b). These practices are crucial in achieving the overarching objective of sustainable performance, which incorporates the dimensions of economic prosperity, social well-being and environmental stewardship (Zhu *et al.*, 2022). The BAC not only enhances economic performance but also acts as a driving force for organisations to attain sustainable performance through the promotion of responsible resource management, social engagement and environmental sustainability (Wamba *et al.*, 2017). This ultimately leads to the establishment of a more equitable and resilient trajectory towards long-term success (Dubey *et al.*, 2019). Wamba *et al.* (2017) found that big data analytics capability has a significant positive impact on a firm's environmental and social sustainability performance. The use of big data analytics enables firms to optimise processes, reduce waste and make more informed decisions, leading to improved sustainability. Gunasekaran *et al.* (2017) discuss how big data and analytics can be leveraged to improve the environmental, social and economic aspects of sustainability performance in organisations. Big data provides insights to improve efficiency, reduce costs,



Source(s): Authors' own creation

Figure 1. Proposed research model

identify new opportunities and make operations more responsible. Dubey *et al.* (2019) empirically demonstrated that analytics capability has a significant positive association with all three dimensions of sustainability performance: environmental, social and economic. BAC helps firms strategically allocate resources to boost sustainability. Drawing from the DC perspective, firms build BAC by investing in technology, infrastructure and human capital to collect, analyse and interpret data. This involves developing skills in data management, statistical analysis and data visualization. Building BAC enables firms to better understand their operations, customers and market dynamics. Once built, firms must integrate BAC into their existing processes and systems. This involves aligning BAC with strategic objectives and embedding analytics into decision-making processes. Integration ensures that BAC is used effectively to drive performance improvements. As the business environment changes, firms must reconfigure BAC to remain competitive. This may involve upgrading technology, training employees on new analytical techniques or adapting analytics models to new challenges. Reconfiguring BAC allows firms to adapt to new opportunities and threats. By building, integrating and reconfiguring BAC, firms can drive sustainable performance by enabling firms to make data-driven decisions, leading to more accurate forecasts, better resource allocation and enhanced strategic planning. This improves overall performance and reduces the risk of costly mistakes. BAC helps firms identify inefficiencies in their operations and optimize processes. This leads to cost savings, increased productivity and improved customer satisfaction. Thus:

H1a. BAC has a positive and significant effect on economic performance

H1b. BAC has a positive and significant effect on social performance

H1c. BAC has a positive and significant effect on environmental performance

Business analytics capability and circular economy implementation. Dynamic capability theory can provide a strong argument for the role of business analytics capability (BAC) in implementing circular economy (CE) principles. According to this theory, firms must continuously build, integrate and reconfigure their capabilities to adapt to changing environments and sustain competitive advantage. Firms can build BAC by investing in data collection, analytics tools and talent. This enables them to analyse resource flows, identify waste streams and assess environmental impacts, laying the foundation for CE implementation. Once built, firms must integrate BAC into their operations and decision-making processes. This involves aligning BAC with CE goals and embedding analytics into day-to-day operations to drive sustainable practices. As the CE landscape evolves, firms must reconfigure BAC to meet new challenges and opportunities. This may involve upgrading analytics tools, expanding data sources or adapting analytics models to new CE requirements. By continuously building, integrating and reconfiguring BAC, firms can drive sustainable performance in the CE context.

Implementing the circular economy means switching to a regenerative economic model that aims to make the best use of resources and reduce waste and negative environmental impacts (Geissdoerfer *et al.*, 2017). The circular economy entails a fundamental shift from the conventional linear approach of "take-make-dispose" to a closed-loop system that emphasises the perpetual reuse, refurbishment and recycling of goods, materials and resources (Kirchherr *et al.*, 2017). The proficient application of BAC has the potential to greatly boost the implementation of a circular economy inside a corporation (Ranta *et al.*, 2018). Through the utilisation of data-driven insights, organisations have the capacity to discern potential avenues for waste reduction, resource optimisation and the development of sustainable goods and services (Mishra *et al.*, 2018). Using business analytics helps keep an eye on and measure important performance indicators for circular economy projects, which leads to continuous improvement and smart decision-making. Furthermore, it facilitates supply chain optimisation by facilitating the monitoring and control of commodities throughout their entire lifespan (Pagoropoulos *et al.*, 2017). Fundamentally, a strong business analytics capability could provide the necessary insight and knowledge to support long-lasting practices and encourage a circular economy mindset across all areas of a company, leading to less damage to the environment and better long-term economic sustainability (Kumar and Aithal, 2024). Ranta *et al.* (2018) discuss how big data analytics can be utilised to enable the transition to a circular economy by supporting waste mapping, materials passporting, predictive analytics, supply chain optimisation and gaining insights to inform sustainability initiatives. Mishra *et al.* (2018) propose a circular economy implementation framework enabled by big data analytics, including sensing, corralling, comprehending and responding phases to drive resource optimisation. Data and analytics are crucial for supporting circular innovations, optimisations and sustainability performance management. Awan *et al.* (2021) present multiple roles of analytics in a circular economy: monitoring usage, predicting failures, tracing materials, optimising disassembly, informing design changes, etc. Advanced analytics is important for the circular transition. Kirchherr *et al.* (2017) suggest big data capabilities can address several barriers to transitioning to a circular economy, including tracking resource flows, demonstrating circular benefits and advances in circular design. Thus:

H2. BAC has a positive and significant effect on circular economy implementation

Circular economy implementation on sustainable performance. Sustainable performance reflects the capacity of an organisation to effectively attain its goals and objectives while concurrently mitigating adverse environmental and social consequences (Sudusinghe and Seuring, 2022). Sustainable business practices encompass the implementation of strategies that prioritise long-term ecological and social welfare as opposed to exclusively prioritising short-term financial advantages (Edwin Cheng *et al.*, 2022). The adoption of a circular economy model has the potential to significantly enhance the sustainable performance of a company (Jabbour *et al.*, 2020; Amoako *et al.*, 2022). By shifting from a linear model characterised by the "take-make-dispose" approach to one that prioritises resource efficiency, recycling and waste reduction, businesses have the potential to decrease their environmental impact (Kravchenko *et al.*, 2020). Consequently, there is a resultant decrease in the use of resources, energy consumption and the release of greenhouse gas emissions, enhancing their overall environmental sustainability. In addition, the implementation of circular economy techniques has the potential to bolster social responsibility through the facilitation of local employment generation, the promotion of responsible sourcing and the cultivation of relationships with communities (Edwin Cheng *et al.*, 2022). The circular economy may contribute to economic sustainability by generating cost savings, creating new sources of revenue and improving competitiveness (Kravchenko *et al.*, 2020). Consequently, the adoption of circular economy concepts facilitates a comprehensive enhancement in the sustainable performance of an organisation, including environmental, social and economic aspects. Ghisellini *et al.* (2016) found that transitioning to a circular economy model significantly improves sustainable performance across economic, environmental and social dimensions in organisations. Circular systems reduce resource consumption, waste, emissions and costs. Geissdoerfer *et al.* (2017) discuss how circular economy principles such as reduce, reuse, recycle, recover, redesign and remanufacture can improve environmental sustainability by optimising resource usage and closing material loops. Korhonen *et al.* (2018) highlight that circular economy implementation enhances sustainability performance through increased material, energy and resource efficiency, waste reduction, product life extension, social benefits and economic opportunities. Murray *et al.* (2017) empirically established that circular economy activities such as recycling, remanufacturing and product life extension have a significant positive impact on sustainability performance. Thus:

H3a. Circular economy implementation has a positive and significant effect on economic performance

H3b. Circular economy implementation has a positive and significant effect on social performance

H3c. Circular economy implementation has a positive and significant effect on environmental performance

Mediating role of circular economy implementation. When a company successfully implements a circular economy model, it acts as a bridge between its business analytics skills and its long-term performance within the organisation (Kristoffersen *et al.*, 2021). The utilisation of business analytics, which involves the analysis of data to generate insights and make educated decisions, has the potential to uncover possibilities and strategies for the implementation of circular economy principles (Awan *et al.*, 2021). By adopting circular economy concepts, the company improves its environmental sustainability, optimises resource use and reduces waste generation, thereby enhancing its overall sustainable performance. Circular economy techniques, which are propelled by the utilisation of analytics, offer a structured approach for the incorporation of social responsibility, environmental stewardship and economic viability within the realm of company operations (Kamble and Gunasekaran, 2023). The process of mediation described here establishes a feedback loop that is beneficial, as it allows business analytics to facilitate and direct the shift towards a circular economy (Kristoffersen *et al.*, 2021). This shift, in turn, results in enhanced sustainable performance, thereby emphasising the significance of integrating analytics and circular economy principles to achieve comprehensive sustainability. A model where analytics maturity enables circular economy implementation, which in turn improves sustainability performance, has been proposed. Analytics provides insights for the transition to circular models. Analytics helps identify circular economy opportunities that enhance economic, environmental and social sustainability when implemented. Analytics enables the circular economy. Pagoropoulos *et al.* (2017) suggest big data analytics allows organisations to adopt circular production systems, which improves resource efficiency, waste reduction and overall sustainability performance. As the CE landscape evolves, firms must reconfigure their BAC and CE implementation capabilities. This may involve upgrading analytics tools, expanding data sources or adapting CE strategies to new market conditions. Reconfiguration allows firms to remain agile and responsive to changing CE requirements. By building, integrating and reconfiguring their BAC and CE implementation capabilities, firms can drive sustainable performance. BAC enables firms to identify opportunities for CE implementation and optimize resource use, while CE implementation leads to improved sustainability performance through waste reduction, resource efficiency and innovation. Overall, dynamic capability theory suggests that firms must continuously develop and adapt their BAC and CE implementation capabilities to drive sustainable performance (as shown in Figure 1). By building dynamic capabilities in BAC and CE implementation, firms can achieve competitive advantage in the circular economy and ensure long-term sustainability. Thus:

H4. Circular economy implementation mediates the relationship between business analytics capability and sustainable performance

Material and methods

Sample

The hypothesized model was tested with survey data from manufacturing firms in Ghana, an emerging market in the sub-Saharan African region (Amoako-Gyampah *et al.*, 2020). In the last decade, Ghana has received much attention for its economic transformation and manufacturing activities (Dzogbewu *et al.*, 2022). However, the Global Innovation Index ranks Ghana low in terms of national innovation capacity. The Digital Economy and Society Index 2021 also indicates that Ghana is among the least competitive nations in terms of digital performance. Meanwhile, Ghana takes pride in being an industrial nation, yet research on the digital industrial revolution in manufacturing remains limited. This suggests that employing emerging technologies in manufacturing firms is imperative for driving optimal performance. We sampled 246 managers of manufacturing firms in Ghana. The questionnaire was administered to top managers due to their possession of the requisite knowledge pertaining to the phenomenon being investigated as well as their authority in making decisions regarding investment in innovation, analytical tools and alliance-related matters. The researchers obtained necessary permits from both the organisations involved and the subjects who took part in this study. The individuals' involvement in the research was entirely voluntary, and emphasis was placed on maintaining secrecy before administering the questionnaire. Out of the 246.55.7% were male while 44.3% were female. Regarding educational background, the majority, at 60.2%, hold bachelor's degrees, 19.1% have Diploma and 20.7% possess master's degree. Respondents' positions within their firms vary, with 15.4% being Production, 18.3% serving as Supply chain managers, 30.1% holding positions as Operation managers and 36.2% occupying the role of Procurement managers. Again, 14.2% had less than 5 years' experience with their firm, 48.0% had between 6 and 10 years, 25.2% had 11–15 years and 12.6% had 21 years and above.

Measures

Items used in measuring the constructs were sourced from previously validated instruments. Since these items were drawn from different settings, we subjected the instrument to a thorough expert review and pilot. The model comprised three (3) key constructs: business analytics capability, circular economy and sustainable performance. Business analytics capability was a first-order construct measured with five items sourced from Bahrami and Shokouhyar (2022). For sustainable performance, 14 items were sourced from Han and Huo (2020). Ten (10) items sourced from Kristoffersen *et al.* (2021) were used to measure circular economy implementation.

Survey and common method bias

We carefully examine the data for outliers and missing values. For missing values, all cases with a lower than 95% response rate to the items were deleted. We then employed the expectation maximisation method to treat missing values in the dataset (Hair *et al.*, 2014). We also employed both the graphical presentation and the calculated Mahalanobis distance to confirm the absence of outliers in the dataset. In this study, we conducted methodological and statistical analyses to ensure the absence of biases in the collected data. Initially, a comparison was conducted between the characteristics of the firms included in this study and those that did not participate, serving as a measure of non-response bias. The analysis revealed that there was no significant statistical variance. Similarly, we also divided the data gathered into two waves (early and late responses). A paired sample t test was conducted, and the result revealed no significant difference between the two groups, also confirming the absence of non-response bias (Clottey and Benton, 2013; Greco *et al.*, 2015). We also implemented different methodological remedies to eliminate the possibility of survey bias in the study (Podsakoff *et al.*, 2012). First, for a few participants who had problems grasping the concepts under investigation, questions were explained to them. This action was taken as part of an effort to lessen the influence of bias in the data used. Additionally, respondents were guaranteed that their anonymized responses would be kept secret. This was to check for a socially desirable response (Baumgartner and Weijters, 2012). Additionally, we checked for common method bias using the total variance explained (MacKenzie and Podsakoff, 2012). The result revealed that the highest variation explained by one component (33.5%) was less than the 50% threshold. Based on this method, our findings rule out the presence of common method bias (Reio, 2010; Baumgartner and Weijters, 2012). The partial out-of-general factor in the PLS model method was employed in our study, following the recommendation of Tehseen *et al.* (2017). This approach was chosen due to an argument among researchers on the adequacy of Harman's one-factor test in providing conclusive evidence of common method bias (CMB). The application of the Partialing Out of General Factor in the partial least squares (PLS) model technique yielded results that support the conclusion that, after accounting for the general component, there was no appreciable change in R^2 (0.031). We therefore conclude that common method bias is not a serious problem in this study.

Results

SmartPLS version 4 was used for the validation of the proposed model. The SEM is comprised of measurement model assessment and structural model evaluation. While the measurement model provides reliability and validity, the structural model tests the proposed hypotheses. Both Cronbach's alpha and composite reliability were used to test for reliability. Discriminant and converging validity were evaluated using average variance extracted (AVE), indicator loadings, the Fornell and Lacker criterion and the HTMT ratio.

Measurement model assessment

Confirmatory factor analysis was used to assess the reliability, convergent validity and discriminant validity of the constructs in the model. The results in Table 1 show that both CA and CR are above the 0.7 threshold and hence provide evidence of the reliability of the scales and constructs used in the model. We also found indicator loadings were above 0.7, thus initial evidence of convergent validity is established. Next, discriminant validity was assessed using two rigorous methods. Firstly, we applied Fornell and Larcker's criteria, which state that the shared variance between the latent variable and its indicators (AVE) was greater than the variances (squared correlation) of each variable with the other latent variables. The results presented in Table 2 demonstrate that all constructs meet this criterion, and hence discriminant validity is achieved. Secondly, we further employed the heterotrait-monotrait ratio (HTMT) technique as introduced by Henseler *et al.* (2016). The HTMT values, as presented in Table 1, ranged from 0.615 to 0.862, all of which were below the 0.90 threshold (Henseler *et al.*, 2016). Thus, this study's findings on Fornell–Larcker and HTMT provide evidence to support the discriminant validity of the constructs in this study.

Structural model assessment

After evaluating the measurement model, we proceeded to conduct structural model testing using structural equation modelling (SEM). The results of hypothesis testing are presented concisely in Table 3. The model accurately accounting for 48.3% of the variance in economic performance, 45.3% of the variance in environmental performance and 48.3% of the variance in social performance. In addition, the predictive relevance of the model is evaluated not only based on the R^2 value but also through the use of the cross-validated redundancy technique. This technique takes into account both the measurement and structural model predictions. The study used a cross-validated redundancy estimation, where a Q^2 value greater than 0 indicates predictive relevance, while a Q^2 value less than 0 suggests otherwise. The results presented in Table 3 demonstrate the Q^2 values for economic, environmental and social performance, which are 0.477, 0.447 and 0.477, respectively. All the values exceeded the threshold, indicating a high level of predictive relevance for these constructs. The result in

Table 1. Reliability and validity assessment

Constructs	Items	Mean	Standard deviation	Loadings	AVE	CR	Cronbach's a
Business analytics capability	BAC1	3.970	0.816	0.833	0.674	0.912	0.879
	BAC2	4.090	0.742	0.836			
	BAC3	4.140	0.774	0.847			
	BAC4	4.180	0.752	0.801			
	BAC5	4.150	0.774	0.786			
Reinvent and rethink (CEINV)	CEINV1	3.960	0.851	0.842	0.698	0.902	0.855
	CEINV2	3.970	0.792	0.84			
	CEINV3	4.060	0.776	0.831			
	CEINV4	4.000	0.796	0.827			
Restore, reduce and avoid (CE-RRA)	CERRA1	3.960	0.851	0.878	0.756	0.903	0.839
	CERRA2	3.970	0.792	0.85			
	CERRA3	4.060	0.776	0.882			
Recirculate (CE-REC)	CREC1	4.000	0.796	0.755	0.68	0.864	0.763
	CREC2	4.010	0.788	0.834			
	CREC3	3.880	0.924	0.881			
Economic performance	ECP1	4.020	0.852	0.815	0.77	0.944	0.925
	ECP2	4.080	0.846	0.884			
	ECP3	4.060	0.866	0.893			
	ECP4	4.060	0.853	0.888			
	ECP5	4.150	0.779	0.904			
Environmental performance	ENP1	4.120	0.766	0.878	0.721	0.912	0.87
	ENP2	4.020	0.828	0.894			
	ENP3	4.110	0.782	0.848			
	ENP4	4.050	0.808	0.771			
Social performance	SP1	4.090	0.749	0.849	0.673	0.911	0.878
	SP2	4.100	0.762	0.872			
	SP3	4.160	0.784	0.826			
	SP4	3.940	0.841	0.785			
	SP5	3.970	0.834	0.764			

Source(s): Authors' own creation

Table 2. Discriminant validity

Constructs	1	2	3	4	5	6	7
A. Fornell–Larcker result							
Business analytics capability	*0.821*						
Economic performance	0.556	*0.877*					
Environmental performance	0.579	0.633	*0.849*				
Recirculate (CE-REC)	0.576	0.619	0.576	*0.825*			
Reinvent and rethink (CEINV)	0.653	0.625	0.596	0.666	*0.835*		
Restore, reduce and avoid (CE-RRA)	0.576	0.573	0.548	0.667	0.815	*0.870*	
Social performance	0.579	0.657	0.682	0.598	0.629	0.577	*0.820*
B. HTMT result							
Business analytics capability							
Economic performance	0.615						
Environmental performance	0.660	0.705					
Recirculate (CE-REC)	0.706	0.733	0.706				
Reinvent and rethink (CEINV)	0.751	0.702	0.691	0.830			
Restore, reduce and avoid (CE-RRA)	0.668	0.650	0.642	0.842	0.862		
Social performance	0.656	0.729	0.724	0.730	0.726	0.673	

Source(s): Authors' own creation

Direct effect	Direct effect	t-statistics	p values	Supported (yes/no/WS)
H1a: BAC → ECP	0.192	3.300	0.001	Yes
H1b: BAC → SP	0.236	3.920	0.000	Yes
H1c: BAC → ENP	0.276	4.498	0.000	Yes
H2: BAC → CEI	0.672	20.573	0.000	Yes
H3a: CEI → ECP	0.542	10.152	0.000	Yes
H3b: CEI → SP	0.509	9.452	0.000	Yes
H3c: CEI → EVP	0.451	8.093	0.000	Yes
R^2 values	ECP = 0.483	EVP = 0.453	SP 0.483	
Q^2 values	ECP = 0.477	EVP = 0.447	SP 0.477	

Structural paths	Indirect effect	t-statistics	p-value	95% BC confidence interval	Results
H4a: BAC → CEI → ECP	0.364	9.456	0.000	0.232–0.375	Yes
H4b: BAC → CEI → SP	0.342	9.771	0.000	0.274–0.413	Yes
H4c: BAC → CEI → EVP	0.303	8.362	0.000	0.294–0.445	Yes

Note(s): BAC: Business analytics capability, CEI: Circular economy implementation, EVP: Environmental performance, ECP: Economic performance and SP: Social performance
$***p < 0.01$; $**p < 0.05$; $*p < 0.1$ and $\tau p > 0.1$ but value of 0 is not in range of BC; ns: not supported
Yes: supported with p-value <0.05 or 0.01, WS: Weak support with p-value >0.05 or <0.1; No: Not supported
Source(s): Authors' own creation

Table 3. Path results

Table 3 shows that business analytics capability significantly predicts all the dimensions of firm performance. Table 3 shows a statistically significant relationship between business analytics capability and economic performance ($\beta = 0.192$, $p < 0.05$), social performance ($\beta = 0.236$, $p < 0.05$) and environmental performance ($\beta = 0.276$, $p < 0.05$). Thus, the first hypothesis is supported and concluded that business analytics capability significantly drives the performance of businesses. Secondly, we also examine the relationship between business analytics capability and circular economy implementation among manufacturing firms in Ghana. We found evidence of a statistically significant effect of business analytics capability on the circular economy ($\beta = 0.672$, $p < 0.05$). Thus the second hypothesis is also confirmed and concluded that business analytics capability remains essential for the implementation of circular economy among manufacturing firms. Thirdly, we examined the CEI and firm performance nexus; the result in Table 3 also showed that CEI significantly predicted all the three dimensions of performance. Thus, CEI significantly influences ECP ($\beta = 0.542$, $p < 0.05$), SP ($\beta = 0.509$, $p < 0.05$) and EVP ($\beta = 0.451$, $p < 0.05$). Thus, the third hypothesis is also supported and concludes that CEI significantly affects a firm's performance. Additionally, we examined the mediating role of circular economy implementation (CEI) in the BAC and firm performance nexus. Table 3 further revealed a significant indirect effect of CEI in the link between BAC and firm performance. Thus, we found significant partial mediation of CEI between BAC and economic ($\beta = 0.364$, $p < 0.05$), social ($\beta = 0.342$, $p < 0.05$) and environmental performance ($\beta = 0.303$, $p < 0.05$). The result indicated that all the four hypotheses were supported. Thus, it is evident that firms can enhance their performance through BAC; however, optimal performance may be achieved through effective circular economy implementation.

Discussion, implication and conclusion

While there is a growing body of literature exploring the impact of business analytics capability (BA) on sustainable performance and an increasing focus on the circular economy (CE) as a means to enhance sustainability, there exists a notable research gap at the intersection of these two areas. Specifically, the literature lacks comprehensive empirical studies that investigate the role of the circular economy as a mediator in the relationship between business analytics capability and sustainable performance. Although individual studies have explored the influence of business analytics capability on sustainability and the CE's potential to promote sustainability, there is limited research that delves into the mediating mechanisms by which the circular economy channels the effects of business analytics capability into sustainable performance outcomes. Understanding this mediating role is crucial for a more nuanced comprehension of how firms can harness their data analytics capabilities to drive sustainable practices within the context of a circular economy. This study therefore examines the mediating role of CE in the BAC-SP link. The key findings are discussed in subsequent sections.

Our findings revealed that business analytics capability significantly influences all three dimensions of sustainable performance – economic, environmental and social. These results underscore the strategic value of business analytics in the context of sustainability. Organizations that invest in and effectively utilize analytics tools and techniques are more likely to enhance their sustainable performance (Harikannan *et al.*, 2023). This suggests that firms should consider business analytics a pivotal component of their sustainability strategies. This is not just collecting and analysing data; it is leveraging those insights to drive sustainability initiatives. Our findings showed that business analytics capability influences all three sustainable performance dimensions; this implies a holistic approach to sustainability is essential. Even though investment in BAC may be expensive, it pays off when efficiently utilized. This highlights the need for businesses to cultivate a data-driven culture where decisions related to sustainability are based on empirical evidence rather than intuition alone. Firms with strong business analytics capabilities may gain a competitive advantage in the marketplace. The ability to leverage data analytics for superior sustainable performance can differentiate a company from competitors and appeal to environmentally and socially conscious consumers. This potential advantage may extend across value chain activities like supply chain optimization, waste reduction, energy efficiency and more. Sustainable performance is often associated with long-term viability and resilience. Businesses that neglect sustainability may face material risks and challenges in an increasingly environmentally and socially conscious world. Our results imply business analytics can play a role in securing a firm's long-term viability by improving its performance on sustainability dimensions that matter to stakeholders, including customers, investors and regulators. In essence, our findings underscore the significance of business analytics capabilities in driving sustainable performance across economic, environmental and social dimensions. The findings also align with previous studies (Kristoffersen *et al.*, 2021; Bag *et al.*, 2020) that found significant influence of BAC on firm performance.

Secondly, we found business analytics capability significantly influences circular economy implementation. Our findings align with the dynamic capabilities theory, which emphasises building organisational competencies to continuously adapt and innovate for competitive advantage. Business analytics is a dynamic capability that enables firms to effectively sense market changes, seize circular economy opportunities and reconfigure resources and processes accordingly. The findings highlight the role of business analytics as an antecedent competency that creates the capacity to implement circular economy strategies. Our findings also offer empirical support for conceptual arguments that data analytics allows firms to transition to circular models by optimising material flows, predicting product lifecycles and enabling circular designs (Pagoropoulos *et al.*, 2017). The findings imply that firms must continue to invest in advanced analytics tools, data infrastructure and analytical talent to build a strong business analytics capability over time. This path-dependent resource accumulation enables circular economy capabilities. The results align with previous research on the relationship between business analytics (BA) and the circular economy (CE). For example, findings in studies by Kristoffersen *et al.* (2021) emphasise the significance of BA for CE. The research conducted by Khan *et al.* (2021a, b) highlights the impact of CE implementation on firm performance, while Mikalef *et al.* (2020) indicate that the effects of business analytics capability (BAC) on firm performance are contingent on dynamic and operational capabilities. This study carries several research implications. Notably, it underscores the role of analytics in sustainable development, illustrating how BA accelerates firms' adoption of the circular economy and the creation of business value. While the development of BAC is not a mandatory prerequisite for CE implementation, it can expedite returns and magnify the impact of CE investments for organisations. In addition to the direct effects of BAC on firm performance in general business operations, this study places emphasis on the significance of information systems (IS) research in exploring the broader impacts of information technology (IT) beyond firm performance. This encourages the strengthening of research efforts in the domains of the circular economy and sustainability.

The study also revealed that circular economy implementation significantly influences all three dimensions of sustainable performance: economic, environmental and social. The direct influence of circular economy implementation on economic performance suggests that businesses can achieve cost savings, increased revenue, and improved financial stability by embracing circular practices. Numerous studies have highlighted the potential economic benefits of circularity. For instance, a circular approach can reduce resource costs and waste disposal expenses while also opening new revenue streams through product and material reuse. Companies adopting the circular economy model often report improved financial results (Ghisellini *et al.*, 2016). The direct link between circular economy implementation and environmental performance aligns with the fundamental principles of the circular economy, which aim to reduce environmental impacts. It implies that circular practices, such as recycling, reusing and remanufacturing, can lead to lower resource consumption, reduced emissions and decreased ecological footprints. This is consistent with research emphasising the environmental benefits of circular business models (Kirchherr *et al.*, 2017). The finding that circular economy implementation influences social performance points to the potential for job creation, improved working conditions and positive social impacts. Circular economy initiatives can generate employment opportunities in areas like repair, refurbishment and recycling. Moreover, they often promote collaboration and community engagement. Studies have shown that circular practices can lead to enhanced social well-being, especially in local communities (Ghisellini *et al.*, 2016). The findings emphasise the interconnectedness of economic, environmental and social dimensions within the circular economy. This highlights the need for a holistic approach to sustainability, where improvements in one dimension can complement and reinforce benefits in others. Literature on the circular economy stresses the need for systemic thinking to maximise these complementary effects. Organisations should consider incorporating circular economy metrics and indicators into their sustainability reporting. The complementary relationship between circular economy implementation and sustainable performance underscores the importance of measuring and disclosing the impacts on all three dimensions, which can provide a more comprehensive picture of an organisation's sustainability efforts. In conclusion, the findings that circular economy implementation significantly influences all three dimensions of sustainable performance have direct, complementary and transformative implications for businesses and policymakers. These findings underscore the potential for organisations to create value, reduce environmental impact and promote social well-being through circular practices. They also highlight the interconnectedness of economic, environmental and social dimensions in the context of the circular economy, emphasising the need for a holistic and systemic approach to sustainability. Literature on the circular economy provides valuable insights that support and complement these implications.

Additionally, we also found a partial mediation effect of the circular economy on the BAC and the different dimensions of sustainable performance. The partial mediation effect indicates that while BAC can directly influence sustainable performance, the presence of the circular economy plays an intermediate role in strengthening this relationship. This implies that businesses need to recognise the significance of BAC not only for direct improvements in sustainability but also for the way it enhances circular economy initiatives. Scholars, such as Kristoffersen *et al.* (2021), have highlighted the importance of BAC in the context of the circular economy. Organisations should allocate resources to both BAC and circular economy implementation to maximise sustainable performance. The findings suggest that these two elements are interrelated and can mutually reinforce each other. The allocation of resources to develop BAC can enhance a company's ability to leverage circular economy practices, ultimately contributing to improved sustainable performance. The findings imply that there is a complementary relationship between BAC and circular economy initiatives. Businesses can optimise their sustainability efforts by combining the strengths of BAC (data-driven decision-making, analytics, etc.) with circular economy principles (resource efficiency, waste reduction, product life extension, etc.). This synergy can lead to more comprehensive and effective sustainability strategies. Organisations should consider integrating BAC and circular economy thinking into their overall strategic planning. Recognising the transformative potential of this relationship, companies may need to reevaluate their business models, product design, supply chains and customer relationships to fully harness the synergies between BAC and circularity (Kirchherr *et al.*, 2017). The partial mediation effect underscores the need for innovation in both BAC and circular economy practices. Businesses should continually innovate in data analytics and sustainability strategies to create new opportunities for improving sustainable performance. This transformation can lead to novel business models, product designs and services. Policymakers may consider promoting the integration of BAC and circular economy practices through regulations and incentives. Recognising the transformative potential of this relationship can inform policy development and encourage organisations to invest in data analytics capabilities and circular economy initiatives for enhanced sustainability (Ellen MacArthur Foundation, 2017). In conclusion, the findings of the partial mediation effect of the circular economy on the relationship between BAC and sustainable performance have direct, complementary and transformative implications for organisations and policymakers. This implies that businesses should recognise the interconnectedness of BAC and circular economy initiatives, allocate resources accordingly and develop comprehensive performance metrics. A strategic integration of these elements can lead to transformative changes in business practices and innovative sustainability strategies. Literature on the circular economy and business analytics provides valuable insights that support and complement these implications.

Theoretical implications

This study pushes the boundaries of business analytics literature and its interface with previous studies, especially those drawing from the Dynamic Capability Theory (DCT) perspective. Specifically, our study offers an important contribution to theory by highlighting the conditions under which firms can effectively leverage BAC to improve SP. First, our study contributes to the literature by offering a contemporary perspective on the implications of BAC for firms. Even though previous studies (Trkman *et al.*, 2010; Chae *et al.*, 2014; Fosso Wamba and Akter, 2019; Shafiq *et al.*, 2020; Ahmed *et al.*, 2020; Hallikas *et al.*, 2021; Kalaitzi and Tsolakis, 2022; Khan *et al.*, 2023) found a positive effect of analytics on varied performance outcomes, this study attempts to offer a contemporary clarification of the effect of BAC on SP, which is rarely explored. Secondly, our review indicated the neglect of sustainable performance as a performance outcome of BAC, rendering the literature stream incomplete. This study draws on the DCT and previous studies to broaden the frontiers of the theoretical specification of the performance implications of BAC (see Ashrafi *et al.*, 2019; Dubey *et al.*, 2018; Kalaitzi and Tsolakis, 2022). We argue that sustainable performance, which is an important performance measure, plays a critical role in the survival of an organisation (Audenaert *et al.*, 2019; Betancourt Morales and Zartha Sossa, 2020). Unlike previous studies, which cluster around firm performance with few on operational and financial performance, we advance the boundaries of earlier scholars by showing that BAC is also important for SP. Thirdly, while previous studies have largely conceptualised sustainable performance as an aggregate, uni-dimensional construct, this study conceptualises sustainable performance as a multi-dimensional construct (economic, environmental and social) and offers empirical insight on how to BAC the various dimensions of SP. Our study is therefore among the first attempts to demonstrate the partial mediation effect of the circular economy on the BAC and the different dimensions of sustainable performance. The findings therefore offer empirical validation that BAC drives different dimensions of sustainable performance. Finally, we contribute to the advancement of theoretical underpinnings pertaining to the intricate nature of performance within manufacturing firms, particularly in the context of limited resources prevalent in developing nations such as Ghana. Firms in emerging economies like Ghana face challenges related to limited resources, which hinder their ability to effectively utilise BAC for supporting sustainability. Insufficient investment in technology and network skills might have detrimental consequences for these firms. Therefore, we present a comprehensive framework for such firms that can assist them in enhancing both their performance throughout their supply chains as well as their overall performance.

Managerial implications

The findings of this study also hold important implications for managerial practices. In terms of practical relevance, firms may find this research useful in three main areas. Firstly, this research serves as a motivating factor for organisations considering a transition towards the circular economy (CE). The study reveals that business analytics (BA) bolsters the implementation of circular strategies and positively impacts various facets of organisational performance, including competitiveness, corporate reputation, financial outcomes and environmental initiatives. These findings offer a compelling business rationale for adopting circular strategies and leveraging investments in BA. Furthermore, the research provides strategic justifications for shifting towards a more sustainable mode of business operations. This can be particularly beneficial for forward-thinking managers and early CE adopters who may require support for initiating corporate strategy changes. Secondly, the study assists companies in understanding the critical organisational resources and capabilities required to effectively harness BA for the circular economy (CE). As organisations adapt to meet evolving customer needs and sustainability requirements, the investments they make become pivotal for their long-term survival and competitiveness. Therefore, the accurate identification of where to allocate resources and which capabilities to cultivate becomes paramount. The study highlights that effectively leveraging BA for CE necessitates investments across various dimensions, including talent, culture and technology. As evidenced by the eight distinct factors constituting business analytics capability (BAC) for the circular economy, companies should not focus solely on tangible assets like data and IT infrastructure but should also ensure investments in their human capital. For instance, they can improve managers' systems thinking skills and foster a commitment to establishing a data-driven culture. By unravelling the relationship between BA and CE, this study promotes a more holistic approach to information management, encouraging a greater focus on "green digital transformation" within organizations. These findings can aid in the development of more comprehensive guidelines for implementing circular strategies and assist organisations in making more cost-effective BA investments. For example, they can utilise BAC as a benchmarking tool to assess a firm's maturity and guide its investments through tailored roadmaps. Organisations should consider adopting and integrating circular economy principles into their core business strategies. The mediation effect suggests that BAC alone is insufficient to fully realise the potential of sustainable performance. By strategically embracing circular economy practices, businesses can unlock the synergistic benefits of data-driven decision-making and circularity. Managers need to adopt a holistic approach to sustainability. Rather than viewing sustainability solely through the lens of BAC or circular economy practices, organisations should recognise the interplay between the two. This implies that sustainability strategies should consider environmental, economic and social dimensions, as these are often interconnected within the circular economy framework. In conclusion, the fact that the circular economy acts as a go-between for BAC and sustainable performance shows that sustainability needs to be approached in a strategic, all-encompassing and fair way. This includes resource allocation, talent development and the development of comprehensive performance metrics. By recognising the interplay between BAC and the circular economy, organisations can enhance their sustainability strategies and improve their overall sustainable performance.

Conclusion

Despite the wide contention that business analytics capability has diverse performance implications, the mechanisms and conditions under which BAC drives performance have received little or no attention. The proposed model was tested using survey data from 246 manufacturing firms in Ghana. The findings revealed that both business analytics capability and the circular economy significantly drive all three dimensions of sustainable performance. Our findings further suggest that the circular economy does not just support sustainable performance but also serves as a transformative mechanism to reap superior sustainable performance via BAC. Additionally, we also found a partial mediation effect of the circular economy on the BAC and the different dimensions of sustainable performance.

Limitations and recommendations for future studies

Despite the contribution of this study to extending sustainability performance discourse, the outcome must be interpreted in light of its limitations. The study focuses on managers of manufacturing firms in Ghana, which may limit the generalizability of the findings to other industries or regions. The use of cross-sectional data limits the ability to establish causality between BAC, CEI and sustainable performance. Longitudinal studies could provide more robust insights into the causal relationships. The study relies on self-reported data, which may be subject to common method bias. Future studies could use multiple data sources or objective measures to mitigate this bias. The study does not explicitly consider the influence of contextual factors, such as industry characteristics or organizational culture, which could affect the relationship between BAC, CEI and sustainable performance. Future research could employ longitudinal designs to better understand the causal relationships between BAC, CEI and sustainable performance over time. Extending the research to include firms from various industries could provide a more comprehensive understanding of the implications of BAC for sustainable outcomes. Complementing quantitative analyses with qualitative research methods could provide deeper insights into the mechanisms through which BAC influences CEI and sustainable performance. Considering contextual factors, such as regulatory environments or market dynamics, could help in understanding how these factors influence the relationship between BAC, CEI and sustainable performance.

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