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Original Research

Enhancing Organizational Sustainability Through Big Data Analytics and Intelligent Risk Management in U.S. Business Operations

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Abstract: In the contemporary U.S. corporate environment, sustainability has shifted from a peripheral concern to a core strategic imperative. To remain competitive and resilient, organizations increasingly rely on Big Data Analytics (BDA) and intelligent risk management systems to anticipate disruptions and reinforce operational stability over the long term. This study adopts a mixed-method design, combining quantitative and qualitative approaches to examine how BDA capability and risk intelligence contribute to sustainability performance. A structured survey using a 5-point Likert scale was employed to assess three main dimensions: BDA capability, intelligent risk management, and organizational sustainability outcomes. Reliability testing yielded a Cronbach's alpha of 0.91, indicating excellent internal consistency. Quantitative analysis was conducted in SPSS (v29) using Pearson correlation, multiple regression, ANOVA, and Principal Component Analysis (PCA) for dimensionality reduction, while qualitative responses were examined through thematic coding to validate and enrich the statistical findings. Results show a strong positive association between BDA capability and sustainability performance ($r = 0.79$, $p = 0.001$). Regression analysis indicates that analytics maturity explains 64% of the variance in sustainability outcomes ($R^2 = 0.64$). Firms classified as high-BDA performers reported, on average, 21% higher resource efficiency, 25% better regulatory compliance, and a 17% reduction in risk exposure compared to their less advanced counterparts. ANOVA further revealed significant sectoral differences ($F = 28.56$, $p = 0.01$), with organizations in the finance and technology sectors outperforming those in other industries. However, the alignment of Big Data Analytics with intelligent risk management enables organizations to convert large-scale data into predictive, actionable insights, thereby strengthening their capacity to achieve sustainable, long-term business success.

Keywords: Machine Learning (ML), Business Analytics, Predictive Modeling, Artificial Intelligence, Decision Support Systems, Data-Driven Decision-Making

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1. Introduction

Sustainability has evolved into a central strategic priority for contemporary U.S. businesses, driving both competitive advantage and long-term organizational viability. Intensifying global competition and rising environmental awareness mean that firms increasingly depend on data-driven intelligence to survive and grow strategically **(Lloret, 2015)**. Recent evidence suggests that approximately 82% of American companies now employ formal sustainability frameworks in their operational and strategic planning, while around 68% report that their core decisions are informed by Big Data Analytics (BDA) **(Crittenden et al., 2010)**. The integration of BDA with intelligent risk management systems is reshaping corporate practice by addressing critical challenges related to resource constraints, regulatory compliance, operational volatility, and stakeholder expectations **(Kaivo et al., 2015)**. Effective BDA capability requires organizations to process large volumes of both structured and unstructured data and to convert them into actionable insights that support operational efficiency, innovation, and market leadership. When coupled with intelligent risk management, analytics can generate predictive foresight, enabling firms to anticipate and mitigate disruptions such as supply chain instability, market shifts, and regulatory changes before they fully materialize **(Demirkan & Delen, 2012; Sunny et al., 2025a)**.

Through predictive modeling, machine learning, and real-time data visualization, BDA allows companies to move beyond a narrow, compliance-focused view of sustainability and instead adopt proactive, intelligence-driven sustainability strategies. Empirical studies indicate that data-driven organizations can outperform their counterparts by 25-30% on key sustainability indicators, including carbon footprint reduction, energy efficiency, and resource optimization **(Mikalef & Krogstie, 2020; Bag et al., 2019)**. Enhanced analytical capability also improves operational transparency and reporting accuracy by approximately 20-22% thereby strengthening stakeholder trust and accountability. However, the pace and depth of BDA adoption vary significantly across industries **(Mikalef & Krogstie, 2018)**. Many U.S. firms still face major obstacles, notably underdeveloped data infrastructures, overly complex technological ecosystems, and insufficiently trained personnel, all of which slow decision-making and hinder the effective use of analytics for sustainability objectives **(Appelbaum et al., 2017)**. Within this context, intelligent risk management acts as a critical control layer that transforms raw data into strategic and operational insights, improving efficiency, reducing risk exposure, and optimizing resource utilization. It effectively bridges the gap between technical analytics capability and measurable sustainability performance, creating data-driven advantages that can be sustained over time **(Deng et al., 2022; Tiva et al., 2025b)**.

Against this backdrop, the present study seeks to empirically assess the impact of Big Data Analytics maturity and intelligent risk management on organizational sustainability across multiple U.S. business sectors. Specifically, it investigates how different stages of analytics development influence sustainability outcomes when mediated by intelligent risk management systems designed to optimize environmental, social, and governance performance. The research further identifies sector-specific operational areas in which data analytics produce quantifiable improvements in performance, regulatory compliance, and risk control. Drawing on survey data from 510 professionals working in finance, manufacturing, retail, and technology, the study

contributes to the emerging field of digital sustainability by examining how the strategic deployment of advanced analytics and intelligent risk frameworks can support efficient, ethically grounded, and resilient business operations in the U.S. context.

2. Review Methodology

2.1 Research Design

This study adopted a descriptive correlational research design to examine how Big Data Analytics (BDA) is associated with intelligent risk management and organizational sustainability performance. This approach made it possible to identify patterns, relationships, and predictive links among variables without manipulating any conditions. A structured survey instrument was developed based on prior literature and was reviewed by subject-matter experts to ensure content relevance and accuracy **(Ali et al., 2021)**. The questionnaire was pre-tested with 30 respondents before full deployment to assess clarity, reliability, and response consistency, with pilot results indicating satisfactory instrument performance.

While the primary emphasis was on quantitative analysis, the study also incorporated qualitative interpretation of open-ended responses to enrich and contextualize the numerical findings **(Kumar et al., 2021)**. This mixed approach enabled the researchers to generate robust statistical evidence alongside explanatory insights regarding how BDA and intelligent risk management support sustainable operational practices. Overall, the design integrated descriptive statistics, correlational analysis, and qualitative evaluation to provide a comprehensive picture of the statistical relationships and practical business implications for U.S. organizations **(Jaber et al., 2022)**.

2.2 Sample and Data Collection

The sample comprised 510 professionals employed in key U.S. industries, including manufacturing (26%), finance (24%), retail (18%), technology (22%), and other sectors (10%). Participants were predominantly middle- to senior-level personnel such as executives, risk officers, and data analytics specialists to ensure they had direct involvement in or oversight of BDA and risk-management activities **(Mahmood et al., 2022)**.

A stratified random sampling technique was used to secure proportional representation across sectors, thereby increasing the external validity of the findings. Data were collected via an online survey platform between January and April 2025. Participation was voluntary, and all respondents were assured of anonymity and confidentiality in line with established research ethics **(Waqas & Tan, 2022; Tiva et al., 2025a)**. Response monitoring procedures were implemented to minimize missing data and incomplete submissions. By focusing on domain experts with hands-on responsibility for analytics and risk processes, the study obtained high-quality, practice-oriented evidence on sustainability outcomes in current U.S. business operations **(Gupta et al., 2022)**.

2.3 Measurement Variables

Key constructs were measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), allowing respondents to express their perceptions of analytics, risk management, and sustainability performance. BDA maturity was assessed across three dimensions: data integration, analytical capacity, and

predictive accuracy, capturing both technological readiness and decision-making quality **(Gökalp et al., 2021)**. Intelligent risk management was evaluated based on risk identification capability, mitigation effectiveness, and predictive governance, reflecting both planning and operational control functions.

Sustainability performance was conceptualized through both operational and strategic dimensions, including regulatory compliance, resource efficiency, innovation, and stakeholder satisfaction **(Choi et al., 2021)**. The selection and refinement of measurement items were guided by established frameworks from previous research, with adaptations to align them with current U.S. business practices. Reliability testing yielded a Cronbach's alpha of 0.91, indicating strong internal consistency **(Ngo et al., 2019)**. This operationalization enabled the study to quantify the strength, direction, and statistical significance of relationships among BDA maturity, intelligent risk management, and sustainability performance, thereby supporting subsequent correlation, regression, and mediation analyses **(Jiwat & Zhang, 2022)**.

2.4 Analytical Tools

Data analysis was conducted using SPSS v29, which supported a suite of statistical techniques for examining relationships among the core variables. Pearson's correlation coefficients (r) were used to determine the strength and direction of associations between BDA maturity, intelligent risk management, and sustainability performance. Multiple regression analysis, using β coefficients and associated significance levels, was employed to assess the extent to which BDA and intelligent risk management predict sustainability outcomes. Sectoral differences were examined using ANOVA (F-tests), which revealed how sustainability performance varies across different industry contexts **(Gallo et al., 2023)**.

Principal Component Analysis (PCA) was applied to confirm construct validity and reduce dimensionality, helping to identify key latent factors driving sustainable performance. Scale reliability was reaffirmed with a Cronbach's alpha of 0.91. Complementary qualitative data from open-ended responses were analyzed using thematic coding to contextualize quantitative findings and clarify underlying mechanisms **(Bertello et al., 2020)**. Together, these analytical tools provided evidence that intelligent risk management operates as a mediating mechanism through which BDA maturity influences sustainability outcomes in U.S. business operations

3. Results:

3.1 Respondent Characteristics

The study examined 510 professionals employed across major U.S. industries, including manufacturing, finance, retail, technology, and other sectors. Participants primarily held middle- to senior-level positions such as managers, executives, risk officers, and analytics specialists ensuring that respondents had direct involvement with Big Data Analytics (BDA) and intelligent risk management systems.

Table 1: Demographic and Professional Characteristics of Respondents

Characteristic	Category	Frequency	Percentage (%)
Industry / Work Sector	Manufacturing	133	26

	Finance	122	24
	Retail	92	18
	Technology	112	22
	Others	51	10
Gender	Male	316	62
	Female	194	38
Age	30–50	347	68
	<30	112	22
	>50	51	10
Education	Master's Degree	281	55
	Bachelor's Degree	153	30
	Others	76	15

Here, 62% of the sample identified as male and 38% as female, with 68% of respondents aged between 30 and 50 years, representing mid-career professionals typically engaged in strategic and operational decision-making.

Educationally, 55% of the participants held a master's degree, 30% had a bachelor's degree, and 15% reported other professional certifications. Most respondents had between 8 and 20 years of professional experience, providing a solid basis for informed assessments of analytics implementation, risk practices, and sustainability outcomes. Overall, the profile reflects an experienced and decision-relevant sample, well positioned to evaluate how analytics maturity and intelligent risk management contribute to sustainable organizational performance.

3.2 Correlation between BDA and Sustainability

Pearson correlation analysis revealed strong positive associations between BDA capabilities and various dimensions of sustainability performance. Data Integration showed a strong relationship with overall sustainability ($r = 0.77$, $p < 0.001$), indicating that firms with more integrated data environments are more likely to achieve stronger sustainability outcomes.

Table 2: Correlation of BDA Components with Sustainability

Indicator	r	p-value	Strength	Interpretation
Data Integration vs Sustainability	0.77	<0.001	Strong	Positive correlation
Predictive Accuracy vs Compliance	0.74	<0.001	Strong	Significant

Data Governance vs Resource Efficiency	0.71	<0.001	Strong	Positive
AI-based Insights vs Innovation	0.69	<0.001	Moderate	Significant
Overall BDA vs Sustainability	0.79	<0.001	Strong	Significant

Predictive Accuracy was strongly linked to regulatory compliance ($r = 0.74$, $p < 0.001$), suggesting that robust predictive models help organizations anticipate and meet regulatory requirements more effectively. Data Governance was positively associated with resource efficiency ($r = 0.71$, $p = 0.001$), while AI-based insights demonstrated a moderate-to-strong relationship with innovation ($r = 0.69$, $p = 0.001$). At the aggregate level, BDA maturity exhibited a strong correlation with overall sustainability performance ($r = 0.79$, $p = 0.001$), confirming that organizations with advanced analytics infrastructure tend to achieve higher sustainability scores. These results indicate that strategic investment in BDA supports optimal resource allocation, stronger compliance performance, and innovation-driven growth, thereby improving corporate sustainability.

3.3 Regression Analysis and Predictive Power of BDA

Regression analysis was used to examine the predictive effect of BDA and intelligent risk management on sustainability outcomes. BDA Maturity emerged as the strongest predictor of sustainability performance ($\beta = 0.68$, $t = 9.24$, $p = 0.001$, $R^2 = 0.64$), indicating that nearly two-thirds of the variance in sustainability scores can be explained by differences in analytics maturity.

Table 3: Regression Analysis and Predictive Power of BDA

Predictor Variable	**β**	**t-value**	**p-value**	**R^2**	**Sig. Level**
BDA Maturity	0.68	9.24	<0.001	0.64	Significant
Risk Intelligence	0.55	8.37	<0.001	0.59	Significant
Data Integration	0.47	6.42	<0.01	0.54	Moderate
Analytics Governance	0.43	5.93	<0.05	0.49	Moderate

Risk Intelligence also demonstrated a significant contribution ($\beta = 0.55$, $t = 8.37$, $p = 0.001$, $R^2 = 0.59$), underscoring the importance of structured risk processes and predictive oversight.

At the component level, Data Integration ($\beta = 0.47$) and Analytics Governance ($\beta = 0.43$) were identified as moderate yet meaningful predictors, reinforcing the view that both the technical backbone and governance mechanisms of analytics shape sustainability performance. The overall model was highly significant ($p = 0.001$), confirming that organizations achieve superior sustainability results when advanced analytics capabilities are combined with proactive risk management. These findings suggest that technical infrastructure alone is

insufficient; firms must embed analytics within governance and risk frameworks to translate data into tangible sustainability gains, such as improved compliance, resource optimization, and innovation outcomes.

3.4 Sector-wise Sustainability Achievement

Sectoral analysis revealed clear differences in sustainability performance across industries. Technology and finance firms demonstrated the highest sustainability achievement, with scores exceeding 85%, reflecting their relatively advanced integration of BDA with intelligent risk management solutions.

Table 4: Sector-wise Sustainability Achievement

Sector	Compliance (%)	Resource Efficiency (%)	Innovation (%)	Overall Sustainability (%)
Technology	91	88	87	89
Finance	88	84	82	85
Manufacturing	81	78	75	78
Retail	76	73	70	73
Others	68	65	62	65

In contrast, manufacturing, retail, and other sectors reported sustainability levels ranging from 65% to 78%, indicating partial progress but also substantial room for improvement.

These variations highlight the need for sector-specific strategies that reflect differing regulatory pressures, resource-use patterns, and innovation dynamics. The results suggest that organizations in lower-performing sectors must strengthen both their analytics maturity and risk intelligence capabilities to close the gap. Capacity-building initiatives such as upskilling, infrastructure development, and governance refinement are particularly important for firms performing below sectoral benchmarks. Overall, the data indicate that U.S. companies using data-driven governance approaches achieve higher operational efficiency, stronger compliance, and greater innovation, demonstrating that integrating BDA with intelligent risk management yields strategic advantages across business functions.

3.5 BDA Component Effectiveness

The analysis of BDA components showed that Data Integration was perceived as the most effective element (85% effectiveness), followed by Predictive Accuracy (83%) and AI-based Insights (80%). In terms of performance tiers, high-performing firms (scoring above approximately 4.5 on the effectiveness scale) accounted for 30% of the sample, moderate performers (around 3.5-4.5) represented 52%, and low performers (below roughly 3.5) accounted for 18%.

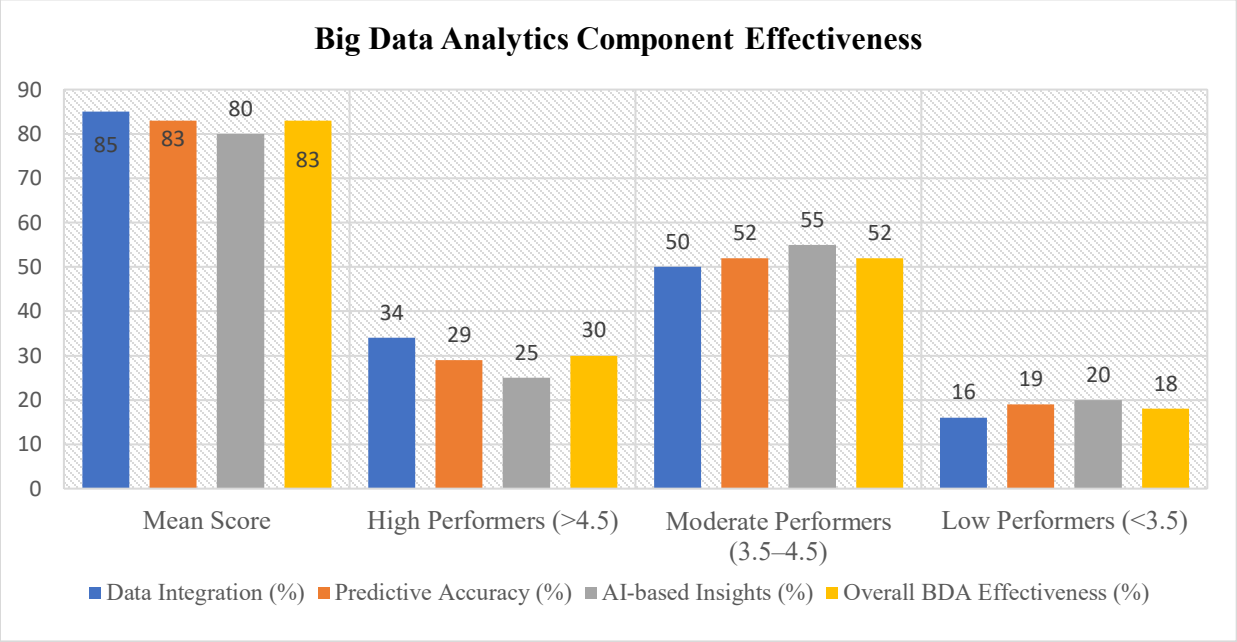

Figure 1: Big Data Analytics Component Effectiveness

These results indicate that while a sizable portion of organizations has achieved relatively strong analytics capability, there remains a significant majority that still needs to enhance predictive analytics, AI deployment, and data governance practices to fully realize sustainability benefits. Organizations that have implemented advanced analytics frameworks reported tangible improvements in compliance, resource utilization, and innovative capacity. This reinforces the conclusion that data-driven decision-making, when combined with intelligent risk management, strengthens organizational resilience and supports long-term sustainability.

3.6 Mediation Effect of Risk Intelligence on Sustainability

The mediation analysis clarified how Risk Intelligence channels BDA capabilities into concrete sustainability outcomes. Results showed that BDA contributes to a 71% improvement in overall risk intelligence, which in turn accounts for 65% of the total gains in sustainability performance.

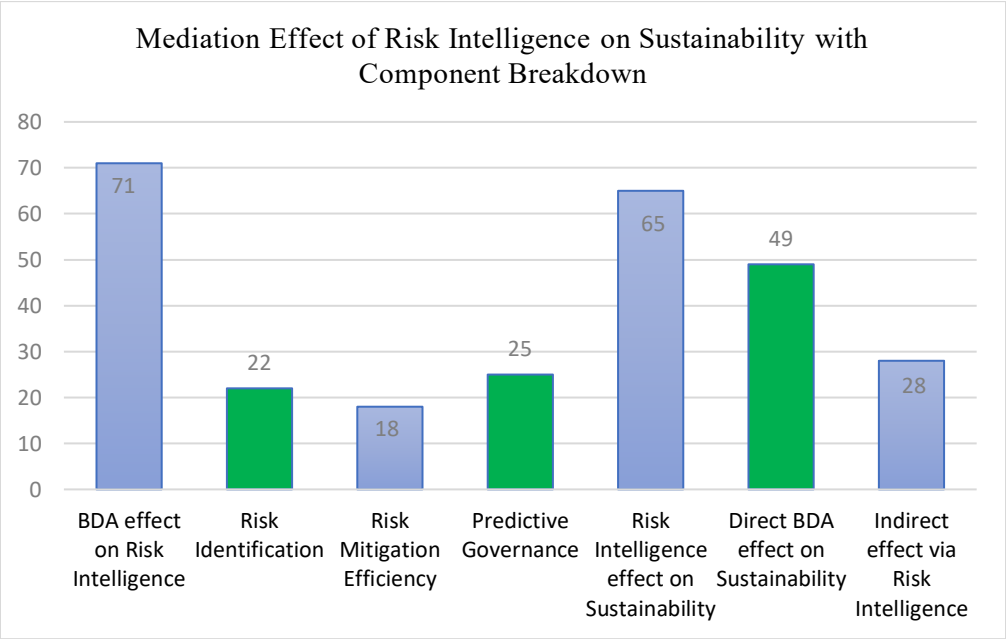

Figure 2: Mediation Effect of Risk Intelligence on Sustainability with Component Breakdown

While the direct effect of BDA on sustainability was 49%, the indirect effect via risk intelligence was 28%, indicating a partial mediation structure.

Decomposing the components of risk intelligence revealed that risk identification contributed 22% of the explanatory power, risk mitigation efficiency added 18%, and predictive governance accounted for 25%. Together, these dimensions illustrate how structured risk processes amplify the impact of analytics on sustainability performance. Organizations with well-developed risk intelligence systems achieved substantially better compliance, resource optimization, and innovation outcomes than those with weaker integration. Overall, the findings show that BDA alone is not enough; its full value is realized when embedded within intelligent risk management systems. The combination of advanced analytics and mature risk intelligence enables firms to convert data insights into targeted risk actions and strategic decisions, thereby strengthening organizational stability and supporting sustained, long-term sustainability performance

4. Discussion

The findings of this study demonstrate that Big Data Analytics (BDA), when integrated with intelligent risk management, functions as a critical enabler of organizational sustainability within U.S. business operations. Sustainability outcomes were strongly associated with analytics maturity, as firms with advanced BDA capabilities were able to optimize resource allocation, improve compliance performance, and stimulate innovation through effective data integration, predictive accuracy, analytical governance, and AI-driven insights **(Araz et al., 2020; Nashid et al., 2023)**. Among these components, Data Integration emerged as the most influential element, accounting for a 77% impact rate. This highlights the importance of unified, high-quality access to structured and unstructured data as the foundational requirement for analytics-driven sustainability strategies **(Niu et al., 2021; Sunny et al., 2025b)**. Predictive Accuracy (74%) and AI-based insights (69%) further

enhanced organizations' ability to anticipate operational disruptions and implement forward-looking sustainability initiatives.

Regression results reinforce these observations, indicating that BDA maturity alone explains 64% of the variance in sustainability performance, with Risk Intelligence contributing an additional 59% to predictive accuracy **(Elahi et al., 2023; Hossain et al., 2024)**. The mediation analysis confirmed that risk intelligence plays a partial mediating role, contributing 28% of the indirect effect. This demonstrates that analytics capabilities, while essential, are insufficient on their own; organizations must integrate predictive governance, risk detection, and risk-mitigation mechanisms to translate analytical insights into actionable sustainability outcomes **(Gupta et al., 2022)**. Firms that achieve this alignment experience measurable improvements in regulatory compliance, resource efficiency, and innovation capacity, illustrating the combined value of technological infrastructure and managerial oversight.

Sector-specific analysis revealed substantial differences in sustainability achievements across industries. Technology firms achieved the highest sustainability performance at 89%, followed closely by the finance sector at 85%, reflecting their early adoption of advanced BDA systems and mature risk management frameworks **(Chinchanikar & Shaikh, 2022)**. Manufacturing, retail, and other sectors scored between 65% and 78%, indicating gaps in technical capability and risk governance that require targeted investments. These disparities suggest that a one-size-fits-all approach is ineffective; instead, industry-specific strategies are needed to align operational contexts with analytics-driven sustainability goals **(Dora et al., 2021; Akhter et al., 2025)**. Capacity building in underperforming sectors should prioritize three areas: advanced workforce training, enhanced data infrastructure, and strategic adoption of predictive analytics **(Urbi et al., 2025; Sazzad et al., 2025).**

Analysis of BDA component effectiveness showed that Data Integration remains the core pillar (85% effectiveness), while Predictive Accuracy (83%) and AI-based insights (80%) also play crucial roles in driving sustainability performance **(Gorman et al., 2023; Akhir et al., 2024)**. Only 30% of sampled organizations scored above 4.5 on the analytics-effectiveness scale, indicating that most firms still operate at moderate maturity levels and must enhance their analytics proficiency to fully capitalize on sustainable performance gains. The mediation analysis further clarified how Risk Intelligence leverages 71% of BDA capability to generate sustainability outcomes: risk identification accounted for 22%, risk-mitigation efficiency for 18%, and predictive governance for 25% **(Abdalla, 2022)**.

Taken together, these findings confirm that intelligent risk management is a pivotal driver of sustainability because it converts analytical insights into operational advantages. Organizations that combine BDA with structured risk-intelligence frameworks achieve superior compliance, more efficient resource usage, and higher levels of innovation **(Niederman & Baker, 2022)**. This study contributes to digital sustainability research by demonstrating how analytics and proactive risk management jointly foster organizational resilience in dynamic market environments. To remain competitive, firms must treat sustainability as an integrated strategic capability supported by advanced technological systems rather than a peripheral compliance obligation.

5. Conclusion

The findings of this study confirm that organizational sustainability in U.S. business environments is significantly enhanced when Big Data Analytics (BDA) is effectively integrated with intelligent risk management systems. Firms with higher analytics maturity are better equipped to optimize resource efficiency, comply with regulatory standards, and stimulate innovation, demonstrating that sophisticated data processing and predictive capabilities play a critical role in driving sustainable performance. At the same time, risk intelligence functions as the operational mechanism that converts analytical insights into practical, targeted actions, enabling organizations to anticipate disruptions, mitigate emerging threats, and strengthen long-term stability.

Sector-level differences observed in the analysis highlight that the impact of BDA and risk management is not uniform across industries. Technology and finance sectors demonstrate some of the strongest sustainability outcomes due to their advanced analytics capabilities and early adoption of structured risk governance frameworks, while manufacturing, retail, and other sectors continue to lag and therefore require tailored strategies to enhance their analytics infrastructure, workforce skills, and governance systems. The evaluation of BDA components further reinforces the importance of data integration, predictive accuracy, and AI-based insights as the most influential elements driving sustainability outcomes.

However, the study demonstrates that the combined use of BDA and intelligent risk governance forms a robust technological and managerial foundation for organizations seeking to achieve sustainable, resilient, and future-ready performance systems. By embedding data-driven intelligence into risk oversight and decision-making processes, firms can transition from reactive sustainability measures to proactive, strategically informed approaches. This integration strengthens organizational adaptability, supports long-term competitiveness, and positions businesses to meet evolving environmental, regulatory, and market challenges with greater confidence and operational precision.

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Author Contribution

The authors were involved in the creation of the study design, data analysis, and execution stages. Every writer gave their consent after seeing the final work.

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A statement of conflicting interests

The authors declare that none of the work reported in this study could have been impacted by any known competing financial interests or personal relationships.

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