Software Quality Journal (2024) 32:607–640
https://doi.org/10.1007/s11219-024-09666-4

RESEARCH

Exploring the role of big data analytics and dynamic capabilities in ESG programs within pharmaceuticals

Antonio Pesqueira[1] · **Maria José Sousa**[1]

Accepted: 20 February 2024 / Published online: 6 March 2024

Abstract

Achieving the United Nations' Sustainable Development Goals (SDGs) requires environmental, social, and governance (ESG) programs in the pharmaceutical industry. Using the Millennium Development Goals, the 2030 agenda aims to transform European Union companies toward sustainability. In pharmaceuticals, in particular, ESG programs come with complexities such as employee skills, corporate goals, and management expectations. Managing these programs effectively requires advanced technologies such as big data analytics (BDA) and dynamic capabilities (DC). In this study, DC theory is used to develop an architecture for managing ESG criteria, focusing on provenance, traceability, and availability. BDA's role in ESG programs is explored, along with its use cases and benefits, and how DC drives success in ESG implementation. The study examined five pharmaceutical companies in Germany, Portugal, and Switzerland, all consulting the same firm for BDA systems, to identify the characteristics of effective BDA implementation. The research explores how BDA and DC jointly enhance ESG efforts, the essential skills needed, and how DC aids in real-time decision-making in BDA projects aligned with ESG standards. It highlights the BDA system's accuracy and effectiveness in managing ESG programs, with DC as a pivotal facilitator. Findings reveal BDA's value in operational efficiency and aligning business models with ESG goals, underscoring the need for diverse skills in BDA implementation and DC's importance in integrating various managerial capacities into effective strategies. The study promotes a dynamic, data-driven approach in the pharmaceutical industry for managing complex ESG initiatives. It stresses continuous learning, adaptation, and integrating technological advances with ethical business practices. The research concludes by emphasizing BDA and DC's vital roles in advocating ethical, socially responsible, and environmentally sustainable practices in the pharmaceutical sector, marrying technology with ethical business strategies.

Keywords Supply and distribution · Big data · Technology · Organization and management · Emerging capabilities

✉ Antonio Pesqueira
antonio_pesqueira@iscte-iul.pt

Maria José Sousa
maria.jose.sousa@iscte-iul.pt

[1] ISCTE-IUL, Lisbon, Portugal

1 Introduction

The pharmaceutical industry, a major contributor to global greenhouse gas emissions due to its R&D and supply chain operations, is under scrutiny for its environmental, social, and governance (ESG) practices. As the industry moves toward a low-carbon economy, integrating ESG principles such as reducing emissions, developing sustainable medicines, and promoting inclusivity become crucial (Akter et al., 2020; Cao et al., 2021; Ciampi et al., 2021).

ESG programs hold increasing importance for pharmaceutical companies and European businesses. They ensure compliance with environmental and health regulations, crucial in the heavily regulated pharmaceutical sector. Furthermore, ESG criteria are becoming a key consideration for investors, enhancing a company's attractiveness, financial performance, and competitive edge in terms of brand equity and social responsibility (Ciampi et al., 2021; Gebhardt et al., 2022).

Regulatory requirements, market expectations, and sustainability challenges all require the use of advanced technologies like big data analytics (BDA) and artificial intelligence (AI). Integrating, building, and reconfiguring competencies to address changing environments require the concept of dynamic capabilities (DC). Technology implementation at DC contributes to broader ESG goals, fosters collaboration across departments, and facilitates resource allocation efficiently (Mostafiz et al., 2022; Pesqueira et al., 2020; Wang et al., 2018a, b).

The complexities of technologies like BDA, combined with AI, are particularly challenging in pharmaceuticals due to regulatory scrutiny and public expectations. These technologies necessitate new organizational and individual competencies in managing governance, people, and operational risks (Mikalef et al., 2019; Mostafiz et al., 2022; Wang & Wu, 2016).

The synergy between BDA and DC in sustainable healthcare performance and ESG program management is emerging but underexplored. While the literature on BDA is extensive, its direct connection to enhancing ESG programs in pharmaceuticals is limited. BDA literature reflects its transformative potential in drug development, personalized medicine, and operational efficiency, offering insights into patient care and streamlining processes. However, challenges like data quality and the need for skilled personnel persist (Bari et al., 2022; Jucevičius & Jucevičienė, 2022; Junaid et al., 2023).

DC literature highlights a firm's adaptability through internal and external capabilities, crucial for innovation, regulatory compliance, and market responsiveness. Future research should focus on the relationship between human capital and DC, aligning organizational culture with dynamic strategies, and managing innovation costs. BDA's potential for enhancing DC within ESG programs is evident, particularly in capturing real-time consumer data, improving operational efficiency, and optimizing supply chain management (SCM). Future research should investigate AI integration with BDA for optimizing ESG outcomes (Kähkönen et al., 2023; Kodama, 2018).

Integrating BDA and DC can advance ESG programs in healthcare and pharmaceuticals. While BDA presents transformative possibilities, it also poses challenges.

An investigation of DC's role in organizational development, business management, networking, and leadership is needed. BDA and DC are combined in this study to enhance ESG initiatives in the pharmaceutical sector. Through their synergistic effects, requisite skills, and roles in BDA implementation, DCs facilitate real-time

decision-making and governance. To optimize sustainable and ethical practices in pharmaceuticals, BDA, DC, and ESG programs are intertwined.

Launched at the end of 2021, the study examines five pharmaceutical companies across Germany, Portugal, and Switzerland. It investigates how DC and agile frameworks like Scrum can mitigate risks in BDA technology implementation amid operational complexities and business uncertainty, especially considering some executives' reservations about ESG programs due to high initial costs and limited understanding of their strategic value.

The research underscores the importance of DC frameworks and agile project management methods like Scrum in high-impact projects. It contributes to academia by highlighting the interaction between BDA systems and ESG initiatives in the European pharmaceutical industry. The study focuses on integrating BDA and DC within ESG frameworks as a key innovation and strategic development area.

This research aims to provide a thorough understanding of the combined use of BDA and DC in advancing ESG initiatives, exploring applications, identifying opportunities and challenges, and emphasizing the intersection of technical expertise and ethical considerations.

The study bridges technological capability and ethical responsibility by exploring BDA and DC's potential to drive ESG initiatives. Designed for industry professionals, policymakers, and academics, it promotes sustainable and responsible practices in the pharmaceutical industry. With its multidimensional approach, this research can be considered a pioneering study in addressing the challenges and opportunities of advanced technologies.

2 Literature review

2.1 Big data

The literature review highlights the transformative role of BDA in healthcare and pharmaceuticals, emphasizing its impact on drug development, patient care, and operational efficiency. BDA's capacity to process large, complex datasets is revolutionizing healthcare by identifying patient trends, enabling personalized treatments, and optimizing processes. In drug discovery and development, BDA enhances the analysis of extensive datasets, predicts drug interactions, and expedites clinical trials, thus improving medication safety and efficacy (Akter et al., 2020; Cao et al., 2021).

Personalized medicine, a major advancement in healthcare, relies on BDA to tailor treatment plans based on patient data, shifting toward proactive healthcare through risk prediction and illness prevention. BDA also increases operational efficiency in healthcare organizations by optimizing resource allocation and service delivery (Mehta & Pandit, 2018; Mikalef et al., 2019; Wamba et al., 2020).

Despite its advantages, BDA in healthcare encounters challenges like data quality, the integration of diverse data sources, and the necessity for skilled personnel to analyze complex datasets. Future research should address these issues, develop advanced data analytics methods, and examine the ethical aspects of data usage in healthcare (Mikalef et al., 2019; Mostafiz et al., 2022; Wang & Wu, 2016).

Data security and ethical usage are paramount, given the increasing volume of healthcare data. Healthcare organizations must focus on robust security measures and protocols to protect data integrity and ensure its ethical use, including patient consent.

The concept of big data (BD) in healthcare is evolving, sometimes confusing its relationship to data science and traditional data management. It includes various data types like diagnoses, vital signs, and electronic health records, useful for predicting diseases in asymptomatic patients (Mehta & Pandit, 2018).

Big data's significance in healthcare lies in developing patient-centric outcomes and sustainable delivery models, maximizing scientific and clinical advancements. However, healthcare systems face challenges in effectively allocating investments in big data. Restrictive data privacy laws and consent requirements could impede big data's full potential in research and treatment. BDA strategies are proving beneficial in healthcare decision-making, generating savings, fostering innovation, and enhancing research and clinical diagnosis efficiency. This trend is evident in healthcare providers and insurance companies dealing with increasing data variety and volume (Shahbaz et al., 2020).

In the pharmaceutical industry, advanced BD infrastructures are creating new digital platforms and business intelligence ecosystems, leading to innovative business models and value creation. BD applications in Pharma are varied, aiding clinical, commercial, and market access teams. Utilizing electronic data capture and advanced analytics, such as machine learning, enhances activities like targeted promotions and patient outcome analysis. The FDA and EMA's approval of wearable medical devices indicates a growing reliance on data collection platforms in pharmaceutical patient engagement. These devices improve data reliability, enhancing dataset quality and research results. BDA differs among pharmaceutical companies and consultants, with pharmaceutical companies focusing on current products and consultancy firms developing new technologies (Wamba et al., 2020; Wang & Alexander, 2016; Pesqueira et al., 2020).

The literature review underscores BDA's significant impact in healthcare and pharmaceuticals, focusing on its potential and challenges in data quality, integration, skillset, security, and ethical concerns. The evolution of BD and its diverse applications in healthcare and pharmaceuticals highlights the ongoing need for innovation and exploration in this domain (Wang & Alexander, 2016; Wang et al., 2018a, b).

2.2 Dynamic capabilities

This literature review delves into the role of DC within the healthcare and pharmaceutical industry. It highlights their crucial role in enabling companies to adapt and excel in rapidly changing environments. The review emphasizes that DC is instrumental for pharmaceutical companies to navigate evolving business landscapes successfully. DC is essential in the healthcare and pharmaceutical sectors for integrating, building, and reconfiguring internal and external capabilities in response to changing environments. These capabilities are vital for maintaining a competitive edge, and responding to market demands, technological progress, and regulatory shifts. Effective DC enables companies to innovate, develop new products, and strategically position themselves for the future (Bari et al., 2022; Jucevičius & Jucevičienė, 2022; Junaid et al., 2023).

In the pharmaceutical industry, DC encompasses innovation in drug development, compliance with healthcare regulations, leveraging technological advancements, and responding to market shifts. Innovation, a key component of DC, extends beyond research and development to navigating complex regulatory environments and managing intellectual property. Technologies like BDA have revolutionized drug discovery, facilitating personalized medicine (Kähkönen et al., 2023; Kodama, 2018).

Adapting to market conditions and complying with regulatory requirements is also a part of DC. Companies must address healthcare policies, consumer needs, and global health trends, ensuring ongoing regulatory compliance to maintain market access and avoid legal issues (Bari et al., 2022).

The literature also notes the importance of DC in SCM, especially highlighted during the COVID-19 pandemic. Effective SCM, including managing disruptions, ensuring drug supply continuity, and adapting to logistical challenges, is a critical aspect of DC in pharmaceuticals. It involves understanding the entire supply chain and responding proactively to changes in customer demand. To meet these challenges, DC must foster strong partnerships, employ innovative strategies, and continuously assess risks and opportunities. Organizational learning and strategic collaboration are crucial for developing and sustaining DC, involving learning from past experiences, continuous employee training, and knowledge sharing. DC enables market and innovation access through strategic alliances, particularly in R&D and market expansion (Liang et al., 2022; Su et al., 2023).

Challenges in DC include aligning organizational culture with dynamic strategies, managing innovation costs, and ensuring data security in the digital age. Future research should focus on sustainable DC development amid global health challenges and technological disruptions. DC involves skills for strategic decision-making and swift adaptation to environmental changes. Leadership is vital for enabling DC, with leaders responsible for identifying capabilities, making strategic commitments, and reconfiguring organizational resources. The micro individual DC skills include interpreting environmental changes for decision-making and asset reconfiguration (Bari et al., 2022; Jucevičius & Jucevičienė, 2022; Junaid et al., 2023).

Collaboration and teamwork are also integral, with DC contributing to sustainability and innovation, although the link between social commitment and sustainability is often more pronounced than between environmental factors and innovation management.

Despite DC's popularity, its interpretations vary, leading to ambiguity and criticism. The complexity of DC in healthcare and pharmaceutical organizations presents significant challenges. A potential research direction is exploring the factors influencing the development of humans at a micro-level. Understanding the interplay between human capital and DC in healthcare, and integrating individual, collective, and organizational competencies in healthcare, could provide valuable insights into adaptive processes and sustainable competitive advantages (Su et al., 2023; Liang et al., 2022).

2.3 Big data analytics in enhancing dynamic capabilities in ESG programs

The integration of BDA within ESG programs in the pharmaceutical industry has become a focal point in recent academic research. This literature review aims to synthesize key findings from various studies to elucidate the role of BDA in enhancing DC in these programs, drawing on available public data sources and previous responses (Eisenhardt & Martin, 2000; Jucevičius & Jucevičienė, 2022; Kodama, 2018).

The integration of BDA into ESG programs in the pharmaceutical industry is a significant focus of recent academic research. This literature review consolidates various studies to clarify BDA's role in enhancing DC in these programs, utilizing public data sources and prior research. BDA's primary role in the pharmaceutical sector is capturing real-time consumer data, crucial for adapting quickly to market changes. This function is essential in healthcare analytics for pattern analysis, decision support, and predictive modeling, key components of

ESG initiatives. Studies by Wang et al. (2018a, b) and Ciampi et al. (2021) underscore BDA's vital role in healthcare analytics.

Moreover, BDA significantly contributes to managing extensive drug data, facilitating innovation and adaptability in the industry. Research by Wang et al. (2018a, b), Akter et al. (2020), and Cao et al. (2021) shows how BDA assists in precise pharmaceuticals and enhances operational efficiency and profitability.

In SCM, BDA's impact is also prominent. Research by Du and Jung (2022) and Mikalef et al. (2019) demonstrates BDA's role in improving customer experience in digital marketplaces, correlating to enhanced supply chain performance. This adaptability reflects BDA's dynamic applications in SCM under varying environmental conditions.

BDA's influence on marketing and innovation is another focal area. Studies by Pesqueira et al. (2020) and Wang et al. (2018a, b) emphasize BDA's effects on pharmaceutical, operations, and sales performance. Then, research by Mikalef et al. (2019) and Ciampi et al. (2021) discusses BDA's facilitation of both radical and incremental innovation.

Transforming data into actionable insights through BDA leads to informed decisions and skill enhancement in the industry, contributing to organizational performance in ESG programs. Chiang et al. (2017) and Pesqueira et al. (2020) explore these benefits, while Junaid et al. (2023) and Kähkönen et al. (2023) find that DC, bolstered by BDA, positively influence financial performance, with ESG management and BD utilization as moderating factors.

The effectiveness of BDA is influenced by environmental dynamics, organizational culture, and technology integration. There is also uncertainty around AI and its synergy with BDA in drug development and market analysis, offering potential research opportunities.

BDA significantly impacts healthcare analytics, operational efficiency, customer experience, marketing, and innovation in the pharmaceutical industry. It enhances DC within ESG programs, but its effectiveness varies depending on environmental, cultural, and technological factors. Future research should explore the integration of AI with BDA, examining how this combination can further enhance ESG programs and DC in the pharmaceutical sector (Linton et al., 2007; Mehta & Pandit, 2018; Randhawa et al., 2022).

The following synthesis demonstrates BDA's multifaceted impact in the pharmaceutical industry, linking concepts with relevant studies for comprehensive insight (see Table 1).

Analytics, operations, customer experience, marketing, and innovation in the pharmaceutical industry can all benefit from BDA. It enhances DC within ESG programs, but its effectiveness varies depending on environmental, cultural, and technological factors. Future research should explore the integration of AI with BDA, examining how this combination can further enhance ESG programs and DC in the pharmaceutical sector. Many challenges and future directions are identified in BDA literature. BDA is not without its challenges, such as data quality, integration difficulties, and skill requirements. Also, the literature on DC emphasizes its importance in integrating, building, and reconfiguring internal and external capabilities to enable firms to adapt. Innovation, regulatory compliance, and market responsiveness are critical to DC in healthcare and pharmaceuticals (Rashid & Ratten, 2021; Secinaro et al., 2022; Shahbaz et al., 2020; Shujahat et al., 2019).

Table 1 BDA in enhancing DC in ESG programs key concepts and findings

Concept	Key findings	Representative studies
Real-time data analysis	BDA captures real-time consumer and market data, essential for timely decision-making and adaptability	Erevelles et al. (2016)
Healthcare Analytics	BDA provides advanced capabilities in healthcare for pattern analysis, decision support, and predictive modeling	Wang et al. (2018a, b)
Drug data management	Effective management of extensive drug data through BDA enhances innovation and adaptability	Wang and Alexander (2016)
Operational efficiency	BDA contributes to precise positioning, targeted marketing, and improved profitability	Wang and Wu (2016)
Customer experience enhancement	BDA plays a crucial role in improving customer experience in digital marketplaces	Akter et al. (2020)
Supply Chain management	BDA improves supply chain agility and adaptability, especially under dynamic environmental conditions	Wamba et al. (2020)
Marketing and sales impact	BDA significantly impacts marketing strategies, brand management, and sales performance	Cao et al. (2021); Shahbaz et al. (2020)
Informed decision-making	BDA enables the conversion of data into actionable insights, leading to more informed business decisions	Chiang et al. (2017)
Professional skills development	Big data technology and processes are instrumental in skill and competency development in the healthcare and pharmaceutical sectors	Pesqueira et al. (2020)
Financial performance	Dynamic capabilities, influenced by BDA, have a positive effect on financial performance, moderated by ESG management	Du and Jung (2022)
Innovation enhancement	BDA indirectly impacts innovation capabilities, thereby strengthening dynamic capabilities	Mikalef et al. (2019)
Business model innovation	BDA capabilities positively affect business model innovation, mediated by entrepreneurial orientation	Ciampi et al. (2021)

3 Methodological approach

3.1 Development of research method

This research adopts a thorough and structured methodology to investigate the intricate dynamics of BDA and ESG integration within the pharmaceutical sector. The findings from this multi-case study are anticipated to shed light on the effective integration of BDA and related technologies in ESG program management, promoting sustainable and responsible practices in the industry. The study's methodical approach, coupled with detailed data analysis, is designed to significantly contribute to academic knowledge by examining the relationship between BDA systems and ESG initiatives in the European pharmaceutical sector (Runeson & Höst, 2009; Yin, 2018; Granger & Lee, 1989).

To justify the use of a multi-case study approach for this research, involving five pharmaceutical companies, the study draws on key insights from the works of Runeson and Höst (2009), Granger and Lee (1989), and Yin (2018). These works collectively provide a comprehensive framework for conducting case study research in complex, real-world scenarios, particularly relevant to multinational corporations and BDA systems.

Runeson and Höst's guidelines are instrumental in guiding case study research in software engineering, closely related to BDA system implementation in pharmaceuticals. Their approach underscores the importance of a structured process in formulating research questions, selecting cases, collecting data, and analyzing it. This ensures the findings' reliability and applicability across various organizational contexts, crucial for understanding BDA system utilization among pharmaceutical companies.

Therefore, the study aims to develop a framework centered on BDA and BD technologies to help organizations effectively manage ESG business imperatives. It focuses on refining control over data sources, provenance, traceability, availability, and data set efficacy.

The research questions guiding this study include (1) examining how BDA and DC collectively enhance ESG initiatives in the pharmaceutical industry, (2) identifying the critical skills and competencies required for effective BDA implementation in line with ESG objectives, and (3) exploring how DCs facilitate real-time adaptation and decision-making in BDA projects aligned with ESG standards. Using a multi-case study methodology, the study, initiated in late 2021 and concluding in August 2023, aims to create a BDA-infused architecture for systematically managing ESG criteria in the pharmaceutical industry. The study seeks to understand the synergistic relationship between BDA and DC and their joint contribution to the effectiveness and advancement of ESG programs. It explores the mechanisms through which BDA and DC interact to optimize ESG outcomes, considering both technological and human behavioral aspects (Runeson & Höst, 2009; Yin, 2018; Granger & Lee, 1989).

The study also identifies the essential skill sets and competencies necessary for pharmaceutical professionals to effectively use BDA in support of ESG goals, delving into the intersection of domain-specific knowledge, technological expertise, and data governance capabilities. Additionally, it focuses on understanding DC's role in enabling pharmaceutical companies to rapidly adapt to changing market conditions, regulatory environments, and technological advancements, examining DCs' contribution to organizational agility in managing BDA projects aligned with ESG objectives.

The methodology, informed by the frameworks of Runeson and Höst, Lee, and Yin, is structured to provide an in-depth understanding of the complex interplay between BDA, DC, and ESG programs. The approach of selecting multiple case studies aims to deeply

understand the complexity of the research questions and use purposeful sampling of cases tailored to the specific study. Hence, this provides various contexts from different organizations to determine interconnections and answer the research questions in detail. The logic behind selecting multiple case studies was to compare more cases to enhance the findings' external validity and generalizability. This allowed the study to investigate BDA implementation in five companies, where three used the DC framework to manage technological implementations.

Therefore, the study utilized a mixed-method approach for data analysis. Quantitative data from dashboards and reports were analyzed for trends, patterns, and correlations, focusing on resource allocation and ESG performance metrics. Additionally, a questionnaire administered to 18 leaders and decision-makers provided a more granular quantitative understanding of the interviews, enhancing the interpretation of the research questions. Also, qualitative data from interviews and documents underwent thematic analysis to gain insights into operational challenges, strategic ESG management approaches, and the impact of BDA on decision-making processes. A cross-case synthesis compared findings across the five companies, offering a comprehensive view of BDA implementation in ESG programs.

3.2 Sample selection and method reasoning

This research focused on five multinational pharmaceutical companies based in Germany, Portugal, and Switzerland. These companies were selected for their diverse geographic locations, engagement in ESG-related practices, and the use of BDA technologies. All five firms collaborated with the same consulting firm to deploy BDA systems, providing insights into the uniformity and variations of BDA applications across different organizational settings.

The choice of these companies was influenced by their active involvement in ESG practices, proximity to the research team, relevance in BDA programs in collaboration with the consulting company, and the operationalization of BDA technologies. The data collection process encompassed a range of sources, including internal company documents, ESG reports, technical documents, interviews, and evaluations of data visualization dashboards for assessing resource distribution and cost-effectiveness in ESG initiatives. Additionally, a simple questionnaire was used to gather feedback from stakeholders in the five organizations, providing quantitative data for analysis.

The study sample consisted of five organizations, two headquartered in Germany, two in Portugal, and one in Switzerland. Among these, three were large multinational companies with global reach. The German companies had extensive portfolios in Europe, Asia, and North America, with the main production site in Germany. The Portuguese companies differed structurally, with one being a local affiliate of a global pharmaceutical conglomerate and the other a medium-sized company headquartered in Lisbon. The Swiss company represented the European headquarters of a major pharmaceutical group. Three of the companies had implemented DC as part of their Project Management Office (PMO) and strategic operational management.

All companies were involved in various ESG programs and measurements, utilizing the same project management framework provided by the consulting firm. Three of these companies exhibited strong executive management involvement in ESG, and four had dedicated ESG teams (see Fig. 1).

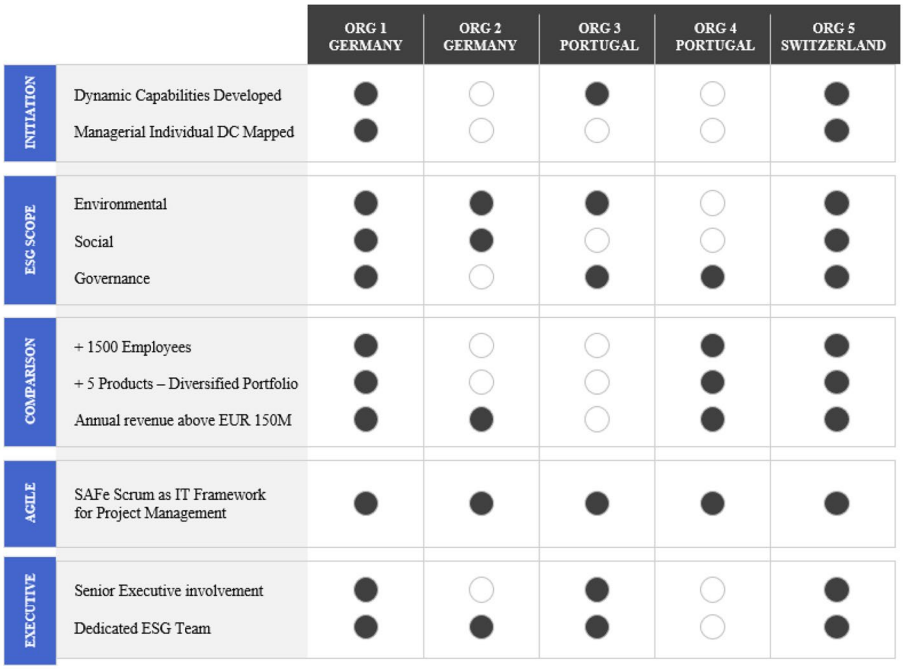

Fig. 1 Matrix comparing several organizations across different criteria

The following matrix (Fig. 1) comparing several organizations across different criteria related to BDA and ESG integration within the pharmaceutical sector includes data from five different organizations across Germany, Portugal, and Switzerland. It assesses these organizations based on several factors, categorized under innovation, ESG score, comparison, agile, and executive.

The matrix compares the five organizations across Germany, Portugal, and Switzerland on various parameters, grouped under categories such as innovation (development and mapping of dynamic capabilities), ESG score (environmental, social, and governance performance), organizational comparison (employee count, product diversity, and financial benchmarks), agile practices (adoption of SAFe Scrum for project management), and executive engagement (senior executive involvement and dedicated ESG teams). Black dots indicate the fulfillment of a criterion, while white circles suggest its absence or irrelevance. The matrix's purpose is to highlight how these companies utilize BDA in their ESG program management, aiming to contribute valuable insights to academic research on the subject.

This methodology was ideal for investigating complex subjects in depth, allowing for an exploration of each company's unique context, including cultural, regulatory, and operational differences, and enabling comparative analysis across various organizational and national contexts. This approach was effective for theory building in emerging areas like BDA in pharmaceuticals concerning ESG considerations.

The research, which began at the end of 2021, benefited from one of the researchers' close professional involvements with the companies. This proximity facilitated the development of a network of contacts necessary for focusing on the selected companies.

Overall, the multi-case study method was chosen to investigate the problem from different perspectives and to gain a deep understanding of the research questions. This method was particularly suitable for the pharmaceutical companies involved due to the complexity of the topic and the need for an in-depth exploration of each company's unique context. It also facilitated comparative analysis and theory building in this emerging field. The involvement of the same consulting firm across all companies provided insights into the role of external expertise in successfully implementing BDA systems, offering practical implications for the pharmaceutical industry and consulting practices.

3.3 Data sourcing

Before initiating the case studies, a detailed list of functional, data, and business requirements was compiled to gain clarity on the growing demands for ESG reporting and the challenges stakeholders encounter in gathering relevant information and evaluating organizational capabilities.

The ESG considerations in the case studies encompassed a range of categories typically seen in global environmental reports, from materials and energy use to waste management, environmental compliance, and broader public ESG reporting areas. Risks were divided into two categories: risk exposure and risk preparedness. This distinction enabled companies to enhance their ESG scores by demonstrating effective risk management strategies. Additionally, a facet of reputational risk, derived from external sources, was included. While quantifying some ESG aspects like CO_2 emissions was straightforward, others, particularly environmental factors like biodiversity, presented more challenges due to their qualitative nature and lack of standardized reporting norms. Evaluation metrics such as biodiversity impact reduction and environmental restoration efforts were employed, often ranked qualitatively based on their effectiveness.

The study employed both quantitative and qualitative analysis methods. Quantitative data from ESG reports and BD systems were examined for trends and correlations, especially regarding environmental impact and risk management. Qualitative data, including interviews and internal documents, underwent thematic analysis to extract insights on organizational ESG management strategies, BDA's role in decision-making, and its integration into overall business strategy.

The study identified two main areas for execution and operational components. Data collection involved gathering intent data from various sources to meet ESG-related metrics and requirements, including internal documents, ESG reports, technical documents on BDA system deployment, and interviews with key personnel. Data visualization dashboards were also evaluated for their effectiveness in optimizing resource allocation and improving the cost-efficiency of ESG initiatives.

A significant challenge was collecting and processing data from various departments such as manufacturing, SCM, and regulatory affairs, aiming to capture the diverse aspects of ESG management within these organizations.

The key areas visualization in Fig. 2 reveals a structured approach to ESG key components, which can be useful when developing BDA dashboards. Transparency and accountability were fostered through dashboards that track progress, highlight accomplishments, and identify areas for improvement.

Environmental aspects focus on climate change, public health protection, and waste management, aligning with broader objectives such as the Net-Zero Standard. The

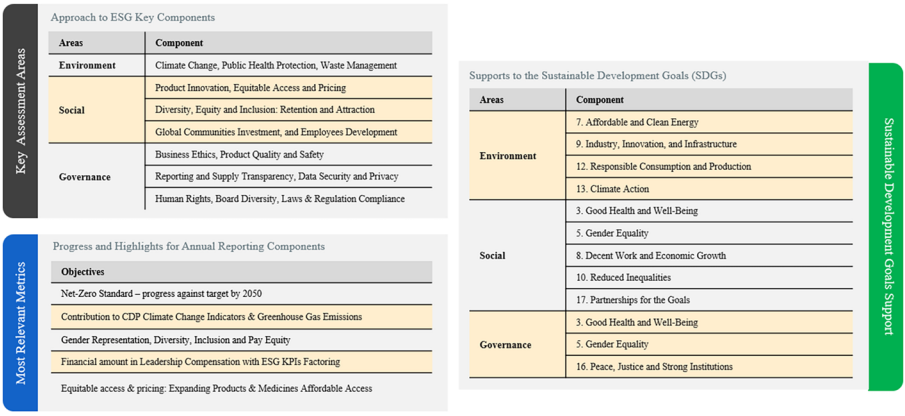

Fig. 2 Key assessment areas, most relevant metrics, and SDGs

integration of these components into analytics dashboards can help in monitoring carbon footprint and the effectiveness of sustainable practices in product life cycles.

A social dimension emphasizes diversity, equity, inclusion, and globalization. Pay equity and gender representation are essential for ensuring an equitable work environment, which drives innovation and employee retention. Inclusion policies can be identified by analyzing demographic distributions. Governance in ESG is underscored by ethical business practices, product quality and safety, and adherence to laws and regulations. Incorporating governance factors into BDA allows for real-time oversight of compliance and ethical performance, which is particularly relevant in the highly regulated pharmaceutical industry. Sustainability Development Goals (SDGs) are evident from the five organizations' ESG agendas. As part of its sustainable strategy, the company aligns with SDGs such as clean energy and infrastructure. In addition, BDA automates data, system integration, and data governance, as well as tracking contributions to these goals.

These components collectively form a comprehensive ESG framework that can guide BDA dashboard development. By using such dashboards, the pharmaceutical company can monitor ESG performance effectively and align strategy with global sustainability initiatives (Fig. 2).

The data analysis approach was exploratory and descriptive, designed to investigate the synergistic relationship between BDA and DC, and their contribution to the efficacy and advancement of ESG programs, aiming for sustainable results for future research.

The research focused on understanding the mechanisms by which BDA and DC interact to optimize ESG outcomes, considering technological and human factors. To address the first research question, insights and materials were gathered, including developed dashboards and discussions with IT data management teams and the consulting company. For the second question, interviews with decision-makers and observations from meetings provided valuable information points. The application of a questionnaire after the interviews was crucial in understanding the critical skills and DC components necessary for successful BDA implementation.

To answer the final question, several interviews were conducted, and observations were made in various meetings. Meeting notes and minutes were also analyzed to provide comprehensive information for assessing the results.

4 Results

4.1 Initial case study comparative and observational analysis

Building on prior sections, this discussion synthesizes key findings, examines their alignment with existing research, and highlights this study's unique contributions. It focuses on enhancing ESG programs in the pharmaceutical sector through BDA. This section delves into the broad spectrum of topics, analyzing BDA and DC's roles in advancing ESG initiatives.

Our findings span from operational to strategic considerations across various functional areas, based on multiple case studies conducted in five distinct companies. The study presents a comprehensive collection of evidence, revealing BDA and DC's significant impact on ESG efforts in these organizations. It highlights not only technological factors but also human behavioral aspects and DC's influence. The results demonstrate the accuracy and efficiency of BDA systems in ESG management, especially when augmented with DC, as evidenced by the enhanced outcomes observed in organizations utilizing DC.

BDA's implementation varied among the five companies, with differing degrees of effectiveness in improving operational efficiency and overall program implementation. In three of these companies, BDA proved crucial in achieving substantial results, aligning with initial expectations and management objectives. These three instances showcased BDA's critical role in refining business models and operations to meet ESG goals.

In these "dynamic organizations," BDA emerged as an essential tool for information management and organizational development, strongly supported by executive management from the outset. Notably, in one company (ORG 1), a second project phase involved deploying advanced algorithms for efficient data structure identification, aiding in internal and external sustainability reporting. This reporting included diverse metrics, such as gender equality, responsible business practices, climate change, and economic inclusion, all automated across various functions like production, logistics, human resources, and global procurement.

In organization 1, these enhancements significantly improved stakeholder engagement comprehension and the use of stakeholder information in shaping firm strategies, practices, and external reporting. This bolstered technical expertise among staff and aligned with broader ESG goals.

Finally, the intersection of BDA and ESG in the European pharmaceutical context is marked by the need for specific skill sets, including decision-making, pharmaceutical expertise, and data analysis related to patients, healthcare providers, and regulatory compliance.

4.2 Cross-organizational data insights

This study revealed significant outcomes, notably the effectiveness of the DC framework and agile methodologies like Scrum in reducing technological implementation risks. It examined challenges such as executive engagement deficits and knowledge gaps, highlighting DC's role in fostering resilient ESG analytical tools and competitive edges. Key elements like data privacy and industry-specific business model understanding were crucial in all examined organizations. However, effective data governance and processing,

distinguishing features of successful BDA implementation, were notable only in organizations 1, 3, and 5.

Technological skills, including software engineering, programming, and cloud computing, were indispensable in these organizations. They profoundly impacted SCM, market access strategies, and clinical trial oversight. The adoption of Scrum and the Scaled Agile Framework (SAFe) effectively aligned software development with organizational goals, with DC facilitating a smooth flow of activities and leadership engagement.

Specific skills are crucial for the convergence of BDA, ESG programs, and DC. These include domain knowledge, decision-making, pharmaceutical expertise, and data analysis relevant to various stakeholders. Skills in data visualization, prescriptive analytics, and data mining are equally vital. Competencies in bioinformatics, pharmacovigilance, and supply chain functions are imperative, ensuring comprehensive data analysis that aligns with both BDA and ESG objectives.

The study identified key data sources for ESG programs in pharmaceuticals, including Environmental Compliance Reports, Corporate Social Responsibility (CSR) reports, Supply Chain Data, Employee Data, Regulatory Compliance Records, Research and Development (R&D) data, financial reports, and Stakeholder Engagement Records. These sources are essential for assessing environmental impacts, social initiatives, supply chain sustainability, workforce diversity, regulatory adherence, sustainable R&D practices, financial performance, and stakeholder interactions.

Discussing compliance frameworks and data management strategies was crucial, encompassing GDPR and HIPAA compliance, consent management, patient data anonymization, and data privacy certifications. These are fundamental for maintaining data integrity and ethical data usage, aligning with broader ESG goals.

DC's success factors include adaptability to market changes, competitive advantages, risk mitigation, resource allocation, and strong alignment with ESG goals. The integration of DC with agile methods like Scrum is significant for technology absorption and operational readiness, aiding in rapid technology integration and iterative BDA project refinement.

Product innovation emerged as a key finding, focusing on reducing cycle times, increasing success rates, and ensuring equitable access to medicines. The study also emphasized the need for ESG programs to address external factors like affordable access and pricing, product quality, and safety.

The final critical finding highlighted the need for strong business ethics in ESG programs, emphasizing corporate governance, risk management, diversity, equity, inclusion, and climate change mitigation. This underlines the importance of promoting long-term stakeholder interests and addressing environmental challenges.

4.3 Quantitative analysis of data

This research employed a data analysis approach to investigate the synergistic relationship between BDA and DC, and their collective impact on enhancing ESG programs. The primary aim of the quantitative data analysis was to understand how BDA and DC work together to improve ESG outcomes. This involved analyzing various insights and materials, including developed dashboards and responses from post-interview questionnaires.

For the first research question, insights and materials were gathered from dashboards and discussions with IT data management teams. The second question involved a five-question questionnaire administered after interviews, focusing on critical skills and DC

components essential for successful BDA implementation and execution. The final question incorporated all previous data collection points, supplemented by qualitative data insights.

4.3.1 Dashboards

The dashboards provided comprehensive information, enhancing understanding of software development across the organizations. Agile practices were key in identifying necessary resources and competencies, contributing to competitive positioning.

The dashboards covered a wide range of ESG considerations, similar to those in global environmental reports, including materials, energy use, waste management, and environmental compliance. Risks were categorized into exposure and preparedness, with additional emphasis on reputational risk from external sources.

Quantifying certain ESG topics, like CO_2 emissions, was straightforward, but others, like biodiversity-related metrics, were more complex due to qualitative aspects and lack of standardization. Various evaluation metrics were used, such as biodiversity impact reduction and environmental restoration initiatives, some of which were qualitatively ranked based on effectiveness.

In the evolving eco-innovation landscape of the five companies, several factors like organizational culture, strategic outlook, performance metrics, and stakeholder engagement played a significant role. This demanded a comprehensive approach that balanced organizational growth and financial stability with sustainability and social responsibility. Global collaboration became essential, especially in addressing challenges connected to BDA. One dashboard objective was to develop a framework for international supply chain activities, enhancing global data-sharing capabilities. Eco-innovation marked a shift in business operations, integrating sustainability into core functions.

The visualization in the following figure (see Fig. 3), elucidates a comprehensive ESG scorecard for a pharmaceutical company, encapsulating various facets of ESG metrics and their integration into BDA for effective monitoring and management.

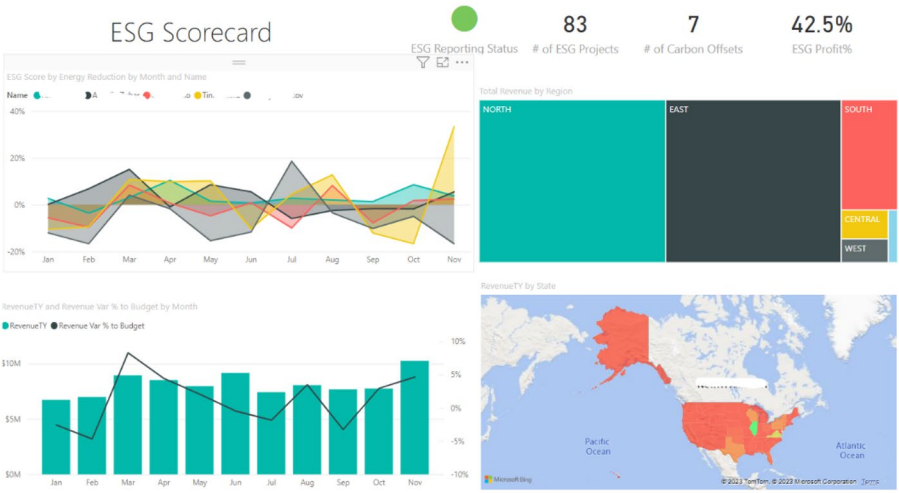

Fig. 3 ESG scorecard first dashboard page

Beginning with environmental metrics, energy reduction by month and name is depicted, suggesting an emphasis on operational efficiency and sustainability. Such data can be instrumental in tracking the effectiveness of energy conservation measures and in contributing toward achieving a Net-Zero target.

Through ESG projects, social issues are implicitly addressed, such as community engagement, healthcare access, and employee welfare programs. The company's social impact and reporting transparency can be quantified alongside its ESG reporting status.

Using the ESG profitability metric, governance is represented as how ESG initiatives affect financial performance. Aligning ethical practices with business success is achieved by this integration of financial data and ESG objectives.

Incorporating geographical revenue data from different regions and states, the dashboard offers a granular view of financial performance, which is vital for assessing market penetration and regional compliance with ESG standards.

Also included in the following Fig. 3 is an overview of the number of carbon offsets, which reflects the company's commitment to environmental responsibility.

Then, the developed dashboards encouraged a comprehensive evaluation of the ecological, social, and economic impacts of business operations according to Fig. 4.

Several developed pages entailed the development and implementation of environmentally friendly data views, services, and processes aimed at minimizing resource depletion, reducing waste, and lowering operational costs according to Fig. 5.

From a Resource-Based View (RBV), internal competencies were the linchpin for achieving a sustained competitive edge. Organizations focused on amplifying their unique internal resources and capabilities rather than solely relying on external market conditions. However, this necessitated agility in adapting to ever-changing market conditions and consumer preferences (Fig. 6).

Strategy execution transformed as pivotal, guided by RBV principles such as resource rarity and non-substitutability. The case studies revealed that companies can leverage a

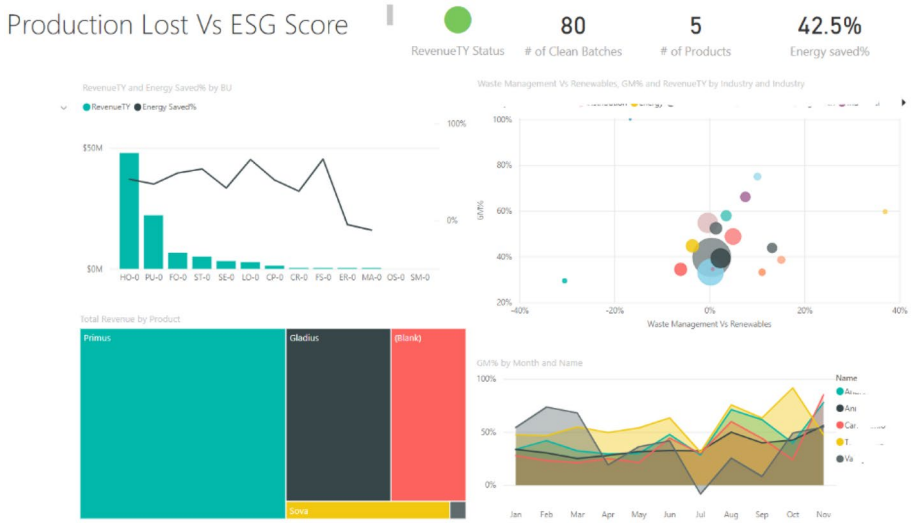

Fig. 4 ESG production lost ratios and ESG score

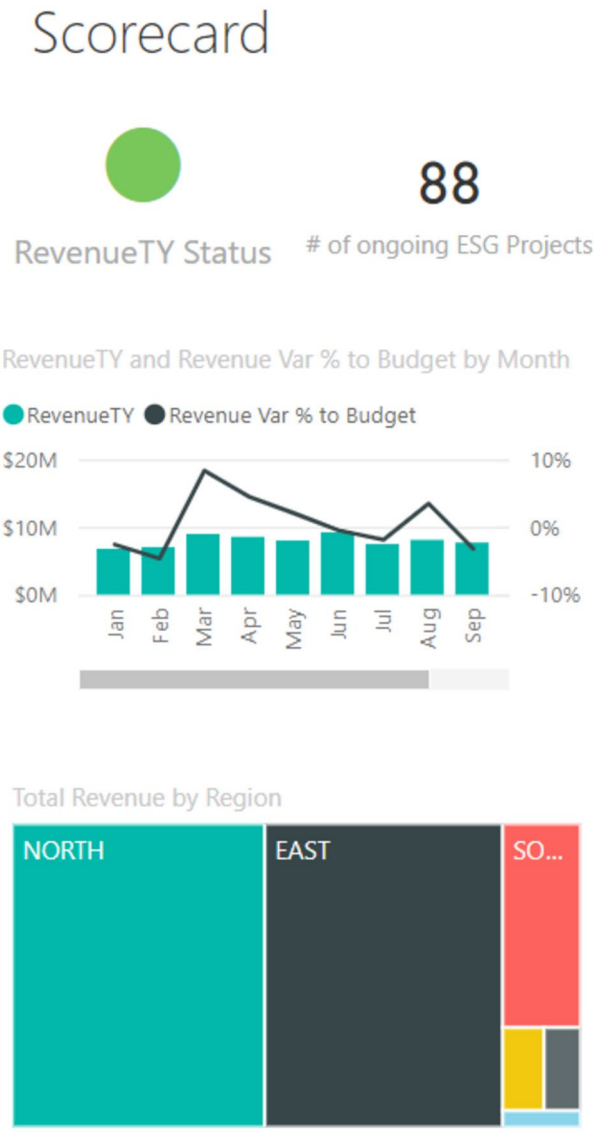

Fig. 5 ESG Scorecard executive management

diverse range of resources—from human capital to tangible assets like medical equipment and intangibles such as patents—to gain a market advantage.

In the broader spectrum of governance, striking a balance among diversity equity rates, sustainability, and adaptable governance frameworks was crucial (as Fig. 7).

Governance played a critical role in addressing challenges related to distribution and supply chain complexities. Dashboards offered a viable solution for monitoring and reporting in this context as presented in Fig. 8.

Adhering to ESG standards was crucial for effective governance, ensuring accountability, transparency, and optimal resource allocation. A robust BDA culture reinforced

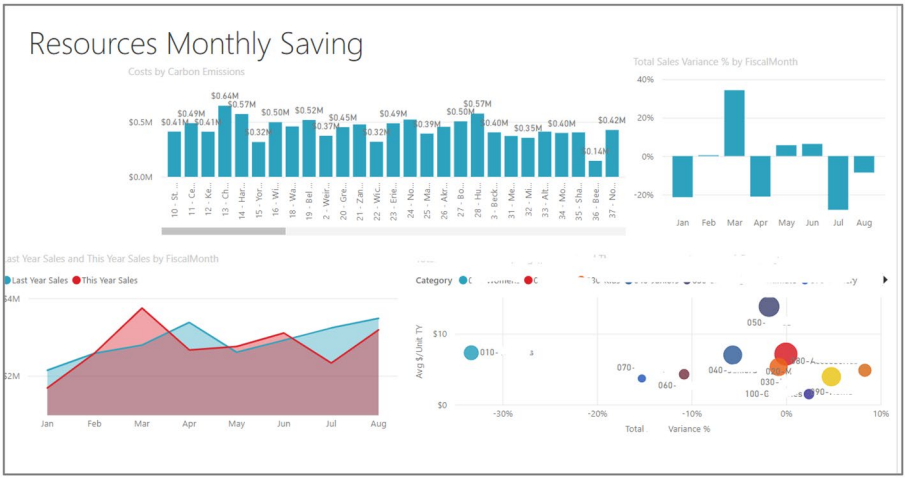

Fig. 6 Resources savings

these ESG commitments, significantly enhancing public health outcomes. Environmental sustainability, particularly in SCM, emerged as a key focus, necessitating strategies such as eco-friendly transport, optimized distribution routes, and energy-efficient cold chain systems.

Digital transformation became essential for maintaining competitiveness and formed a major part of the project's scope. While sustainability efforts incurred short-term costs, their long-term benefits, especially in response to unforeseen challenges, were significant. The role of dashboards and BDA in promoting equitable distribution was

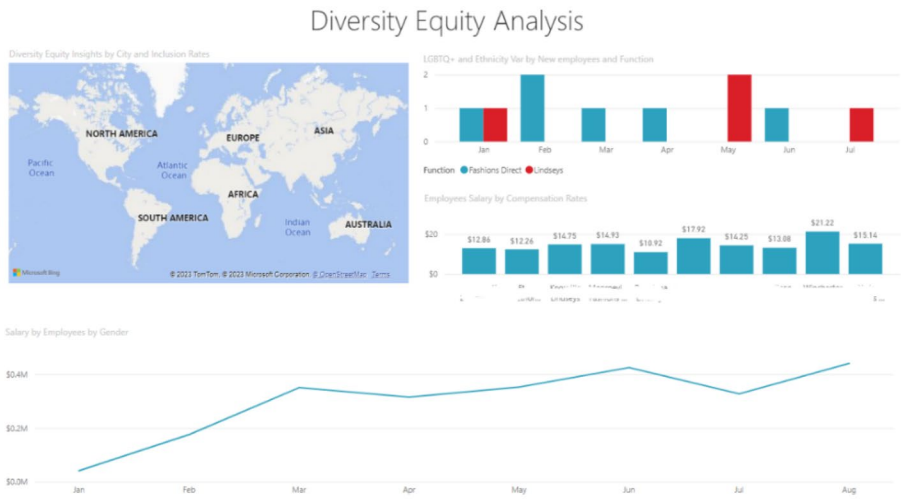

Fig. 7 Diversity equity analysis dashboard

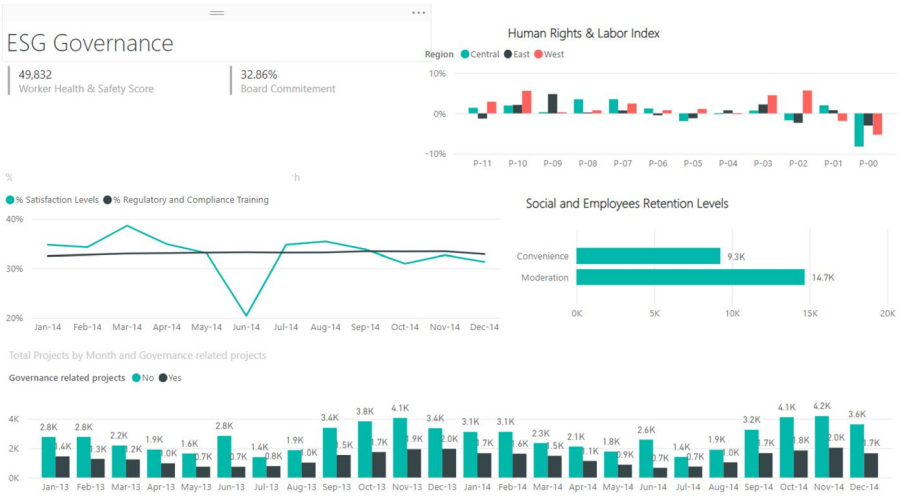

Fig. 8 ESG governance dashboard

clear and undeniable. However, governance within the analyzed companies played a crucial role in achieving efficiency, sustainability, and reducing environmental impact.

4.3.2 Questionnaires

The questionnaire in this case study was primarily used to gain a deeper understanding of the essential data points relevant to the research questions and to gauge the organizational leaders' perceptions of the performance of BDA and the contribution of DC to the ESG program implementation.

Administered in person during the final 30 min of the interview sessions with 18 participants, these individuals were strategically chosen based on their organizational roles, levels of responsibility, involvement in the ESG program, and expertise in relevant areas. This strategic selection aimed to ensure informed and reliable responses from these expert participants, whose insights are critical for enhancing group activities' value and engagement. This approach also mitigated common survey selection biases, such as the "volunteer effect." The personal delivery of the questionnaire, complementing the face-to-face interviews, allowed for clarification of points and was preferred for its cost-effectiveness, rapid data collection, and convenience, given its brief nature (consisting of only five questions).

The questionnaire's primary objective was to explore the perceptions of BDA and DC's roles and impacts on the success of ESG programs. It also examined basic data correlations and recommended strategies for adopting BDA technology, with a particular focus on DC involvement. The five key research questions addressed the respondents' roles, their views on BDA's contributions to the program, their satisfaction levels, the criticality of BDA techniques and agile methodology, and, if applicable, the influence and importance of DC in the program. Responses were collected using a 5-tiered Likert scale, ranging from "strongly disagree" to "strongly agree," to categorize feedback quantitatively. The methodology was simple, designed to gather additional data points without being the central focus of the investigation.

Table 2 Academic/professional position distribution of the 18 expert participants

Academic/professional position	Number	Percent
Executive Director	11	61%
VP/SVP	4	22%
Executive	3	17%
Grand total	18	100%

The distribution of the 18 expert participants was as follows: 61% were Executive Directors (11 participants), while Vice Presidents or Senior Vice Presidents (VP/SVP) and members of the Executive Management team each constituted 22% and 17%, respectively (see Table 2).

The survey revealed a diverse array of professionals, underscoring the significance of their roles and leadership in the field. It demonstrated the effective amalgamation of BDA within ESG goals, highlighting the efficiency of agile approaches such as Scrum and SAFe. These methodologies were further enhanced by the detailed perspectives offered by DC. The implementation of DC, especially in involving top-tier executives in pivotal discussions, streamlined data analysis, and expedited agile decision-making processes.

The heat map delineates the correlation coefficients among four key variables: DC presence, organization ID, BDA contribution, and satisfaction level (Fig. 9). The varying shades of blue and the displayed values in the heat map reflect the magnitude and nature

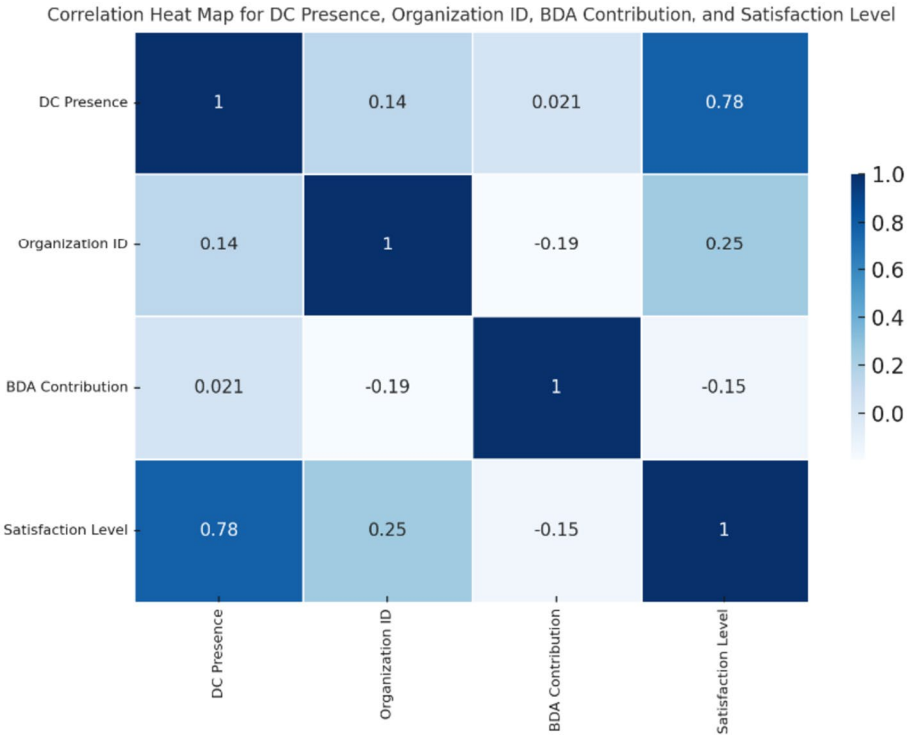

Fig. 9 DC presence, organization ID, BDA contribution, and satisfaction level

of these relationships. Correlation coefficients approaching 1 or − 1 indicate a robust positive or negative correlation, respectively. Conversely, coefficients near 0 suggest a lack of correlation. This visual representation, crafted in professional blue hues, is tailored for an academic audience.

The box-and-whisker plot depicted here effectively illustrates the distribution patterns of three critical variables: BDA contribution, satisfaction level, and DC importance (Fig. 10). This type of plot is particularly insightful in its representation of statistical data. The "box" portion of the graph encapsulates the interquartile range (IQR), providing a visual summary of the middle 50% of the data. The median, a key measure of central tendency, is marked by a distinct line within the box. Moreover, the "whiskers" of the plot extend beyond the box, delineating the full scope of the data distribution, excluding any outliers. These outliers are noteworthy for their deviation from the typical range and are indicated as individual points on the plot.

This graphical tool serves as an invaluable resource in the realm of data analysis, particularly within the sphere of ESG programs. It affords researchers and analysts a clear understanding of the central tendencies within their datasets, the range of variability of each variable, and crucially, the identification of any anomalous data points. The ability to discern these outliers is particularly beneficial in ESG contexts, where data-driven insights can influence key decisions and strategies.

The study's outcomes are significant for the pharmaceutical industry, demonstrating the benefits of integrating BDA and DC in ESG programs and indicating a shift toward more data-driven, agile organizational cultures. Additionally, the focus on developing individual capabilities in line with DC principles suggests a trend toward enhancing skills that align with organizational strategies.

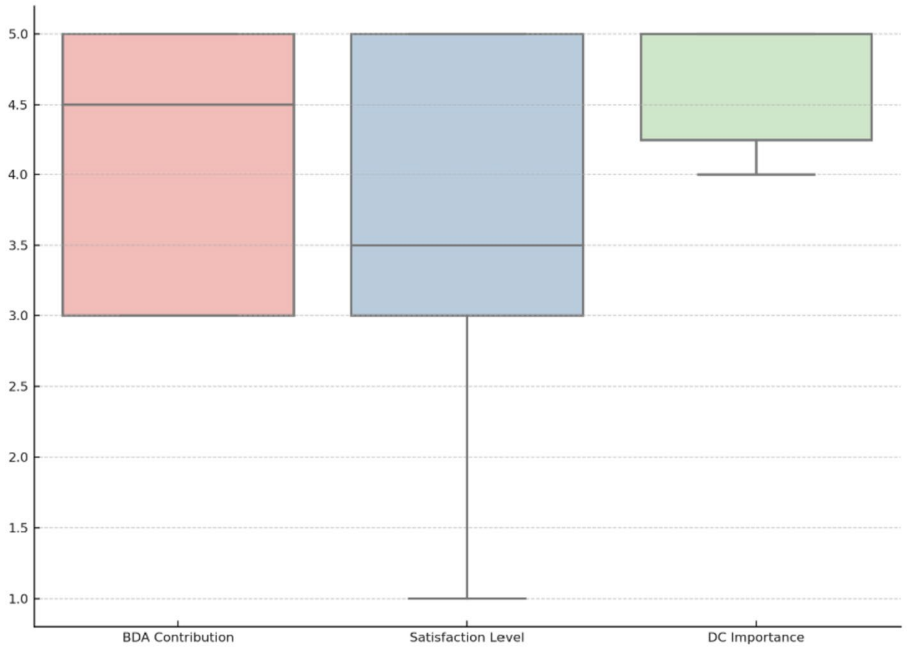

Fig. 10 BDA contribution, satisfaction level, and DC importance

A key element of this research was the active involvement of senior leadership and the establishment of "Innovation Labs" within the companies. These labs functioned as entrepreneurial units that integrated ESG goals into business models, encouraging the use of DC for identifying and capitalizing on new opportunities. This approach highlighted the crucial role of executive management in personnel development aligned with DC, thereby increasing organizational adaptability.

4.4 Qualitative observations

The qualitative data analysis approach in this study was designed to be exploratory and descriptive, enhancing the sustainability of results for future research. Regarding the first research question, insights were gathered through discussions with IT data management teams and consulting companies to understand all parameters involved in the assessment. For the second question, interviews with decision-makers and observations as passive participants in various meetings provided diverse information points. Additionally, post-interview questionnaires helped understand critical skills and DC components necessary for successful BDA implementation.

The final question involved multiple interviews and observations from different meetings, with notes and minutes condensed for analysis and to inform result assessment. Initial observations indicated a high demand for technological understanding among engineering teams, project sponsors, executive management, and other functions involved in the ESG program, such as SCM and HR.

Challenges were noted in collaboration and process management between R&D, clinical development, regulatory affairs teams, and IT departments responsible for BDA implementation. Disconnection between management and technical teams was evident, particularly in defining data governance, quality assurance parameters, and involved metrics. Over eight different functions were engaged in these projects. Notably, one company established a center of excellence for DC concepts, which was a cross-functional team responsible for all project stages.

For companies not utilizing DC, a clear disconnection was observed between management language and technical information systems. Findings also revealed that DC in the pharmaceutical industry is crucial for drug development innovation, adapting to healthcare regulations, exploiting technological advances, and responding to market changes. Successful studies highlighted DC as a key complement to innovation, encompassing research and development, regulatory navigation, and intellectual property management. BDA has significantly transformed the drug discovery process, enabling personalized medicine and improved drug discovery.

Discussions primarily focused on key ESG pillars, with governance being critical in establishing ethical standards, transparent decision-making processes, and effective leadership practices to ensure accountability and responsible corporate behavior. Identified risks related to governance failures included aggressive tax avoidance, corruption, excessive executive pay, and intensive lobbying.

Governance elements discussed included ethical standards, regulatory compliance, transparency and accountability, board of directors' roles, patient safety, and quality assurance (QA). Social responsibility aspects like healthcare access, environmental sustainability, and community well-being were also emphasized.

Environmental parameters such as carbon footprint, GHG emissions, renewable energy use, and resource management were highlighted, along with social parameters

focusing on employee welfare, diversity, supply chain, and community engagement. Governance parameters included corporate ethics, transparency, board composition, and risk management.

Effective ESG measurement and BDA in Europe require investment in advanced data analytics tools, integration of ESG into business strategy, and stakeholder engagement platforms. Reporting should adhere to standardized frameworks like GRI, SASB, and TCFD, encompassing both quantitative and qualitative metrics.

The landscape is evolving with regulations, technological advancements, and shifting stakeholder expectations. Interviews highlighted the importance of identifying significant ESG issues, setting aligned targets, embedding ESG values in organizational culture, and partnering with NGOs and industry associations for shared initiatives. Regular, accessible ESG reporting, demonstrating both positive results and areas for improvement, is vital for transparency and continual progress, enhancing corporate reputation and stakeholder trust.

4.5 Most relevant themes-specific findings

This study fills a gap in existing research by integrating both technological aspects of BDA and theoretical applications of DC within the pharmaceutical industry. A significant advancement of this research is the combination of agile principles with DC, enabling strategic and micro-adjustments for rapid adaptability. This integration was crucial in tailoring BDA systems to the demands of ESG programs, with a particular focus on environmental performance metrics like climate change and pollution.

The novelty of this study lies in the practical application of DC across various organizational levels, involving cross-functional teams and aligning strategies from team activities to broader organizational goals. This approach ingrained DC principles within the organizational culture, ensuring a comprehensive strategy for implementing complex systems that address multifaceted ESG objectives.

This research makes a substantial contribution to the academic field, offering a detailed analysis of BDA and DC implementation in ESG programs within the European pharmaceutical industry. It provides insights for industry professionals, policymakers, and academics, highlighting the potential of BDA and DC in promoting sustainable and responsible practices.

From a data governance perspective, effective data governance was vital, aligning with legal requirements and ensuring data integrity for accurate ESG initiative analyses. Increased transparency and accountability in data governance enhanced stakeholder trust. Strategic alignment of data utilization with ESG goals allowed for agile responses to technological and regulatory changes, emphasizing data security and privacy.

DC enabled quick adaptation to market changes, providing competitive advantages and risk mitigation. It facilitated the absorption of new technologies and methodologies crucial for BDA, offering operational capacity for real-time business process reconfiguration to meet ESG standards.

Agile principles and environmental performance played a pivotal role, particularly in adapting BDA systems to ESG program demands. Practical application of DC across organizational hierarchies involved cross-functional teams, including data scientists and ESG specialists, in regular Scrum meetings to shape ESG initiatives.

Senior leadership involvement was a key success factor in dynamic organizations, actively participating in strategy and review meetings. The creation of “Innovation Labs”

and leadership development programs focused on understanding and implementing DC, fostering a culture of performance management.

The study also examined systematic software development approaches, with agile practices identifying essential resources and competencies for competitive positioning. A mixed-method approach was used for data analysis, combining quantitative data from dashboards with qualitative insights from interviews and thematic analysis. This comprehensive approach provided a detailed view of BDA implementation in ESG programs. The study's iterative design, emphasizing data accountability and regulatory compliance, was crucial in exploring BDA in ESG management.

In summary and according to the following Table 3, the study highlights the interplay of BDA with ESG goals in the European pharmaceutical sector, focusing on essential skills, data management strategies, and the importance of DC for effective implementation.

4.5.1 Technology components

The technological infrastructure common to the participating companies prominently featured Microsoft technologies for data handling and storage, especially Azure, coupled with data visualization tools like Microsoft Power BI. Master Data Management (MDM) platforms, including Informatica and Microsoft Azure, were employed to ensure data reliability and integrity.

Azure was chosen for data storage and manipulation, incorporating Azure Data Lake Storage and Azure Synapse Analytics for scalable, robust data warehousing. Azure Synapse Analytics' real-time analytical capabilities play a crucial role in aligning BDA strategies with ESG objectives.

The selection of Azure Data Lake Storage and Azure Synapse Analytics was influenced by several factors. Azure Data Lake Storage's scalability is vital for managing the extensive data volumes in the pharmaceutical industry, from clinical study data to patient records. Its compliance with regulations like the GDPR, combined with a strong security framework providing encryption, access management, and auditing, ensures the security and legality of sensitive ESG-related data.

Azure Data Lake Storage's ability to handle various data formats, including Parquet, JSON, and Avro, is crucial given the diversity of data types in the pharmaceutical industry, from structured databases to unstructured medical images and text documents. Integrated Azure analytics services enable seamless analytics, facilitating quick, ESG-aligned decisions.

Azure Synapse Analytics provides real-time analytics, merging BDA with data warehousing capabilities, essential for timely ESG-related decisions like waste regulation or energy conservation. Its serverless data exploration feature in Synapse Studio allows analysts to review data before full integration into storage, offering early insights into sustainability strategies.

Furthermore, Azure Synapse Analytics offers both on-demand and pre-allocated resources, enhancing cost efficiency—a vital aspect considering the often-limited budgets of ESG programs. Additionally, the adoption of Scrum and the Scaled Agile Framework (SAFe), in conjunction with DC, ensured the seamless integration of software development with organizational goals, enhancing performance and operational efficiency.

These technological choices were designed to provide a thorough understanding of how a data-centric technology ecosystem can effectively support the intricate requirements of ESG programs in the pharmaceutical industry.

Table 3 Key categories and collected insights

Category	Main concepts and observations
BDA in pharmaceuticals	- Revolutionizes customer engagement and operational efficiencies - Enhances patient experience through personalized treatments - Improves understanding of patient journeys and treatment pathways
BDA and ESG	- Aligns business models and operational use cases with ESG objectives - Crucial for information management and organizational development in European pharmaceuticals
Skills required for BDA and ESG	- Domain knowledge in pharmaceuticals, data analysis, and regulatory compliance - Data privacy, data visualization, prescriptive analytics, and data mining skills - Proficiency in software engineering, data quality management, and cloud computing
Supply chain and market strategies	- Management of supply chain, market access strategies, product commercialization, and clinical trials
Technical skills	- Specialized competencies in bioinformatics, pharmacovigilance, and microbiological techniques - Comprehensive understanding of data related to drugs, molecules, and adverse events
Data sources and types	- Clinical and claims data, sentiment analysis, market metrics, and patient-generated information - Research and Development (R&D) data, sales metrics, and emerging data sources like smartphone apps and patient portals
Importance of mature data models	- Foundational for optimizing pharmaceutical operations and ESG initiatives - Enhances data integrity, interoperability, and analytical accuracy
Data governance and compliance	- Ensures legal compliance, data integrity, and quality - Fosters stakeholder trust and strategic alignment with ESG objectives - Secures patient data privacy and facilitates holistic integration of ESG objectives
Data management strategies	- Compliance with regulations like GDPR and HIPAA - Anonymization and pseudonymization techniques for patient data - Training modules on data privacy and deployment of security tools
DC in BDA	- Adaptability to market changes, risk mitigation, and resource allocation - Alignment with ESG goals, operational flexibility, and resource reallocation - Enhanced data security and pre-emptive action for ESG risk mitigation
Key highlights	- Strengthening senior leadership involvement in ESG initiatives - Cultivating a culture of innovation and adaptability - Promoting cross-functional collaboration - Developing robust data governance frameworks - Creating sophisticated environmental performance metrics - Investigating the potential of emerging technologies in ESG management

4.5.2 Data Integration, transformation, and governance

The utilization of Azure Synapse Analytics for data integration was discussed, highlighting its compatibility with a variety of data sources, including Customer Relationship

Management (CRM) systems and social media platforms. This versatility facilitates a comprehensive analysis of ESG metrics, covering aspects such as social sentiment, financial stability, and operational impacts.

Azure Synapse Analytics also offers advanced data transformation capabilities, including data flows for cleansing, aggregation, enrichment, and conversion. These features are particularly vital for ESG indicators, which often require the merging of different data types within a unified analytical framework.

In terms of governance and compliance, Azure Synapse Analytics and Azure Data Lake Storage demonstrate exceptional governance capabilities. These include automated threat detection, vulnerability assessments, and data masking, which are crucial for protecting data in the highly regulated ESG sector. Consequently, these technologies not only satisfy analytical and data storage needs but also provide a secure, scalable framework suitable for the dynamic requirements of ESG programs.

For data visualization, Microsoft Power BI was chosen for its ability to create user-friendly dashboards displaying real-time ESG metrics. Custom Key Performance Indicators (KPIs) were developed for diverse stakeholders, providing actionable insights into sustainability, social impact, and governance standards. Master Data Management (MDM), achieved through the integration of Informatica and Microsoft Azure, played a key role in ensuring data quality and adherence to strict governance standards.

The technical implementation involved ingesting data from various sources such as clinical trials, ESG reports, and patient records into Azure Data Lake Storage. Azure Data Factory facilitated Extract, Transform, Load (ETL) processes, aligning the data with GDPR and other compliance frameworks. The processed data was then transferred to Azure Synapse Analytics for complex queries vital for effective ESG analysis. Informatica's MDM served as an abstraction layer, ensuring data consistency and governance compliance.

Power BI dashboards, populated with these visual components, provided a dynamic interface for decision-making. Additionally, the adoption of agile methodology and DevOps (DC) significantly contributed to the successful deployment of these technologies. Agile sprints allowed for iterative development and feedback from ESG experts, while DevOps enabled organizations to rapidly adapt to changing ESG regulations and market trends, keeping Business Data Analytics (BDA) systems both compliant and competitive.

The agile methodology offered numerous advantages in the ESG context. Its flexibility catered to the fluctuating nature of ESG metrics and regulations, while Scrum facilitated cross-departmental collaboration, essential for informed ESG decision-making. Agile's user-centric approach aligns ESG efforts with stakeholder expectations, and its continuous feedback loops allow for ongoing assessment and realignment of objectives, enhancing the effectiveness of ESG initiatives. Agile's inherent transparency and accountability were beneficial, aligning with ESG reporting requirements.

This research elucidated the complex technological and methodological configurations optimal for implementing successful ESG programs in the studied companies. A special emphasis was placed on leveraging individual DevOps practices for ecological innovation.

4.5.3 Dynamic capabilities and agile principles

The investigation highlighted the crucial role of Individual DC (IDC) in adapting and managing resources to meet the dynamic demands of ESG programs. For example, IDC's capabilities were vital in rapidly reallocating resources for enhanced computational power required for innovative ESG analyses. These capabilities, deeply embedded with a "learn

and adapt" approach, enable smooth integration of new metrics or Key Performance Indicators (KPIs) into existing frameworks.

In the complex pharmaceutical sector, IDC's strategic roadmap is key for ensuring sustainability and regulatory compliance. It facilitates quick strategic changes and incorporates risk anticipation and management, essential for governance and risk management in ESG metrics. Furthermore, the effective use of BDA in ESG programs, supported by IDC, has provided firms with a lasting competitive advantage, helping them exceed governance and sustainability goals.

The integration of agile methodologies with IDC has provided companies with the necessary agility and foresight to navigate the ever-changing ESG landscape. This combination enhances operational resilience and strategic mindset, aligning with evolving ESG standards and stakeholder expectations. Our multi-case analysis emphasized the importance of a robust BDA infrastructure in aligning corporate goals with ESG objectives. Technologies like Microsoft Azure and Power BI, alongside Master Data Management (MDM) systems such as Informatica, have equipped organizations to leverage data analytics effectively in ESG decision-making. The synergy between agile methodologies and IDC further enhances the adaptability of these systems, highlighting BDA's critical role in the ESG strategies of these enterprises.

The study also revealed how IDC and BDA synergistically enhance the implementation of ESG programs. It delved into the transformative potential of Agile and Scrum methodologies in deploying BDA for ESG initiatives. The research encompassed various perspectives, including managerial and executive roles, and other organizational capabilities essential for implementation.

In today's technology-driven and socially evolving era, managerial cognitive skills are increasingly important. Employees, as agents of change, are expected to seize external opportunities and adapt to ongoing changes, particularly in dynamically shifting systems. IDC involves the capacity of organizations to assimilate, develop, and reconfigure both internal and external resources in response to rapid environmental changes, often demonstrated by employees innovating and adapting to new regulations and challenges.

Digital health services have introduced patient care beyond traditional interactions, requiring specific skills and organizational capabilities. Scaling these services for sustainable digital health, however, poses challenges in training and communication. IDC's relevance in governance, particularly in environmental sustainability and vaccine distribution, is significant. It enables companies to implement sustainable initiatives and effective medication distribution, crucial amid global health, and environmental crises.

Leaders with strong IDC skills enhance organizational performance through strategies like green supply chain practices and renewable energy use. This approach promotes proactive strategies, collaboration with eco-friendly logistics providers, and investment in energy-efficient technologies, fostering a culture of sustainability and data-driven ESG decision-making.

While the study primarily focused on DC's influence within governance, particularly in environmental sustainability and SCM, their role in performance metrics, especially in environmental governance and sustainability, is undeniable. The pharmaceutical industry, facing increasing sustainability and corporate responsibility pressures, finds BDA's role in ESG programs as a novel approach to managing complexities and meeting diverse stakeholder expectations.

In ESG initiative deployment, Agile and Scrum methodologies have proven essential. They provide speed, and a framework for collaboration and communication across departments, facilitating effective decision-making. These methodologies also ensure

transparency and accountability through incremental progress tracking, enabling cost efficiency by breaking projects into smaller segments for better task prioritization and resource allocation. Consequently, these frameworks have transformed ESG compliance from a challenging task into a strategic advantage.

The adoption of Agile and Scrum methodologies has provided companies with an efficient, flexible approach to ESG management, allowing them to stay ahead of regulations, exceed stakeholder expectations, and transform ESG compliance into a strategic asset.

4.6 Possible implications of the work presented

Our study underscored the vital role of DC in enhancing ESG programs through BDA, demonstrating a broad spectrum of applications. DC, encompassing the integration, construction, and reconfiguration of competencies, proves highly effective in various contexts observed throughout the study. The three phases—sensing, seizing, and reinforcement—reveal extensive use cases and potential research avenues.

In environmental scanning, pharmaceutical companies utilize DC to identify emerging technologies aligned with ESG goals. For seizing opportunities, these identified technologies are quickly adopted and integrated into existing ESG strategies. This includes aligning new technologies with specific ESG objectives through BDA, ensuring their contribution to broader sustainability goals.

Another significant aspect is cross-functional collaboration. Leveraging DC fosters collaboration across departments like R&D, IT, and sustainability, ensuring cohesive technology implementation in line with ESG objectives. Additionally, DC aids in strategically allocating resources (financial, human, technological) toward promising ESG-related technologies.

Further observations connect to adaptability and learning capacity. DC enables companies to learn from implementation, adjust strategies, and maximize the impact of technology on ESG goals. This extends to fostering a culture of innovation and encouraging the development of new technologies or innovative applications for ESG initiatives.

Moreover, DC facilitates strategic and compliance monitoring, as well as continuous improvement, particularly in adopting technologies like AI and data analytics for effective monitoring of ESG regulations and standards.

Overall, the findings suggest DC's role in enabling organizations to be agile, innovative, and strategic in integrating technology with ESG programs, leading to enhanced sustainability, competitive advantage, and stakeholder value creation.

Addressing the research questions:

- How do BDA and DC collectively enhance ESG initiatives in the pharmaceutical industry? BDA and DC collaboratively enhance ESG initiatives by providing data-driven insights for optimizing patient experiences and streamlining operations in line with ESG goals. DC is crucial to integrating these insights into actionable strategies, fostering agile adaptation to market and regulatory changes. This synergy leads to more informed and responsible ESG decision-making, addressing complex challenges in the pharmaceutical industry.
- What skills and competencies are essential for effective BDA implementation in alignment with ESG objectives in the pharmaceutical sector? Essential skills for effective BDA implementation include pharmaceutical domain knowledge, data analysis expertise, regulatory compliance understanding, and data privacy awareness. Technical skills

in data visualization, analytics, software engineering, and cloud computing are also crucial. These skills ensure that BDA insights are applied effectively, adhering to ethical, social, and governance standards.

- How does DC facilitate real-time adaptation and decision-making in BDA projects aligned with ESG standards in the pharmaceutical industry? DC plays a critical role in enabling real-time adaptation and decision-making in BDA projects aligned with ESG standards. They allow pharmaceutical companies to quickly assimilate and act on BDA insights, responding effectively to market trends, technological advancements, and regulatory changes. These improvements are key in maintaining the relevance and efficacy of ESG programs, promoting continuous improvement and innovation in line with ethical and sustainable practices.

The integration of BDA and DC is crucial for fostering ethical, socially responsible, and environmentally sustainable practices in the pharmaceutical industry. This synergy highlights the importance of a dynamic, data-informed approach to managing complex ESG initiatives, emphasizing continuous learning, adaptation, and innovation.

5 Conclusions

5.1 Final discussions

The case studies showcased the precision and effectiveness of the proposed BDA system in managing ESG programs. These systems satisfy the immediate demands of both BDA and ESG applications, proving their practical usefulness. Notable is their adaptability to market shifts and the ability to harness data for improved drug development, effective marketing, and efficient SCM.

Our research emphasizes the significant contributions of BDA and DC to advancing ESG programs within the pharmaceutical industry. It extends beyond mere technology to include human behavior and managerial insights (MIDC). The studies provide a detailed understanding of critical industry factors, aiding informed decision-making in ESG initiatives and highlighting the importance of mature data models and data standards.

BDA and DC integration within pharmaceutical ESG programs are technologically sophisticated and attuned to human and organizational dynamics, offering a holistic approach to sustainable, ethical business practices. These systems' real-time application highlights their value in the ever-changing pharmaceutical industry. Operationalizing DC goes beyond theory, with active application at managerial and executive levels, fostering leadership engagement and ensuring thorough ESG program management.

BDA systems are increasingly crucial in pharmaceuticals for their data-driven decision-making, essential in areas like R&D and waste management. Additionally, integrating DC for ecological innovation is vital for sustainable healthcare performance in an ESG context, promoting transparency and operational efficiency. However, the application of BDA and DC in ESG-centric systems within this sector remains limited, indicating the need for further exploration, as identified in our initial findings.

Other findings point to significant demand for support in complex technological initiatives like BDA implementation and ESG program development. Organizations emphasized the importance of fostering cross-functional collaboration to enhance the understanding

and application of BDA and DC in ESG programs, with DC playing a key role in illustrating organizational vision, strategy, and business development phases.

ESG-related challenges and opportunities were discussed in regular interdisciplinary forums and workshops. To evaluate the effectiveness of ESG programs and to monitor ongoing performance, consistent assessments, and sprint retrospectives are essential.

Data governance frameworks are critical to managing the ethical implications of BDA and ensuring compliance with evolving data privacy laws. It is also crucial to improve environmental performance metrics and integrate systems for measuring such performance, especially in qualitative and hard-to-standardize areas. As a result, organizations 1 and 5 excelled in creating universally accepted reporting standards for complex environmental factors like biodiversity in collaboration with external agencies. To improve BDAs in ESG management, organizations are exploring emerging technologies like AI and machine learning. Consequently, these organizations can remain relevant and efficient by adapting their BDA infrastructure to technological advancements.

5.2 Future recommendations

This research has led to several key recommendations aimed at enhancing the integration of BDA and DC in ESG initiatives, extending beyond the pharmaceutical industry to various sectors.

A primary recommendation is the wider adoption of BDA and DC in ESG programs across the pharmaceutical industry. This involves developing adaptable guidelines and best practices for BDA and DC implementation, suitable for different organizational sizes and contexts.

Furthermore, there is an emphasis on strengthening agile methodology applications in conjunction with DC. This includes promoting ongoing training and development in agile methodologies for employees at all levels, as well as exploring the integration of emerging agile frameworks that align with the dynamic nature of ESG programs.

Insights from interviews suggest additional recommendations. One is to deepen executive engagement in ESG initiatives, enhancing senior leadership's involvement in strategic alignment and resource allocation. This would be supported by leadership development programs focused on the integration of BDA, DC, and ESG. Additionally, fostering a culture of innovation and adaptability is crucial, encouraging the creation of "Innovation Labs" within organizations to stimulate creative and experimental approaches to ESG initiatives.

These recommendations are designed to build on the successful application of BDA and DC in ESG programs within the pharmaceutical industry, as highlighted by this research. The ongoing development and refinement of these practices are expected to contribute to more sustainable, accountable, and effective ESG initiatives. This advancement will not only benefit the pharmaceutical sector but also have wider implications for various industries and society as a whole.

5.3 Conclusions

This paper presents a thorough analysis of the role of BDA and DC in advancing ESG programs within the pharmaceutical sector. Conducted between August 2021 and August 2023, the study utilized a multi-case analysis of five multinational pharmaceutical

companies based in Europe. The findings illustrate the profound impact of BDA and DC integration on the evolution and efficacy of ESG programs in this industry.

Research on BDA and DC within ESG frameworks within the pharmaceutical industry enriches academic discourse. We advocate a unified, agile approach to managing ESG programs for practitioners, policymakers, and scholars. BDA and DC dynamics are changing rapidly, especially when it comes to ESG initiatives in other sectors. The structured methodology and practical depth of this study establish a benchmark for future research, highlighting the potential of BDA and DC in promoting sustainable and responsible practices in pharmaceuticals.

A key focus of the study was addressing technological implementation risks using the DC framework and Agile methods. There were challenges such as limited executive engagement and knowledge gaps. ESG analytical tools are developed with DC, which provides competitive advantages. Using agile methodologies such as Scrum and the Scaled Agile Framework (SAFe), BDA systems improve software development alignment with organizational goals, thereby enhancing performance, operational efficiency, and decision-making within ESG programs.

A significant finding is the practical application of DC at managerial and executive levels, moving beyond theory to enhance leadership commitment and ensure a comprehensive approach to ESG program management. This practical application has been instrumental in navigating the complex interactions of technology, processes, and human factors.

BDA systems are crucial for adapting to the varied demands of ESG programs thanks to a synergistic relationship between agile principles and DC. Environmental performance metrics, such as climate change and pollution, are particularly highlighted, underscoring the industry's impact on public health. These aspects should be integrated into ESG strategies, both ethically and practically.

The research has multiple implications for the pharmaceutical industry, demonstrating the effectiveness of a layered, integrated approach to ESG program management. It underscores the shift toward data-driven, agile decision-making at the organizational level, with a strong focus on innovation labs to continuously meet ESG objectives.

As a result, this study contributes significantly to the academic understanding of BDA and DC integration within ESG frameworks. Diverse stakeholders benefit from its insights, promoting an agile and cohesive ESG management strategy. In the future, future research will examine the long-term effects of BDA and DC on organizational performance and sustainability across industries. As a model for improving ESG programs across different sectors, this study underscores the vital role of BDA and DC.

Author contribution All authors (AP, MJS) contributed to the presented research work. AP, Dr. Antonio Pesqueira: conceptualization, methodology, and writing. MJS, Dr. Maria José Sousa: data collection, analysis, and writing.

Funding Open access funding provided by FCT|FCCN (b-on).

Availability of data and materials All data generated or analyzed during this study are included in this published article and can be provided upon request.

Declarations

Conflict of interest No conflict of interest exists in the present study.

References

Akter, S., Motamarri, S., Hani, U., Shams, R., Fernando, M., Babu, M. M., & Shen, K. (2020). Building dynamic service analytics capabilities for the digital marketplace. *Journal of Business Research, 118*, 177–188.

Bari, N., Chimhundu, R., & Chan, K. C. (2022). Dynamic capabilities to achieve corporate sustainability: A roadmap to sustained competitive advantage. *Sustainability, 14*(3), 1531.

Cao, G., Tian, N., & Blankson, C. (2021). Big data, marketing analytics, and firm marketing capabilities. *Journal of Computer Information Systems, 62*, 442–451.

Chiang, L. H., Lu, B., & Castillo, I. (2017). Big data analytics in chemical engineering. *Annual Review of Chemical and Biomolecular Engineering, 8*, 63–85.

Ciampi, F., Demi, S., Magrini, A., Marzi, G., & Papa, A. (2021). Exploring the impact of big data analytics capabilities on business model innovation: The mediating role of entrepreneurial orientation. *Journal of Business Research, 123*, 1–13.

Du, Y., & Jung, J.-S. (2022). The effect of dynamic capability on innovation and financial performance: Focused on the moderating effect of ESG management and the big data utilization in Chinese SMEs. Korea International Trade Research Institute.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? *Strategic Management Journal, 21*(10–11), 1105–1121.

Erevelles, S., Fukawa, N., & Swayne, L. (2016). Big Data consumer analytics and the transformation of marketing. *Journal of business research*, *69*(2), 897–904.

Gebhardt, M., Kopyto, M., Birkel, H., & Hartmann, E. (2022). Industry 4.0 technologies as enablers of collaboration in circular supply chains: A systematic literature review. *International Journal of Production Research*, *60*(23), 6967–6995.

Granger, C. W., & Lee, T. H. (1989). Investigation of production, sales and inventory relationships using multicointegration and non-symmetric error correction models. *Journal of Applied Econometrics, 4*(S1), S145–S159.

Jucevičius, G., & Jucevičienė, R. (2022). Enabling collaborative dynamic capabilities in strategic communities: Firm-vs. network-centric perspectives. *Journal of Management & Organization*, *28*(3), 587–604. 12.

Junaid, M., Zhang, Q., Cao, M., & Luqman, A. (2023). Nexus between technology enabled supply chain dynamic capabilities, integration, resilience, and sustainable performance: An empirical examination of healthcare organizations. *Technological Forecasting and Social Change, 196*, 122828.

Kähkönen, A. K., Evangelista, P., Hallikas, J., Immonen, M., & Lintukangas, K. (2023). COVID-19 as a trigger for dynamic capability development and supply chain resilience improvement. *International Journal of Production Research, 61*(8), 2696–2715.

Kodama, M. (2018). Collaborative dynamic capabilities for service innovation creating a new healthcare ecosystem. *Palgrave Macmillan*, *14*.

Liang, Y., Lee, M. J., & Jung, J. S. (2022). Dynamic capabilities and an ESG strategy for sustainable management performance. *Frontiers in Psychology, 13*, 887776.

Linton, J. D., Klassen, R., & Jayaraman, V. (2007). Sustainable supply chains: An introduction. *Journal of Operations Management, 25*(6), 1075–1082.

Mehta, N., & Pandit, A. (2018). Concurrence of big data analytics and healthcare: A systematic review. *International Journal of Medical Informatics, 114*, 57–65.

Mikalef, P., Boura, M., Lekakos, G., & Krogstie, J. (2019). Big data analytics capabilities and innovation: The mediating role of dynamic capabilities and moderating effect of the environment. *Change Management Strategy eJournal*.

Mostafiz, M. I., Musteen, M., Saiyed, A., & Ahsan, M. (2022). COVID-19 and the global value chain: Immediate dynamics and long-term restructuring in the garment industry. *Journal of Business Research, 139*, 1588–1603.

Pesqueira, A., Sousa, M., & Rocha, Á. (2020). Big data skills sustainable development in healthcare and pharmaceuticals. *Journal of Medical Systems*, *44*.
Randhawa, K., Wilden, R., & Akaka, M. A. (2022). Innovation intermediaries as collaborators in shaping service ecosystems: The importance of dynamic capabilities. *Industrial Marketing Management, 103*(183–197), 25.
Rashid, S., & Ratten, V. (2021). Entrepreneurial ecosystems during COVID-19: the survival of small businesses using dynamic capabilities. *World Journal of Entrepreneurship, Management and Sustainable Development*, *26*.
Runeson, P., & Höst, M. (2009). Guidelines for conducting and reporting case study research in software engineering. *Empirical Software Engineering, 14*, 131–164.
Secinaro, S., Calandra, D., Lanzalonga, F., & Ferraris, A. (2022). Electric vehicles' consumer behaviours: Mapping the field and providing a research agenda. *Journal of Business Research, 150*, 399–416.
Shahbaz, M., Gao, C., Zhai, L., Shahzad, F., Abbas, A., & Zahid, R. (2020). Investigating the impact of big data analytics on perceived sales performance: The mediating role of customer relationship management capabilities. *Complex*, *2020*, 5186870:1–5186870:17.
Shujahat, M., Sousa, M. J., Hussain, S., Nawaz, F., Wang, M., & Umer, M. (2019). Translating the impact of knowledge management processes into knowledge-based innovation: The neglected and mediating role of knowledge-worker productivity. *Journal of Business Research, 94*, 442–450.
Su, X., Wang, S., & Li, F. (2023). The impact of digital transformation on ESG performance based on the mediating effect of dynamic capabilities. *Sustainability, 15*(18), 13506.
Wamba, S. F., Dubey, R., Gunasekaran, A., & Akter, S. (2020). The performance effects of big data analytics and supply chain ambidexterity: The moderating effect of environmental dynamism. *International Journal of Production Economics, 222*, 107498.
Wang, F., & Wu, X.-M. (2016). The opportunities and challenges of pharmaceutical enterprises in big data. *Journal of Residuals Science & Technology*, *13*.
Wang, G., Wei, Y., Qiao, S., Lin, P., & Chen, Y. (2018a). *Generalized inverses: Theory and computations* (Vol. 53). Springer.
Wang, L., & Alexander, C. (2016). Big data analytics for medication management in diabetes mellitus. *International Journal of Security and Networks, 1*, 42.
Wang, Y., Kung, L., & Byrd, T. A. (2018b). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change, 126*, 3–13.
Yin, R. K. (2018). *Case study research and applications* (Vol. 6). Sage.

Antonio Pesqueira (MSc in Innovation Management) a healthcare commercial leader specializing in life sciences, is a university professor and a research fellow at ISCTE/IUL. The current areas of his research interest are digital technologies, healthcare data management, and blockchain, as well as innovation and business management. The last chair of the Pharmaceutical Supply Chain & Security World Forum and a regular keynote speaker at the Pharma Track & Trace, Serialization & Labeling Summit are among his other activities. In addition to co-authoring more than 20 articles and book chapters, Antonio published in several scientific journals (such as Journal of Business Research, Future Generations Computer Systems, Journal of Medical Systems, Knowledge Management, WSEAS Transactions on Business and Economics, Information Systems Frontiers, and others) as well as peer-reviewed international conferences. Furthermore, he holds a certification in data science and agile coaching.

Maria José Sousa (PhD in Management with Habilitation in Management and Public Management) is Pro-Rector for the Development of Distance Learning and a professor and a research fellow at ISCTE/Instituto Universitário de Lisboa. She is also an expert in digital education and digital skills, as she has assumed a post-Doc position from 2016-2018, researching that field, with several publications in journals with high impact factor (Journal of Business Research, Journal of Grid Computing, Future Generation Computer Systems, and others). Worked as an expert, in a project of the European Commission for the creation of a new category regarding digital skills to be integrated with the European Innovation Scoreboard (EIS). She was a member of the Coordinator Committee of the Ph.D. in Management at Universidade Europeia. She was also a Senior Researcher at GEE (Research Office) in the Portuguese Ministry of Economy, responsible for Innovation, Research, and Entrepreneurship Policies, and a Knowledge and Competencies Manager at AMA, IP, Public Reform Agency (Ministry of the Presidency and the Ministers Council). She was also a Project Manager at the Ministry of Labor

and Employment, responsible for Innovation, and Evaluation and Development of the Qualifications Projects. Her research interests currently are public policies of Innovation and Education. She is a best seller author in Research Methods, ICT and People Management and has co-authored over 100 articles and book chapters in high-level journals (as the European Planning Studies, Information Systems Frontiers, Systems Research, and Behavioral Science, Computational and Mathematical Organization Theory, Future Generation Computer Systems, and others), and is the guest-editor of more than 5 Special Issues from Elsevier and Springer. Is the former President of the ISO/TC 260 – Human Resources Management, representing Portugal in the International Organization for Standardization. She was/is the coordinator of several European projects of innovation (funded by programs as Erasmus +, Horizon Europe, and ICMPD) and is also External Expert of COST Association - European Cooperation in Science and Technology.