BIG DATA ANALYTICS TO SHAPE INNOVATIVE ESG SOLUTIONS THROUGH HUMAN-GENERATIVE-AI LENSES

ANÁLISE DE BIG DATA PARA MOLDAR SOLUÇÕES INOVATIVAS DE ESG ATRAVÉS DAS LENTES HUMANO-GENERATIVA-IA

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Abstract: *Are companies led by big data analytics capabilities likely to improve environmental, social, and governance (ESG) issues? This study suggests big data analytics capabilities as a booster to enhance ESG performance and disclosure – that is, we introduce and examine the strength of big data analytics capabilities to enhance ESG performance. We hypothesize and find robust evidence for a positive relationship between big data analytics capabilities and ESG performance and disclosure through the lens of generative artificial intelligence (GEN-AI) and managers of innovative multinational companies from three sectors of an emerging economy. The main findings of our study suggest that big data analytics capabilities are substantive and enhance environmental, social, and governance performance and disclosure. The results also imply that governance is more responsive to the adoption of big data analytics; while social performance was more muted. We shed new light on the relevance of big data analytics capabilities to shape ESG under a human-machine lens. Our findings therefore contribute to the conversation on the role of big data analytics capabilities in improving ESG issues in organizations by unearthing the organizational implications of big data analytics capabilities for ESG. As organizations increasingly develop analytics capabilities, ESG becomes more powerful. Our study offers a timely warning to companies that aim to make progress on ESG but remain inactive regarding big data analytics capabilities.*

Keywords: *Big Data Analytics Capability. ESG Performance and Disclosure. Generative Artificial Intelligence.*

Resumo: *As empresas lideradas por recursos de análise de big data provavelmente melhorarão as questões ambientais, sociais e de governança (ESG)? Este estudo sugere recursos de análise de big data como um impulsionador para melhorar o desempenho e a divulgação de ESG — ou seja, apresentamos e examinamos a força dos recursos de análise de big data para melhorar o desempenho de ESG. Nós levantamos hipóteses e encontramos evidências robustas para uma relação positiva entre os recursos de análise de big data e o desempenho e a divulgação de ESG através das lentes da inteligência artificial generativa (GEN-AI) e gerentes de empresas multinacionais inovadoras de três setores de uma economia emergente. As principais descobertas do nosso estudo sugerem que os recursos de análise de big data são substanciais e melhoram o desempenho e a divulgação ambientais, sociais e de governança. Os resultados também implicam que a governança é mais responsiva à adoção de análise de big data; enquanto o desempenho social foi mais atenuado. Lançamos nova luz sobre a relevância dos recursos de análise de big data para moldar ESG sob uma lente humano-máquina. Nossas descobertas, portanto, contribuem para a conversa sobre o papel dos recursos de análise de big data na melhoria de questões de ESG em organizações, desenterrando as implicações organizacionais dos recursos de análise de big data para ESG. À medida que as organizações desenvolvem cada vez mais capacidades analíticas, o ESG se torna mais poderoso. Nosso estudo oferece um aviso oportuno para empresas que pretendem progredir no ESG, mas permanecem inativas em relação às capacidades analíticas de big data.*

Palavras-chave: *Capacidade de Análise de Big Data. Desempenho e Divulgação ESG. Inteligência Artificial Generativa.*

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Introdução

Building on contemporary debate and stakeholder theory (Friedman and Miles, 2006) on the challenges and opportunities surrounding the complex adoption of environmental, social, and governance (ESG) principles at the firm level, this study tests an original research framework and evaluates hypotheses on the role of big data analytics capabilities for ESG performance and disclosure. We aim to shed light on the unique context of Brazil, an emerging economy in South America that still faces challenges in advancing the ESG debate. We offer useful expected and unexpected insights to understand the diffusion of ESG in companies operating in stressful and complex environments such as the situation in emerging economies and contribute to the ongoing debate on ESG adoption worldwide. Understanding the current status in terms of the relevance of big data analytics capabilities for ESG performance and disclosure is an important priority for a number of reasons:

First, ESG issues can lead to notable financial gains in market valuation, enhance a company's reputation and reliability, build long-term future resilience, and achieve sustainable prosperity (Treepongkaruna and Suttipun, (2024). ESG creates value (McKinsey & Company, 2024), improves organizational performance (Maji and Lohia, 2024), generates green innovation (Li; Lian, and Xu, 2023), and informs stakeholders in their decisions (Asif *et al.,* 2023). Companies are incorporating ESG factors into their business strategies (Asif, Searcy, and Castka, 2023). Therefore, it is essential to unravel how ESG performance can be amplified and generate insights for decision-making by investors or other important stakeholders. At the same time, ESG research is still evolving (Asif, Searcy, and Castka, 2023).

Second, ESG data come from different sources, both internal (e.g. reports) and external (news, media, reports, etc.), and transforming these raw data into authentic ESG reports depends on access to relevant, accurate, and reliable data, the ability to process information, and the robustness of reporting and disclosure structures (Asif, Searcy, and Castka, 2023; and Hutton *et al.,* 2001). Thus, measuring, analyzing, and disclosing authentic ESG information are challenging activities and a fragmented practice within companies (Asif, Searcy, and Castka, 2023; and KPMG, 2023). These activities depend on the integrated use of technologies. Drawing an analogy with (Wamba *et al.,* 2017), big data analytics tools have the potential to identify, capture, analyze data, and generate insights to shape performance and generate authentic ESG information. In this way, companies are increasingly incorporating big data analytics into their decision-making and encouraging their actions towards ESG adoption (Asif, Searcy, and Castka, 2023; KPMG, 2023; and Sariyer *et al.,* 2024). In this sense, the transition to a more sustainable ESG-based economy cannot be fully understood without considering the relevance of big data analytics capabilities. It is imperative that organizations develop big data analytics capabilities (Gupta and George, 2016; and Mikalef *et al.,* 2020) to stimulate authentic ESG performance and disclosure and shed light on organizational sustainability. While a rich body of previous work has shown the prominence of big data analytics capabilities in improving business performance, the relationship between big data analytics capabilities and ESG performance and disclosure has received less attention. To our knowledge, there are no existing empirically-based studies linking big data analytics capabilities and ESG performance and disclosure in companies from emerging economies. This approach needs to be further explored and understood.

We present big data analytics capabilities as a force for achieving environmental, social, and governance performance. We draw on research in data science and information technology to help us build the core building blocks of analytics capabilities (Gupta and George, 2016; and Mikalef *et al.,* 2020). At the same time, several studies also suggest that dynamic capabilities (Mikalef *et al.,* 2018; Mikalef *et al.,* 2020; and Gong and Ribiere, 2021) and digital capabilities (Gong and Ribiere, 2021; Warner and Wäger, 2019) are ingredients that can be integrated with analytics capabilities (Mikalef *et al.,* 2020; and Mikalef *et al.,* 2018) and enhance earnings performance. Thus, we hypothesize that big data analytics (and dynamic and digital) capabilities strengthen ESG performance and disclosure. Our arguments build on recent advances in data science research that link big data analytics capabilities to increased performance, green innovation spillovers, increased inclusion and social justice, reduced corruption, and improved decision-making.

Consequently, we argue that capabilities can improve ESG outcomes and generate insights to meet stakeholder expectations. Thus, the research problem to be addressed in this study is: Q: What is the relevance (current state of capabilities) of big data analytics capabilities, dynamic capabilities, and digital capabilities to amplify ESG performance and disclosure? To achieve the proposed objective, two surveys were conducted through a hybrid approach. First, a survey was conducted with GEN-AI/ChatGPT using a structured questionnaire to collect data related to information disclosed by companies' Integrated Reports. A second original (empirical) survey based on primary data was conducted with company managers. Both surveys targeted innovative multinational corporations (Most Innovative Companies Report 2024) from three sectors (consumer products industry and Industrial Goods and health care industry) operating in Brazil. These sectors are among the most innovative (BCG, 2022) and ESG-responsible groups of companies in Brazil (Corporate Reputation Business Monitor; 2023), which has the largest economy in South America (Secretariat of Economic Policy (SPE) of the Ministry of Finance, 2024). Furthermore, Brazil aims to advance sustainability through ESG through the lens of Industry 4.0 technologies.

The dual approach of this study aims to confirm the results generated from the human-GEN-AI framework. Our results prove to be robust under both views. Our study offers important theoretical and practical implications for research on big data analytics capabilities and ESG performance and disclosure in organizations. First, we advance existing perspectives that big data analytics capabilities are important for ESG performance and disclosure. Here, we empirically show (through two views) that analytics capabilities shed light on managers who intend to advance ESG through the lens of big data analytics capabilities; at the same time, they serve as a filter through which stakeholders evaluate information to justify their decisions.

Second, we join the research that offers rich insights into how analytics capabilities can guide stakeholder decision-making, which tends to bias organizations toward greener and more socially responsible organizations. By shedding light on the potential of using GEN-AI on the relevance of analytics capabilities for ESG, this study provides insights for organizations to draw on a greater variety and quality of authentic ESG information for stakeholder decision-making. Stakeholder theory helps to fill this gap in the relationship between big data analytics capabilities and ESG performance. Third, we contribute to research at the nexus of organizational studies, data science, and sustainability to show how big data analytics capabilities can shape ESG outcomes. Our approach is timely to examine implications for theory, managers, and other stakeholders. Following this introduction, the remainder of the paper is structured into five additional sections. Section 2 presents the theoretical concepts of the study. Section 3 describes the research methodology used in the study. Section 4 reports the findings. Finally, Section 5 highlights the research discussions and conclusions.

Theoretical Framework and Hypothesis Development

Environmental, social and governance performance

Global sustainable governance faces an unprecedented dilemma to balance green development, high economic growth without compromising ecological balance (Li *et al.,* 2023) and ensuring a more just and inclusive society (Naderpajouh *et al.,* 2024). This inspires organizations to rethink conventional ways of leading, managing and organizing (Madsen *et al.,* 2024) for a sustainable future. Previous studies have shown that organizations have a central role in actions towards a resilient and just future, whether in anticipation, response, learning or monitoring (Naderpajouh *et al.,* 2024). Organizational sustainability is a research field that has begun to take note of a number of emerging and complex concepts (Hahn *et al.,* 2015), such as ESG.

Several scholars (Esposito *et al.,* 2023; and Wang *et al.,* 2024) and stakeholders have recognized the importance of implementing ESG in organizations. The last decade has witnessed an acceleration in the transition towards a "greener" economy, and ESG has been proposed as a force for shaping sustainable growth (Cheng *et al.,* 2024; and Bagh *et al.,* 2024). Previous research has highlighted that increased ESG performance reduces risks associated with environmental impact

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and social responsibility (Meng *et al.,* 2023), improves corporate reputation (Maaloul *et al.,* 2021), and attracts conscious investors (Bresciani *et al.,* 2024).

Thus, ESG investing has gained considerable traction in recent years, led by growing investor interest (Mohammad and Wasiuzzaman, 2021) in companies inclined towards sustainability and social responsibility (KPMG, 2023). Previous studies (Asante-Appiah and Lambert, 2023) suggest that stakeholders increasingly rely on ESG metrics as a reflection of a corporation's ethical standing and long-term viability (Bresciani *et al.,* 2024). ESG encompasses three main metrics aimed at corporate sustainability: environmental, social, and governance (Sariyer *et al.,* 2024).

Environmental: The environmental component is oriented towards a company's initiatives and policies related to environmental issues. This component measures the company's activities directed towards energy consumption, conservation of natural resources, energy efficiency, waste management and climate change emissions, waste, water and resource management (Bagh *et al.,* 2024; and Mohammad *et al.,* 2021).

Social: The social component concerns the companies' strategies related to the social practices and social responsibility that companies should adopt. This covers issues such as protection of human rights, workplace and product safety, inclusion and diversity, public health issues, relationships with employees and local communities (Bagh *et al.,* 2024; and Mohammad and Masiuzzaman, 2021).

Governance: Governance suggests the structures used to manage the company based on integrity, transparency, equity and participation, accountability, and reliability and regulatory improvement. This component concerns factors related to "good corporate governance", such as board independence, control and monitoring activities, protection of shareholders' rights, anti-competitive procedures, and compliance with laws and regulations (Bagh *et al.,* 2024; and Mohammad and Wasiuzzaman, 2021). Thus, it is imperative that corporations improve their ESG performance (Lu *et al.,* 2024) to embody the commitment to sustainable practices (Bresciani *et al.,* 2024; Sariyer *et al.,* 2024) and at the same time, meet the interests of stakeholders (customers, suppliers, affected communities, governments, employees, and others Giordino *et al.,* 2024; Shin, Moon, and Kang, 2023).

In other words, large investors globally have started to base their investment decisions through the lens of companies' ESG performance, which is associated with the disclosure of authentic ESG information (Asif, Searcy, and Castka, 2023; and Wamba *et al.,* 2017). Thus, measuring performance and disclosing authentic ESG information has become crucial for corporations (Bresciani *et al.,* 2024), as it allows companies to maintain sustainability, establish a solid reputation, gain the trust of stakeholders, and contribute to solving sustainable development problems (Chen, Song, and Gao, 2023). Disclosing high-performance information provides corporate management and external investors with more information and serves as a substantive resource for additional investments, as it increases their confidence in the long-term sustainable growth of corporations (*Popov* and Makeeva, 2022; and Alsayegh *et al.,* 2020).

By improving ESG disclosure, there is an increase in company performance (Mohammad and Wasiuzzaman, 2021). Therefore, authentic information should be conveyed and serve as a guide to stakeholders in their decision-making. Although stakeholders' interest in ESG is growing, access to authentic information is still particularly difficult (Mohammad and Wasiuzzaman, 2021; Asif, Searcy, and Castka, 2023). Ensuring reliable and accurate ESG data is essential to enhance decision-making (Mohammad and Wasiuzzaman, 2021). Previous research suggests that one of the main challenges concerns data management. Integrating ESG data is a complex and time-consuming process that companies may not have the capacity to perform frequently.

Data to measure companies' ESG performance comes from various sources, such as annual reports, stock exchanges, business groups, non-profit organizations, government, corporate social responsibility reports, NGO websites, corporate social responsibility reports, new content from ESG-trained research analysts, etc. (Mohammad and Wasiuzzaman, 2021; Asif, Searcy, and Castka, 2023). Thus, measuring, analyzing, integrating, and disclosing ESG factors is one of the main challenges for companies (Asif, Searcy, and Castka, 2023) to generate authentic information around ESG dimensions. In other words, making data available, providing, tracking, and ensuring its security is a critical process for the effectiveness of ESG strategies. It is often mentioned that IT

strategists and data analysts are particularly concerned about the quality and availability of the data they analyze (Mikalef *et al.,* 2020).

In addition, the methodologies for assessing ESG factors effectively are not standardized, as companies adopt different approaches. As such, they generate different results. Thus, the practice is fragmented and disparate. Therefore, it is necessary to eliminate this noise and obtain relevant and authentic information quickly (KPMG, 2023). Previous research has recognized the importance of big data analytics capabilities for environmental, social, and governance issues. However, the relationship between big data analytics capabilities and ESG performance is much less established. We are therefore left with only a partial picture of the contributions of big data analytics capabilities to corporate ESG performance and disclosure. In the following section, we shed light on the relationship between big data analytics capabilities and ESG performance.

Big data analytics capabilities

Big data analytics has the credentials and promise to shape environmental (Le and Vu, 2024), social (Mishra *et al.,* 2021), and governance (Bhardwaj and Singh, 2017) performance and disclosure and ensure a more sustainable future for companies (Barnes, Guo, and Chan, 2022). Based on previous studies, big data analytics empowers companies in collecting, processing, and analyzing large and varied volumes of data and generates accurate and authentic insights (Sariyer *et al.,* 2024 ; Wamba *et al.,* 2017 ; and Ciampi *et al.,* 2021) on ESG factors and trends. This involves informing companies' performance, sustainable value and decision-making, based on data integrity and validated by algorithms to enhance ESG data quality and provide insights into sustainability efforts (Pesqueira and Sousa, 2024; and Abdelhalim, 2024). Although the benefits of big data analytics are widely recognized, companies still need to strengthen their capabilities to take advantage of big data analytics (Mikalef *et al.,* 2020). Researchers often describe big data analytics capabilities as a strength for implementing big data analytics. Based on citation volume (cf. Web of Science), the main literature is highlighted below:

Akter *et al.* (2016) (693 citations): (i) management, (ii) technologies and (iii) talent as analytical capabilities to assess firm performance. In short, the authors describe the analytical capabilities of management, technology and humans to improve performance and obtain sustained competitive advantage (Akter *et al.,* 2016).

Gupta and George (2016) (686 citations): (i) tangible: data (internal and external), technologies (Hadoop, NoSQL), basic resources (time and investments); (ii) human: management skills and technical skills; (iii) intangible: data-driven culture and organizational learning intensity (skills to explore, store, share and apply knowledge). In short, these authors highlight the capabilities to gather, integrate and implement specific big data resources.

Wamba *et al.* (2017) (1028 citations): (i) infrastructure flexibility capability: connectivity capability, compatibility, modularity; (ii) management capability: planning, investment, coordination, control; (iii) people expertise capability: technological knowledge, technology management capability, business management, relational knowledge. In other words, these authors defined big data analytics capabilities as "the competence to provide business insights using data management, infrastructure (technology), and talent capability (people) to transform business into a competitive force".

Mikalef *et al.* (2020) (450 citations): (i) tangible: basic resources, data, and technology; (ii) human skills: technical and managerial skills; (iii) intangible: data-driven culture and organizational learning. In short, Mikalef *et al.* (2018) defined big data analytics capability as "the ability of a company to provide insights using data management, infrastructure, and talent to transform business into a competitive force". At the same time, Mikalef *et al.* (2020) highlighted that the implementation of big data depends on technological resources and talents to capture, store and analyze data, with the aim of generating insights.

We argue that ESG adoption should be analyzed through consideration of big data analytics capabilities, since big data analytics tools can contribute to amplifying ESG performance (Sariyer *et al.,* 2024). Research on analytics capabilities in organizations has mainly been subject to the perspective of resources that motivate action and guide organizations to exploit big data analytics and serve as a filter through which stakeholders evaluate information to guide and justify their decisions (Gupta and George, 2016). This implies that resources that underpin capabilities can lead

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stakeholders to justify decisions. We qualify this line of thinking as follows. We see that resources imply stakeholders' decision-making, who are more likely to ingest information and arguments that reinforce their decisions. Thus, existing research has found that ESG performance can strengthen as resources are amplified. In this sense, big data analytics capabilities can shape environmental, social, and governance perspectives.

On the other hand, previous research has reported that digital transformation can effectively promote companies' ESG performance (Lu *et al.,* 2024). Thus, Gong and Ribiere (2021) (231 citations) developed a unified definition of digital transformation based on a rigorous review and systematic analysis of the literature. The authors discovered 134 definitions that allowed them to unify different conceptual fragments that resulted in the following definition for digital transformation: "A process of fundamental change, enabled by the innovative use of digital technologies accompanied by the strategic leverage of core resources and capabilities, aimed at radically improving an entity and redefining its value proposition for its stakeholders" (Gong and Ribiere, 2021). Thus, the authors indicated that digital transformation depends on (i) digital technologies (artificial intelligence, blockchain, cloud commuting, data analytics, internet of things, mobile, robotics); (ii) resources (human resources, financial resources, knowledge resources,...); (iii) dynamic capabilities (sensing, seizing and reconfiguration); and (iv) digital capabilities (identification, acquisition and implementation).

Unraveling the intricate role of digital capabilities in corporate ESG performance and disclosure is essential (Bresciani *et al.,* 2024). This set of integrated dimensions reinforces the value proposition of companies' business models and generates value for stakeholders. At the same time, Warner and Wäger (2019) (971 citations) proposed a microfoundations-based model for building dynamic capabilities for digital transformation. Based on this proposal, the authors systematized the following blocks of dynamic capabilities for digital transformation: (i) digital sensing: digital scouting, digital scenario planning; digital mindset crafting; (ii) digital seizing: rapid prototyping, balancing digital portfolios, and strategic agility; (iii) digital transformation: navigating innovation ecosystems, redesigning internal structures, improving digital maturity; and contextual factors: external triggers, internal enables, and internal barriers.

In the authors' view, digital transformation was defined as "the use of new digital technologies, such as mobile, artificial intelligence, cloud, blockchain, and the Internet of Things (IoT), to enable major business improvements to enhance customer experience, optimize operations, or create new business models" (p. 1). Based on this construct, the authors found that agility is a critical mechanism for the strategic renewal of an organization's (1) business model, (2) collaborative approach, and eventually (3) culture. This framework served as a basis for examining the relevance of big data, dynamic, and digital analytics capabilities for ESG performance and disclosure.

ESG, big data analytics capabilities and stakeholder theory

This study is anchored in stakeholder theory Friedman and Miles (2006), which is one of the most robust theoretical lenses for explaining contemporary sustainability concepts (e.g., ESG) and suggests that companies should serve and balance the interests of all their stakeholders (Del Gesso and Lodhi, 2024). By reporting authentic ESG information, organizations inform stakeholders' expectations (Alessa *et al.,* 2024). At the same time, stakeholder theory is guided by companies' ethical behavior in their environmentally-oriented approaches in their operations and sustainability information disclosure (Zhou *et al.,* 2022). This signals that company sustainability information should be supported by comprehensive sources of data on how the company's operations affect the local community and the natural environment (Alessa *et al.,* 2024).

Thus, successful companies are those that are able to respond to the demands of their stakeholders (Donaldson and Preston, 1995 ; and Friedman and Miles, 2006). Companies declare their efforts towards global goals as a means of fulfilling their responsibilities and gaining approval and support from multiple stakeholders. In this study, the theoretical link between big data analytical capabilities, ESG principles and stakeholder theory is supported by the preexisting connections between the concepts of corporate social responsibility and stakeholder theory. This study considers big data analytics tools as necessary and relevant ingredients for organizations to

enhance their performance and disclosure of authentic ESG information as a broad part of the definition of corporate social responsibility and its implications for environmental management.

It is possible to suggest that big data analytics capabilities can boost ESG performance and disclosure. Furthermore, big data analytics can help companies perceive and understand the added value of ESG initiatives. We argue that big data analytics capabilities are capable of facilitating ESG adoption. Consequently, big data analytics capabilities can improve ESG performance and disclosure and generate insights for stakeholder decision-making. Our arguments lead us to the following proposed hypothesis:

Hypothesis: Big data analytics capabilities are relevant to corporate ESG performance and disclosure. That is, corporations with big data analytics capabilities are more likely to achieve higher performance than corporations that do not develop them.

Research methodology

The measures, sample and data collection procedures (3.1) are presented in two stages: stage 1 - with ChatGPT and stage 2 - with the company managers.

Measures, sample and data collection procedures

Stage 1 - With the ChatGPT

To collect data using ChatGPT, a questionnaire was developed based on the research framework and theoretical context presented in Section 2. The questionnaire was tested with two professionals (one from the information technology area and one from sustainable business management). They checked whether the formulation of the questionnaire variables was clear. We took care to inform the experts that the questionnaire (written in Brazilian Portuguese) would be used to extract data (perception) from ChatGPT. The experts did not report any significant difficulties when answering the questionnaire and highlighted that the instrument was adequate in terms of structure and content.

Only a few sentences were revised in the refinement of the final instrument, such as shorter sentences to make the questionnaire clearer. The variables used for capabilities were big data analytical capabilities: data, technologies, basic resources, human skills, culture and learning (Gupta and George, 2016; Wamba *et al.,* 2017; and Mikalef *et al.,* 2020) and dynamic capabilities: sensing, seizing and transformation (Gong and Ribiere, 2021; Gupta and George, 2016; Wamba *et al.,* 2017; Mikalef *et al.,* 2020; Teece *et al.,* 1997; and Warner and Wäger, 2019), and digital capabilities: identification/acquisition and implementation of technologies (Gong and Ribiere, 2021; and Warner and Wäger, 2019). The measures used for environmental, social and governance information disclosure were: reliability, completeness and comprehensiveness, and added value (Wang and Strong, 1996).

The measures adopted for performance were: environmental (variables such as energy consumption, conservation of natural resources, energy efficiency, waste management and climate change gas emissions, waste, water and resource management) (Bagh *et al.,* 2024; and Mohammad and Wasiuzzaman, 2021); social (variables such as human rights protection, workplace and product safety, inclusion and diversity, relationships with employees and local communities (Bagh *et al.,* 2024; and Mohammad and Wasiuzzaman, 2021) and governance (variables such as integrity, transparency, equity and participation, accountability, reliability and regulatory improvement). We assigned the following scores: high, reasonable and low to assess the performance and disclosure of environmental, social and governance information disclosed. Open-ended questions with short answers were designed relating the analytical, dynamic-digital capabilities variables and the performance and disclosure of environmental, social and governance information variables.

At this stage of the work, our objective is to answer the following question: In ChatGPT's view, what is the relevance of big data, dynamic and digital analytical capabilities to encourage

environmental, social and governance performance and information based on the information disclosed in the companies' Integrated Reports (based on the metrics and scores mentioned)? We emphasize that we do not intend to indicate the proportion of right or wrong answers, much less compare the superiority of the results obtained from ChatGPT's perspective with the results extracted from company managers, but rather complement the methods to strengthen our findings). In this experiment, we used the version of ChatGPT released on December 15, 2022.1.

Using the 2022 Integrated Reports (most recent publication at the time of the research) of three innovative multinational companies in the consumer products industry, health care industry, and industrial goods sectors, headquartered in Brazil (based on the BCG, 2022, report ranking), we collected data from ChatGPT on their perception of the relevance of analytical, dynamic, and digital capabilities for ESG performance and ESG disclosure of corporations. The interview with ChatGPT was conducted in two stages. The first stage was conducted in two stages: 1 – by (2) authors of this research; 2 – in the second stage, a brainstorming session was held with the (2) authors of this research to compare and refine the results obtained from the interview with ChatGPT. The results obtained were similar and a Word document was prepared with the refinement of the responses, which served for the analysis of the results.

Stage 2 - With the managers

A second scalar questionnaire (Likert, with 5 points: 1 - least importance and 5 - most importance) was prepared using the following variables (measures): big data analytical capabilities and dynamic capabilities (sensing, seizing and transformation) and digital capabilities (identification/acquisition and implementation of technologies). The instruments were prepared in Brazilian Portuguese. Before the final application, the questionnaire was sent to two IT and business management experts for validation and testing. Again, a few adjustments were highlighted related to clarity and objectivity. Subsequently, the instrument was refined for the final application with the company managers. The professional network LinkedIn was used additionally to identify the company managers.

We sent (by e-mail) the questionnaire to three managers of (three) innovative multinational companies headquartered in Brazil – sectors: consumer products industry, health care industry, and industrial goods. The three respondents in our sample are men, occupying production management positions, with a background in production engineering, with an average age of 38 years, and with (1) bachelor's degree, (1) master's degree and (1) doctorate. To determine whether analytical, dynamic and digital capabilities were relevant to ESG performance and disclosure, we used descriptive statistics techniques as an analytical approach.

Results

This Section shows the results of the relevance of analytical capabilities, digital dynamics for the performance and disclosure of environmental, social and governance information of corporations (Stage 1) from the perspective of GEN-AI/ChatGPT and (Stage 2) from the perspective of humans (company managers).

Stage 1 – GEN-AI vision with ChatGPT - Based on Integrated Reports

Using the 2022 Integrated Reports of three companies from the consumer products industry, health care industry, and industrial goods sectors and based on the metrics: reliability, completeness and comprehensiveness, and added value, we asked ChatGPT to evaluate the relevance of capabilities (scores: high, reasonable, and low) in relation to the performance and disclosure of environmental, social, and governance information disclosed.

Environmental Information: The findings suggest that the information provided by companies in their integrated reports is highly credible, evidenced by third-party auditing and alignment with

international environmental reporting standards that ensure the accuracy and reliability of the data presented. In addition, companies add significant value by disclosing detailed data on their environmental practices. This information reinforces the corporate image and stakeholder trust, demonstrating a strong commitment to sustainability. At the same time, the results indicate that the information is relevant and comprehensive, addressing crucial issues on climate change, sustainable resource management and energy efficiency. Likewise, the reports are complete and cover all important aspects of environmental management. Details on carbon footprint, water consumption, climate change, waste management, greenhouse gas emissions and energy efficiency are highlighted in a clear and comprehensive manner, allowing a complete assessment of each company's environmental performance. Therefore, the environmental information communicated by companies in their 2022 reports is highly credible, with high added value and extremely relevant and complete.

Social: Similarly, the findings show that the quality of social information disclosed by companies in their 2022 integrated reports is high. This assessment is based on transparency, detail, independent verification and adherence to international standards. These factors contribute to the reliability and integrity of the information highlighted, signaling a robust commitment to social responsibility. Both companies demonstrate transparency by providing details on their social practices, such as diversity, employee health and community impact. In addition, this information is frequently audited by third parties, which increases its credibility.

At the same time, companies set clear goals and disclose the results achieved, allowing for a transparent assessment of progress aligned with approaches over time. Likewise, companies provide a wide range of data on their social practices, including areas such as diversity and inclusion, employee health and safety, community development and positive social impact. In addition, they detail their specific initiatives, presenting programs, policies and strategies implemented to address relevant social issues. This information is presented in a clear and accessible way, making it easy for stakeholders to understand. Companies also highlight the positive impacts generated by these initiatives, such as contributing to employee well-being, promoting diversity and inclusion, and supporting the communities in which they operate.

This information not only informs about the social performance of companies, but also demonstrates their commitment to sustainability and creating shared value for society. Finally, quantitative and qualitative metrics are used to measure social performance, providing a comprehensive view of the progress made in relation to the social goals and objectives set by companies. Therefore, the social information presented by companies is reliable, based on their transparency, independent verification, disclosure of goals and results, and long-standing commitment to social responsibility; adds value by demonstrating the tangible benefits of their responsible social practices; and is complete and comprehensive, indicated by transparency and corporate social responsibility.

Governance: the results show that the quality of governance information disclosed in companies' 2022 Integrated Reports is highly reliable. We found that the information is disclosed with transparency, detail, and adherence to recognized international standards. Companies provide transparency by detailing their governance structure, including the composition of the board of directors and audit committees, roles of board members, ethics policies, codes of conduct, and compliance, compliance, and anti-corruption practices, demonstrating a robust commitment to ethics and corporate governance. In other words, governance structures are clear, results are measurable, and frequently audited by third parties. Therefore, the governance information provided by companies is highly reliable, extremely complete, and with high added value. The implications are more reliable and accessible information for stakeholders.

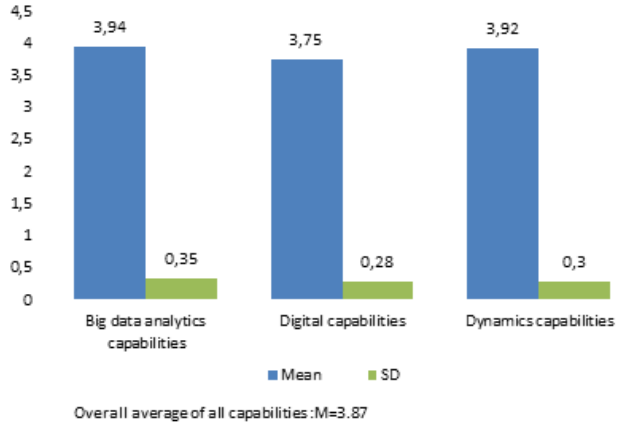
Our findings are in line with the theoretical lenses of (Pesqueira and Sousa, 2024), who highlight the critical roles of big data analytics and dynamic capabilities for ethical, socially responsible, and environmentally sustainable practices. Drawing an analogy with Mikalef *et al.* (2020) and Wamba *et al.* (2017), these results show the power of big data analysis for the performance and communication of environmental, social and governance information. The implications are that companies can stimulate their value (Cai *et al.,* 2024), their reputation, trust (Cornell and Shapiro, 2021) and decision-making (Awan *et al.,* 2021) of stakeholders.

In summary, our findings signal the prominence of the theoretical lenses (Gong and Ribiere, 2021; Gupta and George, 2016; Mikalef et.al., 2020; and Warner and Wäger, 2019) of digital dynamic capabilities (digital foresight, digital scenario planning and digital mindset and strategic agility, capabilities to redesign internal structures, digital maturity and navigation in the innovation ecosystem) to shape environmental, social and governance performance and disclosure and meet stakeholder needs. At the same time, our results are consistent with the literature on ESG implications (Treepongkaruna and Suttipun, 2024), which highlight that companies with strengthened ESG performance have the promise of attracting stakeholders, enhancing the development of new sustainable products, improving competitive advantage and moving towards sustainability.

Stage 2 - Views of Managers of Multinational Companies

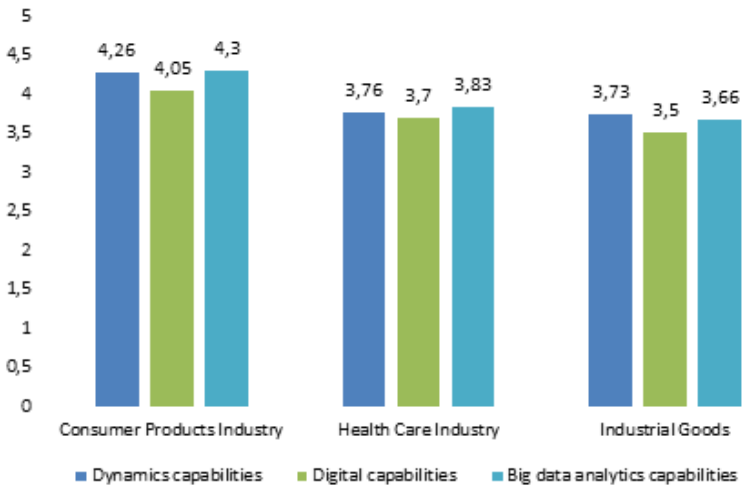
Using descriptive statistics techniques, this section shows the findings of the relevance (mean and standard deviation) of analytical, dynamic and digital capabilities for ESG performance and disclosure (Figures 1, 2 and 3).

Figure 1. Overall results of the means and standard deviation of digital analytical and dynamic capabilities



Source: Produced by the authors (2024).

Figure 2. Overall results of means and standard deviation of digital analytical and dynamic capabilities / by sector - Consumer Products Industry, Health Care Industry, and Industrial Goods



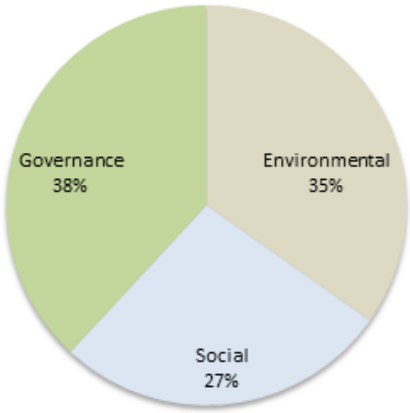
Source: Produced by the authors (2024).

Figure 3. Results of the averages of analytical and digital dynamics capabilities

Source: Produced by the authors (2024).

The results indicate (on average) substantive relevance (M=3.87; SD=0.3) (Fig.1) of capabilities to amplify ESG performance, with emphasis on analytical (M=3.94) and dynamic (M=3.92) capabilities (Figure.1). At the same time, the findings reveal that capabilities are most relevant to performance in the context of companies in the consumer products industry (M=4.21) (Figure.2); then companies in the health care industry (M=3.76), and finally companies in the industrial goods sector (M=3.64) (Fig.2). In addition, managers indicated that companies have strong capabilities to perceive/detect (M=4.26) (Figure.3) technological opportunities and trends oriented to ESG performance. Likewise, they indicated the prominence of managerial skills (M=4) oriented to ESG (Figure 3). At the same time, our findings also reveal that data and technology capabilities (M=3.8), resource allocation and (re)allocation (M=3.6), data-driven culture (M=3.6) and learning (M=3.6), apprehension (M=3.8) and reconfiguration (M=3.7) are weaker (Figure 3). Figure 4 shows the sensitivity of environmental, social and governance performances to analytical, dynamic and digital capabilities. In other words, the results (Figure 4) indicate which capabilities are most relevant to environmental, social and governance performance.

Figure 4. Results of the relevance of capabilities for the environmental, social and governance performance of multinational companies



Source: Produced by the authors (2024).

The results reveal that the benefits of analytical, dynamic and digital capabilities were more biased towards governance performance (M=4.23); while sensitivity to social aspects was more modest (M=3.01). Our findings support the hypothesis of this study, that big data analytics and digital dynamic capabilities enhance ESG performance and disclosure. We acknowledge the importance of the human-GEN-AI hybrid approach to strengthen our conclusions that analytical and digital dynamic capabilities enhance ESG performance. This provides organizations with actionable insights to adjust their strategies towards analytics capabilities, guiding them on when and how to leverage GEN-AI capabilities in the ESG process.

Discussion and final considerations

What is the relevance of big data analytics capabilities to enhance ESG performance and disclosure - GEN-AI-human perspective? This question was addressed through the insights of analytics capabilities and digital sensing, digital seizing, and digital transformation from the perspective of managers in a real-world scenario and by ChatGPT. The unique contribution of this paper is to empirically test evidence of the current state (relevance) of analytics capabilities and digital dynamics for ESG performance and disclosure in the context of an emerging economy. Data from ChatGPT and managers of innovative multinational companies in Brazil provide robust empirical evidence for the link between big data analytics capabilities, digital dynamics, and ESG performance and disclosure. We offer useful insights to understand the diffusion of these capabilities to the current debate around the implementation of environmental, social, and governance issues in these economies.

The findings obtained in this study shed light on the scenario of Brazil, which still faces challenges related to ESG adoption, mainly with the generation of authentic ESG data to meet the interests of stakeholders. The main findings of this study suggest that big data analytical capabilities are substantive and enhance the performance and disclosure of information on environmental, social and governance issues (in our sample), with emphasis on the sub-capabilities: managerial skills (M=4), detection (M=4.26) and technology identification (M=4.1). These findings are in line with theoretical lenses (Pesqueira and Sousa, 2024; Sariyer et.al., 2024; and Cai, Li, and Tu 2024), which highlight the relevance of analytical and dynamic capabilities to enhance ESG results. On the other hand, technical skills, capabilities to implement technologies and reconfigure (allocate and reallocate resources) signaled more timid or moderate results. Our empirical findings highlight that the consumer products industry sector tends to present more substantive capabilities to amplify ESG performance (M=4.21).

The findings show that governance performance was more sensitive to digital analytical and dynamic capabilities, while social performance had weaker results. These results are in line with

previous studies (Govindan, Shaw, and Majumdar, 2021) that suggest neglect of social issues in the past. Although this research confirms the expected results that big data analytical capabilities have the potential to enhance ESG performance and disclosure, it also suggests unexpected and original insights: that is, in the view of managers and GEN-AI/ChatGPT, big data analytical capabilities integrated with dynamic and digital capabilities tend to produce more robust and effective results in terms of ESG performance. Although previous studies tend to indicate the superior performance of ChatGPT due to the vast information database used by AI, the purpose of this study is not to compare and classify the superiority of GEN-AI in relation to humans, but to signal the complementarity of both to enhance the authenticity of authentic ESG results. In this sense, we highlight the need for a hybrid approach in this study was crucial to stimulate ESG performance. Thus, by shedding light on the potential of using GEN-AI, this study generates insights for organizations to draw on a wider variety of authentic information generated to enhance ESG performance and disclosure. By displaying complete, explanatory, and authentic results, GEN-AI offers significant contributions to companies striving to optimize their ESG strategies enabled by big data analytics. These research results can be useful for academics, managers, and end users facing the challenges of adopting ESG enabled by big data analytics in emerging economies that share characteristics with Brazil. These findings have implications for theory and practice.

Implications for theory and practice

First, the findings of this study contribute to advancing the understanding of the theoretical lens of big data analytics capabilities integrated with dynamic and digital capabilities to enhance ESG performance and disclosure from the perspective of corporate managers and GEN-AI with ChatGPT. Second, our study extends the existing literature that suggests that stakeholders have become vocal and aware of the importance of information about ESG initiatives implemented by sustainability-oriented organizations. Therefore, the findings of our study advance the arguments in the literature on the relevance of big data analytics capabilities for companies to improve their ESG initiatives. At the same time, the practical implications are that companies that foster big data analytics capabilities and dynamic digital capabilities have the promise of enhancing their ESG performance.

We urge companies to leverage analytics rather than gut instincts (Davenport, Harris, and Shapiro, 2010). Interestingly, if there were more resources (technology, financial resources, human skills, culture, etc.) to leverage big data analytics to enhance ESG performance, perhaps the findings of this study would be different with respect to the current state of big data analytics capabilities to enhance ESG performance and disclosure; as a result, companies could perform and disclose ESG information even better to meet stakeholder purposes. To be clear, exploiting big data has the potential to radically improve ESG performance, but companies need to be guided by data-driven decision-making (McAfee and Brynjolfsson, 2012).

Big data analytics capabilities are crucial and worthwhile to lead companies towards ESG adoption in the view of GEN-AI and the consulted managers. Therefore, we suggest that managers and leaders meet stakeholders' expectations with authentic information on ESG performance. This study calls on managers and leaders to formulate and implement big data analytics capabilities for ESG. Thus, we urge managers to develop and encourage the use of resources that strengthen the development of big data analytics capabilities, improve ESG performance; and at the same time pave the way for companies' sustainability. Likewise, it is imperative that managers and leaders of companies establish strategic partnerships to share resources and leverage big data analytics capabilities, enabling companies to make a more fundamental shift towards ESG practices; and at the same time, innovate resource efficiency.

The journey towards ESG powered by big data analytics requires leaders to provide more financial incentives, develop a data- and technology-driven culture, adopt a policy to restructure the work of technical teams, and implement policies and training plans for team members. Investments in technologies (big data analytics, for example) are crucial to encourage and lead companies inclined to adopt ESG (Asif, Searcy, and Castka, 2023; and Sariyer et.al., 2024). Finally, we advise company leaders to act to increase investments in big data projects for ESG; encourage teams to

explore new knowledge to proactively design ESG solutions in emerging economies.

Limitations and suggestions for future research

Although this study has numerous theoretical and practical implications, it is not free from limitations. First, this study is a first effort to understand the relationships between big data analytics capabilities and ESG performance and disclosure in an emerging economy. This study adopted the variables big data analytics capabilities (Mikalef et.al., 2018), dynamic capabilities (Mikalef et.al., 2018; Mikalef et.al., 2020; Gupta and George, 2016; Teece, and Pisano, and Shuen, 1997), and digital capabilities (Gong and Ribiere, 2021; and Warner and Wäger, 2019) and their subcapabilities. We acknowledge that other theoretical choices could be adopted from other literature. Thus, the findings of this research should be inherent to the sample of this study and should not go beyond this limit. The sample of this study is limited and the data were collected at a specific point in time. In this sense, different results may emerge if the sample is expanded.

We conducted our study in three sectors (consumer health, care products industry, industrial goods) in Brazil, which indicates that the results of this research cannot be generalized to other countries. We understand that future studies can adopt our research proposal and expand the sample to other sectors and in other countries. Our research suggests opportunities for future research on the adoption of big data analytics capabilities for ESG in companies from emerging economies. We invite future researchers to use our framework (managers' view and artificial intelligence) and conduct a comparative study with samples of companies in emerging economies with those in more mature economies. In addition, different organizational theories (e.g., legitimacy theory, institutional, information, and signaling theory) can add new ingredients to the debate on the adoption of big data analytics for ESG in companies from emerging economies. Despite the limitations highlighted in this study, the findings suggest several important conclusions for theorists, researchers, and organizations on big data analytics capabilities and ESG in the context of emerging markets.

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