

Perspective

From Compliance to Capability: On the Role of Data and Technology in Environment, Social, and Governance

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Abstract: The importance of Environment, Social, and Governance (ESG) considerations for businesses has evolved from compliance to a strategic imperative. This shift is driven by increased investor scrutiny, reputation and brand value impact, talent attraction, innovation stimulation, community relations, and global regulatory requirements. At the same time, the ESG regulations and policies, related technological landscape, and market trends are continuously changing. It is, therefore no longer tenable for firms to stick to a minimalistic approach of ESG regulatory box-ticking ‘compliance’; instead, it is becoming increasingly critical to develop ESG ‘capabilities’ that help firms to seamlessly and proactively adapt themselves to the changing environment and even turning it into new (strategic) opportunities rather than reluctantly reacting to change, being operationally and organizationally overwhelmed, and disrupted, often with inadequate response and poor adoption as result. Many studies show that data and technology can be powerful enablers of such capability. The evidence is, however, unstructured and dispersed. In response, this study consolidates existing research and presents a comprehensive conceptual framework, bridging the fragmented landscape of ESG data and the technology literature. It offers practical guidance for firms, helping them lay holistic data and technology foundations for ESG and advance toward higher maturity levels in their ESG capability.

Keywords: Environment, Social, and Governance (ESG); data and technology; ESG Capability; literature review; ESG maturity model; conceptualization



Citation: Solaimani, S. From Compliance to Capability: On the Role of Data and Technology in Environment, Social, and Governance. *Sustainability* **2024**, *16*, 6061. <https://doi.org/10.3390/su16146061>

Academic Editor: Eduardo Schiehl

Received: 1 June 2024

Revised: 9 July 2024

Accepted: 13 July 2024

Published: 16 July 2024



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1. Introduction

For many firms, Environment, Social, and Governance (ESG) has reached the top of the strategic priority list, evolving from a mere compliance obligation to a business-driven opportunity as firms’ ESG performance is increasingly (i) scrutinized by investors [1], (ii) considered representative for the firms’ (global) reputation and brand value [2], (iii) playing a critical role in attracting and retaining top talent [3], (iv) stimulating innovation [4], (v) considered as a social license to operate based on a sustainable and positive relationship with communities [5], and (vi) becoming a leading regional and global regulatory requirement [6].

With the growing strategic criticality of ESG on the one hand, and the ever-changing (often expanding) regulatory compliance, as well as the ever-increasing social and ethical expectations, on the other hand, firms are prompted to embrace paradigm shifts by developing ESG capability that is not marginalized to regulatory compliance and reporting, but considered as a business imperative, if not strategic opportunity. Within a definitional realm, ESG is not mere compliance with the existing laws and market demands but is increasingly concerned with the ability and competence to deal with uncertain and dynamic regulatory and market developments [7]. Such a shift implies moving away from retrospective (if not reactive) reporting on ESG to a more proactive orientation marked by visionary ambitions, looking beyond the current rules and directives and beyond short-term shareholders’ value.

It means that ESG activities are structured within a multidisciplinary setting (i.e., contemplating ESG from various domains, including business, data and technology, operations and supply chain, compliance, and more) with a holistic frame of reference (i.e., the ESG strategy being baked into the firms' end-to-end operations), beyond the current state of regulatory affairs (i.e., mid- and long-term vision in addition to short-term objectives and obligations). Such ESG capability equips firms with structures, principles, techniques, and tooling that collectively help firms to be and remain agile in sensing, adapting, and even thriving on change.

Establishing ESG capability is, however, easier said than done. Firms need to overcome several barriers, including the unclear distinction between the different ESG methodologies, definitions, and requirements [8], shareholders' conflicting interests vis-à-vis ESG initiatives [9], lack of dialogue and alignment between departments regarding ESG information and performance [10], and lack of materiality, accuracy, and reliability of ESG data [11], as well as a firm's inability to assess, prioritize, scope, and plan ESG initiatives with actual environmental and social impact [9]. In this regard, there appears to be a broad consensus among scholars that data and technology can play a pivotal role in mitigating many of the barriers and facilitating ESG capability development, for instance, by enabling real-time measurement, monitoring, and reporting on ESG performance measures, enhancing ESG data quality, accuracy, and accessibility, extending firms' scope to multi-tier supplier chains, improving the internal transparency of ESG information, inhibiting short-sighted behavior of management teams, and improving (green) innovation capability [12–18].

Notwithstanding the ever-growing body of knowledge on the merits of data and technology for ESG, the existing studies are highly scattered as research, in general, tends to focus on a niche subset of such an intricate domain, leading to a dispersed perception of the interdependence and interplay among various aspects of data and technology. Therefore, the main objective of this conceptual study is to advance our understanding of 'how firms can move more toward future-proofing ESG capability and how data and technology can be of value'. To do so, this study aims to converge the existing insights into a comprehensive conceptual view. Theoretically, the study at hand attempts to structure and integrate the current literature and draw attention to how data and technology can be developed and positioned holistically. In practical terms, the proposed framework can help firms establish their data and technology groundwork, benchmark their status quo, and devise a roadmap toward a higher level of ESG data and technology maturity.

The remainder of this paper is structured as follows. First, a comprehensive account of ESG dimensions and the supporting data and technological aspects are discussed. Next, the interactions and interdependencies between dimensions are elaborated, based on which an ESG maturity model is proposed, and the application of the model is demonstrated with an illustrative case. The paper concludes with a discussion of how the proposed framework can be of academic and practical use, as well as potential themes for future research.

2. Conceptualization of a Generic Framework for Technology and Data-Enabled ESG Capability

Building capability of any kind is challenging as it requires a long-term vision, leadership commitment, and investment in competencies and skills, with a focus on culture and organizational structure [19,20]. To define capability, Lindbom et al. [21] compared several definitions and proposed that '(i) capability is equated to resources, (ii) resources constitute an important component of capability, (iii) capability describes the ability to do something, (iv) capability is a capacity, and (v) capability is a factor affecting an outcome or goal' (p. 48). Similarly, the scholarly debate on data and the technological basis of ESG capability refers to various resources, assets, competencies, and skills. Below, an attempt is made to review the literature and combine the data and technological constituents necessary for achieving a long-term ESG capability, synthesized into leadership, cultural and behavioral, operational, technical, and ethical dimensions.

2.1. Leadership Perspective

Starting from the executive room viewpoint, in particular, the chief data or information office, fundamental principles in building ESG capability include the firms' need for the following:

- i. **Strategic alignment** refers to the boardroom's coherent and integrative view and understanding of the Information Technology (IT) innovation pipeline and project portfolio [22]. In other words, the ESG-oriented IT investments are expected to be positioned within the 'larger picture', synergetic to other planned initiatives, to prevent the emergence of uncoordinated, siloed 'hobby horse' projects, and all the projects should jointly help materialize the ultimate goal of ESG in a verifiable way, namely, 'leaving the world a better place than how we found it'. Inherently, an integrative approach calls for a long-term vision of digitalization.
- ii. **Long-term digital vision** implies firms' cognizance of the highly VUCA (Volatile, Uncertain, Complex, and Ambiguous) business market and changing legal and regulatory developments. While the emphasis on compliance is understandable and necessary, an obsession for the mere 'here and now' leads to a reactive (if not ad hoc) approach and playing catch-up given the ever-changing ESG obligations [23]. Instead, a long-term digital vision tends to focus on resilience and risk management, scalability and flexibility to accommodate future change, and long-term collaborative relationships with vendors, while also adopting agile (and DevOps) methodologies to remain nimble in identifying (e.g., regular assessments and retrospectives) and implementing improvements. Therefore, the congruence and clarity of the long-term digital vision profoundly depend on the executive teams' digital skills, or so-called digital leadership.
- iii. **Digital leadership** involves a mix of innovative and disruptive leadership driven by a digital mindset that includes being aware of digital trends and having practical digital experience, both in visioning and execution [24,25]. Regarding digital vision, [26] underscore the importance of four additional competencies, including (i) digital knowledge (digital tools and technologies), (ii) a learning mindset (experimenting, risk-taking abilities, and fast failing), (iii) empowering those lower in the organizational hierarchy in decision-making, and (iv) managing cross-functional teams through different mediums. There are several digital competence frameworks and tools in the areas of information processing, communication and cooperation, creating digital content, security, and problem-solving, with attention to business objectives, personalization, gamification, and simulations, which can be utilized to upskill the board members as part of a broader literacy program [27].

2.2. Cultural and Behavioral Perspective

Culture and behavior in digitalization and ESG are just as critical in this area as they are in similar settings. Peter Drucker's adage is pertinent: 'No matter how great your business strategy is, your plan will fail without a company culture that encourages people to implement it'. Given the dynamic domain of ESG, both in terms of changing policies and advancing technologies, an agile culture and behavior is advocated, with principles including the following:

- i. **A learning mindset**, which is the cornerstone of firms' innovation capability [28], needs to be cultivated with continuous small experiments, empowering and encouraging proactivity toward change [29], dynamic talent management, and improving knowledge identification, acquisition, diffusion, and renewal [30], all of which help to inspire but also tap into the employees' curiosity and their sense of purpose when exposed to firms' ESG proposition. In facilitating employees in their learning journey on ESG contemporary themes, digital technologies are increasingly valuable for both talent management (e.g., tools for performance evaluation, personalized learning and development, and digital assessment [31]) and knowledge management, e.g., advanced Artificial Intelligence (AI)-enabled text-mining techniques for

document analysis and the extraction of relevant information for employees [32]. Further, Generative AI (GenAI) is increasingly augmenting the processing and cognitive functions [33].

- ii. **Collaborative attitude** is about close collaboration between various internal and external stakeholders in data and knowledge sharing, monitoring, steering, and reporting. Therefore, pursuing cooperation and co-creation with partners from and beyond the value chain (i.e., open innovation) is more of a necessity than an option [30,34,35]. Examples include integrating procurement systems with suppliers and proactive evaluation of ESG performance. Also, AI and GenAI applications are on the rise, with various tools for virtual assistance, brainstorming, remote work support, and online collaboration platforms, for instance [36].
- iii. **Data drivenness** is about nurturing a culture that welcomes the use and piloting of new technologies [37] and where decision-making processes are influenced and guided by data and analytical insights [38,39]. Such a data-driven culture supports ESG initiatives by enhancing decision-making, improving operational efficiency, fostering transparency, driving innovation, and promoting sustainable practices [40]. As discussed in the previous section, top management support and sponsorship are critical factors in establishing such a mindset [41].

2.3. Operational Perspective

Evolving toward ESG capability requires translating and embedding an ESG vision and ambitions as part of the firm's strategy and business model into operations and processes. The operational principles include the following:

- i. **The operating model** refers to the firm's ability to integrate social and environmental needs into its business operations [42]. The firm's strategic standpoint on 'how to differentiate itself within the market' cascades down to the business model that describes 'what value is created and captured in a feasible and viable way for customers', which, in turn, needs to be translated into a blueprint of 'how value is delivered to customers using resources, information, processes, and technology', i.e., the operating model [43–45]. This means the firm's operating model should be explicit about how ESG interacts with and impacts the firms' processes across all functions, such as supply chain management, procurement, manufacturing, finance, and logistics, supported with an underlying governance model regarding roles and responsibilities, associated boards and committees, and the communication and decision-making structures. There are several valuable frameworks that aim to leverage digitalization to transform the firms' operating model (e.g., [46,47]).
- ii. **Data governance** refers to authority and control over data management [48,49]. According to [50], data governance is a consolidation of data scope (i.e., structured and unstructured data), data domain (e.g., data quality, security, architecture, etc.), organizational scope (intra- or inter-organizational), and various governance mechanisms (e.g., roles and responsibilities, policies, standards, procedures, and training (i.e., data literacy), as well as data collaboration between various stakeholders, including, but not limited to, business and IT).
- iii. **Process orientation** refers to the fact that although ESG initiatives typically reside within dedicated units such as corporate sustainability or social responsibility departments, their outreach must be holistic and proactively involve a broad set of stakeholders to ensure comprehensive and effective implementation. From a change management perspective, [51] proposes developing a change leadership including all stakeholders with a dedicated high-level formal committee as the stakeholder group for formulating a compelling ESG vision, communicating about ESG, creating and sharing change-related knowledge, and thus, institutionalizing the change in the company culture and processes. Only through such an end-to-end approach and detailed understanding of stakeholders' interdependencies do the

conflicting interests and trade-offs surface, e.g., ecological gains at the expense of social welfare [52,53].

- iv. **Performance measurement** extends the notion of process orientation by developing and tracking key performance indicators (KPIs) related to ESG goals. Performance measurement is essential for reliable ESG reporting, particularly for standards that encompass the entire firm value chain, such as the European Sustainability Reporting Standards (ESRSs) and its greenhouse gas (GHG) emission categorization (i.e., scopes 1, 2, and 3) [54]. However, these reporting standards are evolving targets with increasingly comprehensive requirements. Data analytics, visualization, and dashboarding technologies can provide dynamic transparency of overarching themes like triple-bottom-line KPIs while progressively extending the data scope and granularity [55]. Also, the use of quality management systems (QMSs) and environment management systems (EMSs) appear to increase ESG performance and assist firms in translating stakeholders' concerns into actionable practices [56].

2.4. Technological Perspective

Unsurprisingly, technology is increasingly recognized as a critical enabler of ESG activities and objectives. However, technological developments' diversity and rapid evolution often leave firms needing clarification on where to focus and invest, resulting in scattered and ineffective efforts. The technological landscape is diverse as it supports firms in every step of operations, from production to performance or service-level monitoring, service and product improvements, and distributing or delivering services or products. Some examples within the ESG context include dashboarding and big data analytics in measuring environmental footprint, blockchain for transparent reporting, digital twins for social and ecological impact assessment and scenario analysis, cloud computing for storing and real-time analytics across complex supply chains, (Gen)AI for privacy and security purposes, robotics both in product and service industry to minimize various types of waste, edge computing to establish intelligent alerts and control mechanisms, and sensorization and datafication for smart assets and utilization management, to name a few [57–60]. With the recent advancements in Industry 4.0, these possibilities are becoming more and more affordable, reliable, accessible, and remarkably scalable. However, across all these applications, as mentioned earlier, firms' ESG maturity is, to an increasing extent, dependent on a few overarching principles:

- i. **Interoperability**, or a harmonious interplay between various technologies and systems in terms of interoperability-friendliness; e.g., Application Programming Interface (API) strategy (API refers to a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service.), data compatibility, access management across applications) as more and more niche expert systems specialized in specific tasks gain momentum, e.g., [12,61]. There are several models and protocols, typically sector-specific, that aim to alleviate the challenges of interoperability, e.g., [62–65].
- ii. **Data quality**, in terms of rules and policies (on top of the earlier-discussed data governance) and checks and balances, potentially using cutting-edge (Gen)AI technologies to support data management and data life cycle management, e.g., [16].
- iii. **System and architectural flexibility**, given the fact that 'change is the only constant', in the years to come, for example, by means of multi-cloud strategy, multi-vendor data architecture, supplier development and co-creation, multi-sourcing and procurement strategies, multi-tier data center networks, and systems' adaptability (e.g., changing users requirements), modularity (e.g., replacing or upgrading without affecting the entire operation), maintainability (e.g., easy updating, clear documentation, support services), and scalability (e.g., handling growth in users, data volume, transaction rates), and last but not least, the energy consumption performance of IT infrastructure itself, e.g., [66–69].

- iv. **Resilience** to disruptions to maintain consistent performance and service delivery to internal and external customers in the face of growing globalization, for example, putting in place disaster recovery procedures, failover mechanisms, redundancy, load balancing, containerization, and suchlike, e.g., [70,71].
- v. **Security and privacy**, which is inherent to our ever-growing reliance on technology, involves protecting systems, networks, and data from cyber threats and unauthorized access (e.g., with encryption, seamless access control, network security, end-point security, security monitoring, incident response plan, security audits) and protecting personal and sensitive information from unauthorized access (e.g., data minimization, anonymization, data retention policies, data transfer, privacy by design), e.g., [71–74]. At the same time, firms need to comply with data protection regulations such as GDPR, CCPA, and HIPAA, using static and dynamic and interactive analysis security testing tools, and Privacy-Enhancing Technologies (PETs) such as synthetic data, differential privacy, homomorphic encryption, federated learning, secure multi-party computation, and zero-knowledge proofs, e.g., [75–78].

2.5. Ethical Perspective

Incorporating ethical principles in the ESG agenda is paramount to ensuring that business practices not only comply with regulatory standards, such as the EU AI Act, AI Liability Act, and NIS2, but also foster trust, accountability, and long-term sustainability. In this regard, the following principles are underscored:

- i. **Responsibility and fairness** aim to ensure that business practices are fair and non-discriminatory, mitigate various biases in design and use, protect privacy, and promote equality and inclusion [79]. The use of technology, especially various AI toolkits, is highly in demand as these tools are becoming more and more effective in detecting and mitigating biases in decision-making processes, ensuring fair and unbiased outcomes by, for instance, increasing the hiring, promotion, and retention of women in the tech industry [80]. Examples include toolkits with fairness metrics testing, case comparison, experimenting with decision thresholds, providing prediction explanations, visualization of fairness and accuracy metrics, and augmenting model-building with fairness considerations e.g., [81].
- ii. **Explicability** tackles the other side of the coin, namely, the (unconscious) bias and noise in data and AI algorithms, by considering transparency that is often described in terms of traceability, explainability, and communication, where (i) traceability entails the ability to track the data sets and processes employed, (ii) explainability involves providing explanations regarding the extent to which an organization and its decision-making processes are influenced by AI technology, along with accompanying justifications, and (iii) communication entails effectively conveying the capabilities and limitations of the technology to relevant stakeholders, including ensuring users are aware when they are interacting with an AI system and identifying the responsible individuals [82]. Interpretability, which is the condition in which systems and their operations can be understood by a human, either through introspection or produced explanation, is another aspect of explicability. In the words of [83], an interpretable system is ‘a system where a user cannot only see but also study and understand how inputs are mathematically mapped to outputs’ (p. 52141). From a tooling perspective, LIME (Local Interpretable Model-Agnostic Explanations), SHAP (SHapley Additive Explanations), and the ELI5 toolkit are some examples of how technology can enhance explicability [84].
- iii. **Accountability** aims to identify who is responsible for how the technology works. It should be ensured that ‘the technology—or, more accurately, the people and organizations developing and deploying it—are held accountable in the event of a negative outcome’ [85] (p. 700). This concept typically includes elements such as audibility, the minimization and reporting of adverse impacts, trade-offs, and adequate redress [82]. Also, the principle of accountability can be assisted with

several compliance and regulatory tools that provide automated compliance checks, documentation, and reporting [86].

3. An Integrative Model for Technology and Data-Enabled Capability

Drawing upon the synthesized insights from the latest studies discussed in the previous section, ESG capability—distinct from mere ESG compliance, which primarily addresses existing regulations and market demands—can be defined as ‘a holistic system with interdependent and reinforcing components that includes visionary digital leadership facilitating and motivating the organization along with employees and value chain partners such as clients and suppliers to adopt ESG values, practices, and metrics, integrated across end-to-end operations, and collaboratively establishing a supportive culture and behavior aligned with ESG norms and values with ethics at the center of attention while leveraging data solutions and emerging technologies to enable, monitor, and steer ESG initiatives, adoption, and performance’. Needless to say, achieving higher scores on the aforementioned overarching principles through data and technology equips firms to fully leverage ESG and comply with rapidly changing regulations most effectively. However, it should be noted that in the proposed definition of ESG capability, the five dimensions and underlying principles discussed are tightly interconnected. As such, the support and engagement of digital leadership pave the way for faster adoption of cultural and behavioral aspects like pursuing a learning mindset with data-driven experimentation in a proactive (digitally) collaborative manner and not flinching from cutting-edge tools and techniques in facilitating their learning journey [24,87]. The role of ethical leaders in virtuously influencing employees’ perceptions of ethical climate [88] and creating a culture where ESG principles are prioritized [89] are other manifestations of the interconnectivity between the five dimensions.

While the role of technology as a powerful facilitator and enabler of the other four dimensions is elaborated in the previous section, a responsible use of technology calls for intrinsically motivated, collaboratively oriented, ethically aware, and data- and technology-literate employees and managers with data-driven KPIs. Similarly, process orientation helps leadership to steer the firms’ operations based on facts, which requires the leadership’s inclination toward a ‘manage by process’ mindset (as opposed to ‘manage by objectives’), and ESG ethics and culture should be embedded in processes and KPIs (e.g., ethics by design) [90]. And finally, ethical principles and organizational culture reinforce each other. For instance, when ethical principles are embedded into the organization’s cultural fabric through hiring practices, performance evaluations, and incentive programs, they become part of the daily experiences of employees. At the same time, a culture that consistently highlights and rewards ethical behavior will encourage employees to prioritize ethical considerations in their decision-making processes. For example, cultural norms emphasizing transparency and accountability will prompt employees to adhere to these values, even in challenging situations [91]. Figure 1 summarizes the framework and its interacting constituting parts.

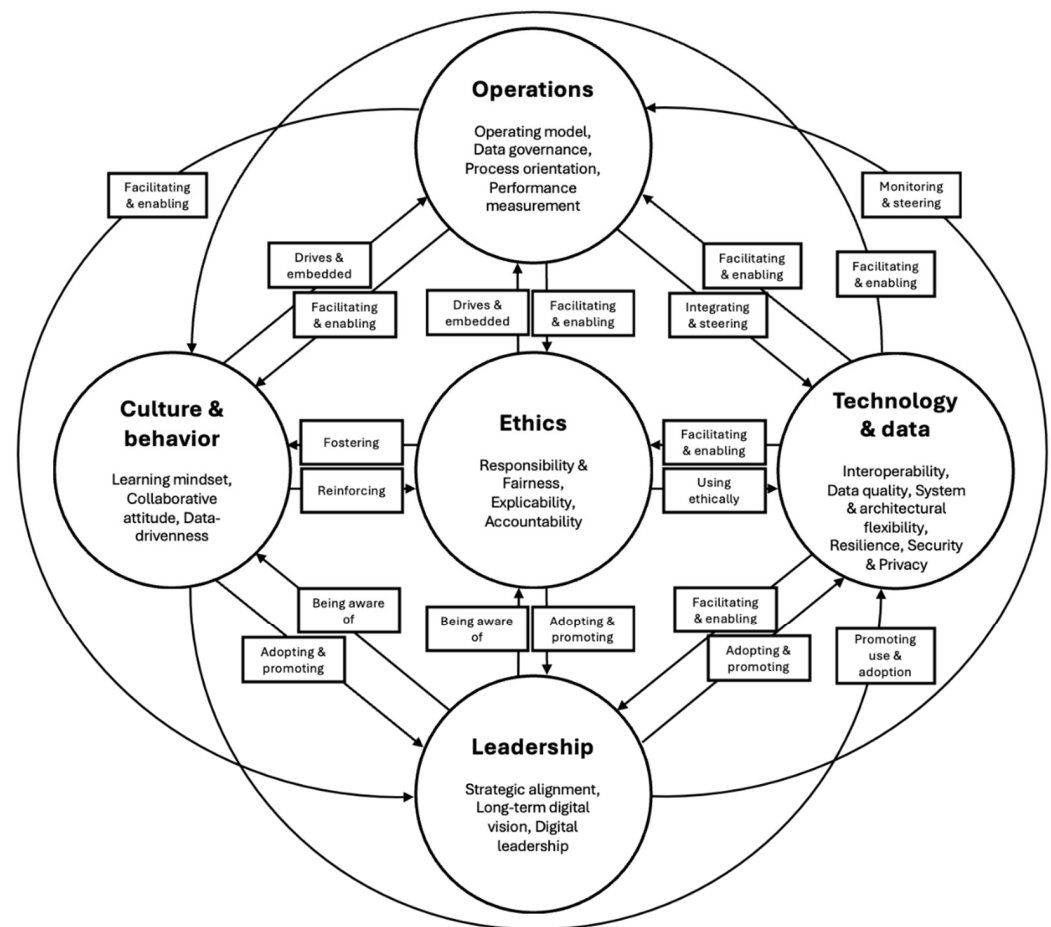


Figure 1. Integrative ESG capability framework.

4. Discussion

While the literature appears to be unanimous about the importance of the proposed five dimensions, the dimensions are not binary factors, and firms can evolve and gain a higher maturity in their ESG capability over time. Given the earlier-discussed interconnectivity between the capability dimensions, the capability-building process needs to involve a holistic and systemic approach where all dimensions are taken into account. In doing so, maturity models help operationalize the conceptual models and assess the qualitative and quantitative capability advancement across various stages [92]. Within the ESG and sustainability domain, the concept of maturity models is well adopted; examples include maturity models for sustainability with supply chain context [93], ESG data and investment [94], and corporate sustainability readiness assessment [95]. However, the literature on maturity models for ESG as a capability enabled with data and technology is scarce, and scholars are increasingly calling for more research on this domain, e.g., [96,97]. In response, the proposed ESG capability framework can serve as an evaluative maturity model, allowing firms to assess and benchmark their data- and technology-driven ESG development over time. Adopting the well-accepted four-step scale of ‘ad hoc’, ‘defined’, ‘managed’, and ‘optimized’, e.g., [98,99], Figure 2 presents how the proposed five dimensions can gradually evolve and be implemented.

	Ad hoc	Defined	Managed	Optimized
Leadership	- No formal ESG strategy - Uncoordinated, occasional (siloed) ESG projects - No clear digital vision (or multiple interpretations of a vision) - The executive board lacks digital literacy in general and ESG-specific - Limited top leadership involvement	- Initial ESG strategy aligned with some business goals - Leadership acknowledges ESG importance (e.g., ESG topics introduced in executive meetings) - Basic ESG governance structures (e.g., appointing an ESG officer, initiating an ESG committee)	- ESG strategy fully integrated into business strategy (e.g., ESG objectives included in strategic planning, ESG budget) - Regular leadership reviews of ESG performance (e.g., quarterly ESG board meetings) - Active stakeholder communication (e.g., publishing annual ESG impact reports) - Clear ESG governance; e.g., regularly updating ESG policies based on involved actors' feedback, ESG performance tied to executive bonuses (Stern, 2020)	- ESG is central to the company's vision and strategy (e.g., Annesi et al., 2024) - Leadership promotes continuous ESG innovation (e.g., Niu et al., 2022) - Proactive industry engagement, e.g., establishing ESG & digitalization industry consortiums on themes like decarbonization or net zero targets (Liao et al., 2023) - Holistic governance (e.g., ESG objectives included in strategic planning)
Operations	- Limited ESG integration in core processes - No clear ESG data roles & ownership structure and governance (of scattered ownership) - Lack of ESG monitoring & steering information systems	- ESG mapped within specific impact areas - Initial ESG process integration in some departments (e.g., incorporating ESG criteria in procurement policies) - Basic data governance (e.g., establishing data management protocols) - Defined roles and responsibilities (e.g., appointing ESG data stewards)	- Full ESG process integration (i.e., ESG criteria integrated into all major processes) - Comprehensive data governance, i.e., implementing a data governance framework (Abraham et al., 2019) - Regular ESG performance measurement (e.g., monthly ESG impact reports) - Streamlined ESG workflows (e.g., Automated ESG compliance checks, regular process reviews)	- ESG is fundamental to operations (e.g., real-time ESG dashboards and adaptive management across all major processes, incorporating ESG in product lifecycle management) - Advanced data governance (e.g., establishing a cross-departmental Center of Excellence for ESG data governance) - Real-time performance measurement (e.g., predictive analytics for ESG performance (e.g., Momeni et al., 2021)) - Continuous process optimization and compliance, e.g., using GenAI to navigate a complex regulatory landscape (Liu et al., 2024)
Data & Technology	- Minimal technology use for ESG - Fragmented technology solutions - Data is retrieved from various unorchestrated sources (often spreadsheets-based) - No data quality policies	- Initial adoption of ESG technologies (e.g., implementing basic ESG tracking software) - Some interoperability and data quality standards (e.g., establishing initial data quality protocols) - Basic automation (e.g., automating ESG data collection, using basic analytics tools)	- Integrated ESG tech solutions (e.g., unified ESG data management system) - Advanced data quality and interoperability, e.g., implementing data quality management systems (Otto et al., 2007) - Continuous tech benchmarking (e.g., establishing and continuous improvement in Green IT) - Proactive IT management (e.g., implementing cloud-based ESG data management systems)	- Cutting-edge tech in ESG strategy (e.g., using AI for ESG data analysis and reporting) - Proactive data quality management, e.g., using innovative tech such as machine learning to improve the accuracy of ESG analysis (Ahmadi & Solaimani, 2021), simulation and digital twins for ESG impact analysis (Solaimani et al., 2021) - Seamless tech integration, e.g., integrating ESG with enterprise resource planning systems (ERP) (Anjaria, 2024) - ESG integrated into the larger Enterprise Architecture (Vandevenne et al., 2023)
Culture & behavior	- No ESG cultural initiatives - Low employee awareness and engagement - No formal ESG collaboration structures	- Initial ESG culture-building efforts (e.g., ESG awareness workshops, launching ESG awareness campaigns) - Basic training and awareness programs (e.g., ESG training sessions for new hires) - Early cross-departmental collaboration (e.g., forming ESG working groups; integrating ESG in team meetings)	- Strong learning culture with ongoing ESG education (e.g., monthly ESG brown bag sessions to learn from delivered and ongoing projects) - Structured collaborative efforts (e.g., cross-functional ESG task forces) - Data-driven decisions based on ESG-specific metrics (e.g., Veenstra & Ellemers, 2020) - Recognized ESG social and behavioral norms	- ESG is deeply embedded in culture - Data-driven continuous improvement mindset (Pesqueira & Sousa, 2024), e.g., annual ESG technological innovation challenges - High internal and external collaboration (e.g., annual ESG partner summits) - Celebrated ethical behavior (e.g., company-wide ESG awards and recognition programs for outstanding contributions)
Ethics	- Ethical considerations to various degrees by some individuals - No formal ethical processes - Limited accountability, explicability and transparency procedures and protocols	- Basic ethical guidelines (e.g., developing a code of ethics) - Initial transparency and accountability policies (e.g., introducing basic ethics reporting) - Ethical considerations in some decisions (e.g., conducting initial ethical risk assessments and basic audit processes)	- Comprehensive ethical guidelines, policies and procedures - Strong accountability and transparency through systematic audits and regular reporting (e.g., integrating ethics into performance appraisals) - Regular ethical audits (e.g., annual third-party ethical reviews and internal audits)	- Ethics as ESG cornerstone, e.g., implementing AI-driven tools for real-time ethics monitoring in terms of explicability, bias, and privacy (Minkinen et al., 2024) - Ethical training programs, e.g., ethical leadership programs (Zahari et al., 2024) - Embedding ethics in all processes and services, i.e., ethics by design (Dignum et al., 2018)

Figure 2. ESG capability maturity model [24,40,50,55,89,90,100–110].

The application of the maturity model can best be demonstrated with an illustrative case of ABC, a global financial institution with more than 20,000 employees across 30 countries. ABC has recognized the growing importance of ESG, given its operations in various jurisdictions where ESG regulations are becoming increasingly stringent. For instance, the European Union's Sustainable Finance Disclosure Regulation (SFDR) requires financial market participants to provide detailed information on their sustainability practices. Similarly, the Task Force on Climate-related Financial Disclosures (TCFD) guidelines mandate comprehensive climate-related financial disclosures. Compliance with these regulations is crucial for the company to avoid penalties and maintain its operating license. Also, institutional investors are increasingly demanding transparency and accountability regarding ESG practices. Many of ABC's major shareholders are signatories to the United Nations Principles for Responsible Investment (PRI), encouraging firms to incorporate ESG factors into their investment decisions. Meeting these expectations is essential to attract and retain investor confidence. ABC has undertaken several initiatives across the five dimensions of the ESG maturity model, leading to varying scores per dimension.

From a leadership perspective, the company's executive team has recognized the importance of ESG and integrated it into its business strategy. The CEO and board members regularly discuss ESG issues, and there is a dedicated ESG steering committee that reports directly to the board. However, there is room for improvement in fully aligning long-term digital vision with ESG goals. Concerning culture and behavior, ABC has initiated several programs to foster a culture supportive of ESG goals (e.g., monthly ESG newsletters are sent to all employees). This includes basic ESG employee training and internal communication campaigns to raise awareness. However, deeper cultural integration of ESG values is still developing, and there is limited cross-departmental collaboration. In terms of operations, ABC has begun integrating ESG considerations into its core operations. The company has set up a data governance framework and established processes for tracking key ESG KPIs. However, the company still needs to enhance its process orientation and fully embed ESG into all operational workflows, particularly those that transcend the company border (e.g., ESG metrics to evaluate suppliers). From a data and technology viewpoint, ABC has initiated a data quality standardization program, a project on developing centralized data hub architecture for better orchestrating ESG data, and a joint program with the ERP vendor on incremental integration of some ESG metrics. The integration of more advanced technologies (e.g., deep analytics, extended dashboarding, and visualization) and proactive management of ESG-related technology is, however, still in progress.

Ethically speaking, ABC's approach is still in its nascent stages. While there are basic ethical guidelines and an ethics hotline to report unethical behavior, comprehensive ethical guidelines and robust accountability mechanisms are not yet fully established. Ethical training programs and systematic (internal/external) audits also need to be improved. In sum, the five dimensions are scored as leadership (managed), culture and behavior (defined), operational (managed), data and technology (defined), and ethics (ad hoc) (see Figure 3 for an overview).

To move up the maturity levels, ABC has decided to focus on ethical aspects of ESG with the following initiatives: (i) implementing robust whistleblower policies and protection mechanisms to encourage reporting of unethical behavior, (ii) establishing clear accountability structures, ensuring that ethical lapses are addressed promptly and effectively, (iii) developing comprehensive training programs on ethical behavior and decision-making for all employees, (iv) regularly updating and communicating the company's code of ethics, ensuring it aligns with the latest regulatory requirements and best practices, (v) adopting advanced compliance and regulatory tools to automate compliance checks, documentation, and reporting, and (vi) utilizing AI-driven analytics to identify and mitigate potential ethical risks proactively. By focusing on these initiatives, ABC aims to enhance its ethical practices, advancing to a higher maturity level in the ESG framework.

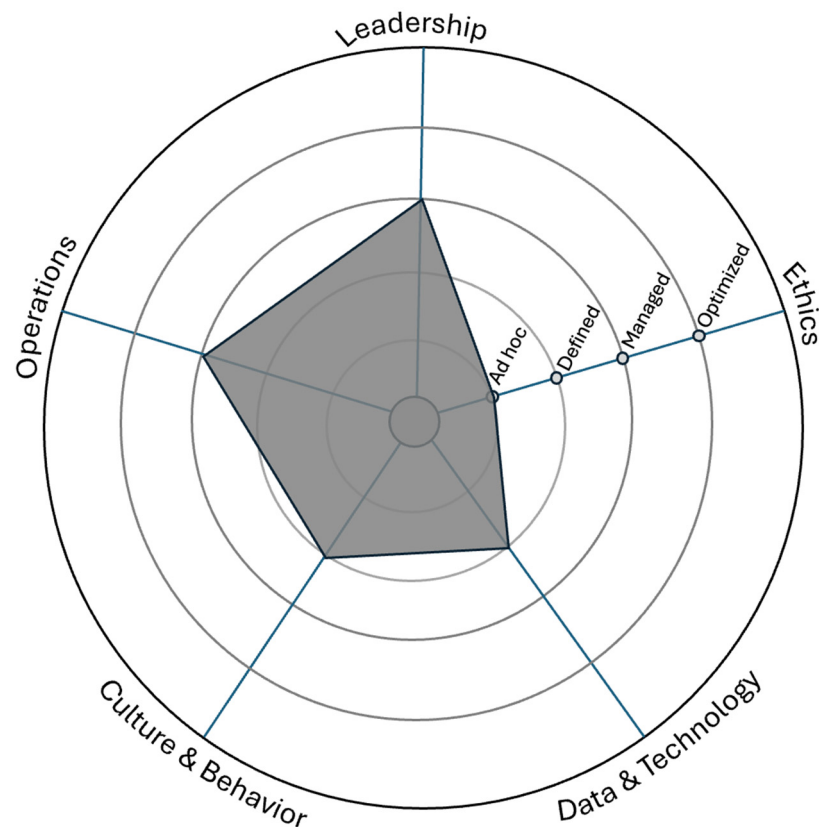


Figure 3. ABC's maturity evaluation in ESG capability.

5. Conclusions

The importance of ESG considerations has shifted from compliance to a strategic imperative due to factors like investor scrutiny and ever-changing regulatory requirements. In this study, it is argued that firms need to develop ESG capabilities beyond mere compliance, and to do so, the five dimensions of leadership, operations, data and technology, culture and behavior, and ethics need simultaneous attention. Without a well-rooted capability, firms are prone to a catch-up game, uncoordinated initiatives, unutilized existing resources, gradual detachment from societal and market values (e.g., difficulty attracting and retaining young talented employees and customers), inadequate response to changing regulatory environment, and even losing, step by step, organizational elasticity that may be needed to change when ESG obligations are no longer incremental.

A holistic approach to ESG, as proposed in this study, is argued to be indispensable in capability building, implying that ESG needs to be ingrained in the firm's DNA from strategy and vision, structures and design, culture and mindset, to processes and procedures. In operationalizing such transformation, the role and impact of data and technology should not be underestimated. Without the pretense of being exhaustive, this study consolidates a large number of studies into an integrative maturity model that points out how firms can lay a data and technology foundation and benefit from its cutting-edge possibilities in order to reach higher levels of ESG capability.

Theoretically speaking, this study calls for more attention to be paid to ESG capability building, and the proposed framework provides a structured departure point for further research into the conditions, prerequisites, and building blocks of an effective, integrative, future-proof capability and how data and (emerging) technologies can be of value. Scholars are invited to elaborate on and validate the proposed framework, and particularly delve into the multilayered and multifaceted systemic structure of ESG capability, and, by doing so, deepen our understanding of how these elements interact and contribute to capability building. On a practical note, firms can form multidisciplinary teams with an organizational

structure that promotes continuity (e.g., an ESG capably group or Center of Excellence), supported by a steering committee, to formulate a progressive ESG vision, gain consensus on ESG definition and norms. These teams can also explore the ongoing ESG initiatives; the existing skills and literacy; perceptions and expectations; and available data, software, and hardware relevant to ESG process, procedures and reporting standards, and suchlike. Based on the collected insights, firms can contextualize the proposed maturity model and rate its various dimensions given their idiosyncrasies to establish a baseline assessment of their current level of maturity. Such insight can help firms mobilize and coordinate their efforts and investments toward those aspects with the lowest scores but highest priorities. At the same time, the model can help firms structure their improvement plan or roadmap according to the proposed dimensions and underlying principles. It is noteworthy that the level of maturity desired or required for each dimension can differ depending on the firm's specific context, industry, and regulatory environment. Nonetheless, the ESG ambition and the corresponding level of maturity need to be explicated and systematically pursued.

That being said, future research is essential to validate and evaluate the applicability of the proposed conceptual model. Future empirical studies should be conducted across various industries and geographical regions—for instance, using cross-case analyses, e.g., [111]—to assess the framework's general applicability, e.g., [6,112]. Additionally, the comprehensiveness of the proposed framework and maturity model should be evaluated to ensure no critical factors are overlooked and to expand the scope by incorporating the various stakeholders' perspectives, considering their specific needs and possible conflicting expectations (e.g., end-users, policy-makers, funds, governmental bodies), e.g., [113,114]. Also, longitudinal studies could provide insights into the long-term impacts of integrating this framework into organizational practices, while survey-based research could help empirically validate the proposed structure and its impact on firms' financial and non-financial performance.

Funding: This research received no external funding.

Data Availability Statement: No new data were created or analyzed in this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Amel-Zadeh, A.; Serafeim, G. Why and how investors use ESG information: Evidence from a global survey. *Financ. Anal. J.* **2018**, *74*, 87–103. [\[CrossRef\]](#)
2. Lee, M.T.; Raschke, R.L.; Krishen, A.S. Signaling green! firm ESG signals in an interconnected environment that promote brand valuation. *J. Bus. Res.* **2022**, *138*, 1–11. [\[CrossRef\]](#)
3. Lee, C.C.; Luppi, J.L.; Simmons, T.; Tran, B.; Zhang, R. Examining the Impacts of ESG on Employee Retention: A Study of Generational Differences. *J. Bus. Manag.* **2023**, *29*, 1–22.
4. Garnov, A.; Ordov, K.; Chelukhina, N.; Perepelitsa, D.; Asyaeva, E. Innovative Financial Economic Stimulation Tools For ESG-Transformation of a Company: Opportunities for application and specifics of regulation. *J. Law Sustain. Dev.* **2022**, *10*, e0219. [\[CrossRef\]](#)
5. Vanclay, F.; Hanna, P. Conceptualizing company response to community protest: Principles to achieve a social license to operate. *Land* **2019**, *8*, 101. [\[CrossRef\]](#)
6. Li, T.T.; Wang, K.; Sueyoshi, T.; Wang, D.D. ESG: Research progress and future prospects. *Sustainability* **2021**, *13*, 11663. [\[CrossRef\]](#)
7. Pollman, E. Corporate Social Responsibility, ESG, and Compliance. In *Cambridge Handbook of Compliance*; van Rooij, B., Sokol, D.D., Eds.; Cambridge University Press: Cambridge, UK, 2021; pp. 662–672.
8. La Torre, M.; Cardi, M.; Leo, S.; Schettini Gherardini, J. ESG Ratings, Scores, and Opinions: The State of the Art in Literature. In *Contemporary Issues in Sustainable Finance*; Springer: Berlin/Heidelberg, Germany, 2023; pp. 61–102.
9. Sheehan, N.T.; Vaidyanathan, G.; Fox, K.A.; Klassen, M. Making the invisible, visible: Overcoming barriers to ESG performance with an ESG mindset. *Bus. Horiz.* **2023**, *66*, 265–276. [\[CrossRef\]](#)
10. Paredes-Gazquez, J.D.; Benito, L.L.; de la Cuesta González, M. Drivers and barriers of Environmental, Social and Governance information in investment decision-making: The Spanish case. *Int. J. Bus. Manag.* **2014**, *9*, 16. [\[CrossRef\]](#)
11. Jonsdottir, B.; Sigurjonsson, T.O.; Johannsdottir, L.; Wendt, S. Barriers to using ESG data for investment decisions. *Sustainability* **2022**, *14*, 5157. [\[CrossRef\]](#)
12. Asif, M.; Searcy, C.; Castka, P. ESG and Industry 5.0: The role of technologies in enhancing ESG disclosure. *Technol. Forecast. Soc. Chang.* **2023**, *195*, 122806. [\[CrossRef\]](#)

13. Hughes, A.; Urban, M.A.; Wójcik, D. Alternative ESG ratings: How technological innovation is reshaping sustainable investment. *Sustainability* **2021**, *13*, 3551. [\[CrossRef\]](#)
14. Lu, Y.; Xu, C.; Zhu, B.; Sun, Y. Digitalization transformation and ESG performance: Evidence from China. *Bus. Strategy Environ.* **2023**, *33*, 352–368. [\[CrossRef\]](#)
15. Wu, S.; Li, Y. A Study on the Impact of Digital Transformation on Corporate ESG Performance: The Mediating Role of Green Innovation. *Sustainability* **2023**, *15*, 6568. [\[CrossRef\]](#)
16. Yu, W.; Gu, Y.; Dai, J. Industry 4.0-Enabled Environment, Social, and Governance Reporting: A Case from a Chinese Energy Company. *J. Emerg. Technol. Account.* **2023**, *20*, 245–258. [\[CrossRef\]](#)
17. Zhao, Q.; Li, X.; Li, S. Analyzing the Relationship between Digital Transformation Strategy and ESG Performance in Large Manufacturing Enterprises: The Mediating Role of Green Innovation. *Sustainability* **2023**, *15*, 9998. [\[CrossRef\]](#)
18. Zhong, Y.; Zhao, H.; Yin, T. Resource Bundling: How Does Enterprise Digital Transformation Affect Enterprise ESG Development? *Sustainability* **2023**, *15*, 1319. [\[CrossRef\]](#)
19. Snell, P.M.W.S. Organizational resources, and capabilities. In *The Routledge Companion to Strategic Human Resource Management*; Routledge: London, UK, 2008; p. 345.
20. Bates, K.; Blackmon, K.; Flynn, E.; Voss, C. Manufacturing strategy: Building capability for dynamic markets. In *High Performance Manufacturing Global Perspectives*; Schroeder, R., Flynn, B., Eds.; John Wiley & Sons, Inc.: New York, NY, USA, 2001; pp. 42–72.
21. Lindbom, H.; Tehler, H.; Eriksson, K.; Aven, T. The capability concept—On how to define and describe capability in relation to risk, vulnerability and resilience. *Reliab. Eng. Syst. Saf.* **2015**, *135*, 45–54. [\[CrossRef\]](#)
22. Heising, W. The integration of ideation and project portfolio management—A key factor for sustainable success. *Int. J. Proj. Manag.* **2012**, *30*, 582–595. [\[CrossRef\]](#)
23. Zumente, I.; Bistрова, J. ESG importance for long-term shareholder value creation: Literature vs. practice. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 127. [\[CrossRef\]](#)
24. Niu, S.; Park, B.I.; Jung, J.S. The effects of digital leadership and ESG management on organizational innovation and sustainability. *Sustainability* **2022**, *14*, 15639. [\[CrossRef\]](#)
25. Roberts, P.W. Product innovation, product-market competition and persistent profitability in the U.S. pharmaceutical industry. *Strateg. Manag. J.* **1999**, *20*, 655–670. [\[CrossRef\]](#)
26. Imran, F.; Shahzad, K.; Butt, A.; Kantola, J. Leadership competencies for digital transformation: Evidence from multiple cases. In *Advances in Human Factors, Business Management and Leadership: Proceedings of the AHFE 2020 Virtual Conferences on Human Factors, Business Management and Society, and Human Factors in Management and Leadership, San Diego, CA, USA, 16–20 July 2020*; Springer International Publishing: Berlin/Heidelberg, Germany, 2020; pp. 81–87.
27. Kateryna, A.; Oleksandr, R.; Mariia, T.; Iryna, S.; Evgen, K.; Anastasiia, L. Digital literacy development trends in the professional environment. *Int. J. Learn. Teach. Educ. Res.* **2020**, *19*, 55–79. [\[CrossRef\]](#)
28. Solaimani, S.; Talab, A.H.; van der Rhee, B. An integrative view on Lean innovation management. *J. Bus. Res.* **2019**, *105*, 109–120. [\[CrossRef\]](#)
29. Miceli, A.; Hagen, B.; Riccardi, M.P.; Sotti, F.; Settembre-Blundo, D. Thriving, not just surviving in changing times: How sustainability, agility and digitalization intertwine with organizational resilience. *Sustainability* **2021**, *13*, 2052. [\[CrossRef\]](#)
30. Christofi, K.; Chourides, P.; Papageorgiou, G. Cultivating strategic agility—An empirical investigation into best practice. *Glob. Bus. Organ. Excell.* **2024**, *43*, 89–105. [\[CrossRef\]](#)
31. Vardarlier, P. Digital transformation of human resource management: Digital applications and strategic tools in HRM. In *Digital Business Strategies in Blockchain Ecosystems: Transformational Design and Future of Global Business*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 239–264.
32. De Bem Machado, A.; Secinara, S.; Calandra, D.; Lanzalonga, F. Knowledge management and digital transformation for Industry 4.0: A structured literature review. *Knowl. Manag. Res. Pract.* **2022**, *20*, 320–338. [\[CrossRef\]](#)
33. Alavi, M.; Leidner, D.E.; Mousavi, R. A Knowledge Management Perspective of Generative Artificial Intelligence. *J. Assoc. Inf. Syst.* **2024**, *25*, 1–12.
34. Zainullin, S.; Zainullina, O. Scientific review digitalization of corporate culture as a factor influencing ESG investment in the energy sector. *Int. Rev.* **2021**, *1–2*, 130–136. [\[CrossRef\]](#)
35. Solaimani, S.; van der Veen, J. Open supply chain innovation: An extended view on supply chain collaboration. *Supply Chain. Manag. Int. J.* **2022**, *27*, 597–610. [\[CrossRef\]](#)
36. Seeber, I.; Bittner, E.; Briggs, R.O.; de Vreede, T.; de Vreede, G.-J.; Elkins, A.; Maier, R.; Merz, A.B.; Oeste-Reiß, S.; Randrup, N.; et al. Machines as teammates: A research agenda on AI in team collaboration. *Inf. Manag.* **2020**, *57*, 103174. [\[CrossRef\]](#)
37. Wang, S.; Esperança, J.P. Can digital transformation improve market and ESG performance? Evidence from Chinese SMEs. *J. Clean. Prod.* **2023**, *419*, 137980. [\[CrossRef\]](#)
38. Chatterjee, S.; Chaudhuri, R.; Vrontis, D. Does data-driven culture impact innovation and performance of a firm? An empirical examination. *Ann. Oper. Res.* **2024**, *333*, 601–626. [\[CrossRef\]](#)
39. Zand, F.; Solaimani, S.; van Beers, C. A role-based typology of information technology: Model development and assessment. *Inf. Sys. Manag.* **2015**, *32*, 119–135. [\[CrossRef\]](#)
40. Pesqueira, A.; Sousa, M.J. Exploring the role of big data analytics and dynamic capabilities in ESG programs within pharmaceuticals. *Softw. Qual. J.* **2024**, *32*, 607–640. [\[CrossRef\]](#)

41. Solaimani, S.; Swaak, L. Critical success factors in a multi-stage adoption of artificial intelligence: A necessary condition analysis. *J. Eng. Technol. Manag.* **2023**, *69*, 101760. [CrossRef]
42. Porter, M.; Serafeim, G.; Kramer, M. Where ESG fails. *Institutional Invest.* **2019**, *16*, 1–17.
43. Solaimani, S. The Alignment of Business Model and Business Operations within Networked-Enterprise Environments. Ph.D. Thesis, Delft University of Technology, Delft, The Netherlands, 2014.
44. Solaimani, S.; Bouwman, H. A framework for the alignment of business model and business processes: A generic model for trans-sector innovation. *Bus. Process Manag. J.* **2012**, *18*, 655–679. [CrossRef]
45. Solaimani, S.; Bouwman, H.; Itälä, T. Networked enterprise business model alignment: A case study on smart living. *Inf. Syst. Front.* **2015**, *17*, 871–887. [CrossRef]
46. Bosch, J. Towards a digital business operating system. In Proceedings of the 2019 13th International Conference on Research Challenges in Information Science (RCIS), Brussels, Belgium, 29–31 May 2019; pp. 1–9.
47. Kwan, A.; Schroeck, M.; Kawamura, J. Architecting an operating model. *Bus. Rev.* 2017. Available online: https://www2.deloitte.com/content/dam/insights/us/articles/5078_architecting-an-operating-model/DI_architecting-an-operating-model.pdf (accessed on 1 July 2024).
48. Liakh, O. Accountability through sustainability data governance: Reconfiguring reporting to better account for the digital acceleration. *Sustainability* **2021**, *13*, 13814. [CrossRef]
49. International, D. *DAMA-DMBOK: Data Management Body of Knowledge*; Technics Publications, LLC.: Sedona, AZ, USA, 2017.
50. Abraham, R.; Schneider, J.; Vom Brocke, J. Data governance: A conceptual framework, structured review, and research agenda. *Int. J. Inf. Manag.* **2019**, *49*, 424–438. [CrossRef]
51. Sancak, I.E. Change management in sustainability transformation: A model for business organizations. *J. Environ. Manag.* **2023**, *330*, 117165. [CrossRef] [PubMed]
52. Solaimani, S.; Sedighi, M. Toward a holistic view on lean sustainable construction: A literature review. *J. Clean. Prod.* **2020**, *248*, 119213. [CrossRef]
53. Solaimani, S.; Guldemon, N.; Bouwman, H. Dynamic stakeholder interaction analysis: Innovative smart living design cases. *Electron. Mark.* **2013**, *23*, 317–328. [CrossRef]
54. Nielsen, C. ESG Reporting and Metrics: From Double Materiality to Key Performance Indicators. *Sustainability* **2023**, *15*, 16844. [CrossRef]
55. Solaimani, S.; Parandian, A.; Nabiollahi, N. A holistic view on sustainability in additive and subtractive manufacturing: A comparative empirical study of eyewear production systems. *Sustainability* **2021**, *13*, 10775. [CrossRef]
56. Ronalter, L.M.; Bernardo, M.; Romani, J.M. Quality and environmental management systems as business tools to enhance ESG performance: A cross-regional empirical study. *Environ. Dev. Sustain.* **2023**, *25*, 9067–9109. [CrossRef]
57. Chauhan, S.; Singh, R.; Gehlot, A.; Akram, S.V.; Twala, B.; Priyadarshi, N. Digitalization of supply chain management with industry 4.0 enabling technologies: A sustainable perspective. *Processes* **2022**, *11*, 96. [CrossRef]
58. Alkaraan, F.; Albitar, K.; Hussainey, K.; Venkatesh, V.G. Corporate transformation toward Industry 4.0 and financial performance: The influence of environmental, social, and governance (ESG). *Technol. Forecast. Soc. Chang.* **2022**, *175*, 121423. [CrossRef]
59. Saxena, A.; Singh, R.; Gehlot, A.; Akram, S.V.; Twala, B.; Singh, A.; Montero, E.C.; Priyadarshi, N. Technologies empowered environmental, social, and governance (ESG): An industry 4.0 landscape. *Sustainability* **2022**, *15*, 309. [CrossRef]
60. Nitlar, T.; Kiattisin, S. The impact factors of industry 4.0 on ESG in the energy sector. *Sustainability* **2022**, *14*, 9198. [CrossRef]
61. Pan, Z.; Sun, Y.; Feng, W.; Zheng, W.; Li, J.; Zhang, Z.; Huang, H.; Zhen, L.; Zeng, Q.; Ma, L.; et al. Straddling Mandatory Standardisation and Voluntary ESG Practices: A Sustainable Innovation Path for Vehicle Intelligence. *Acad. J. Eng. Technol. Sci.* **2024**, *7*, 44–53.
62. Amjad, A.; Azam, F.; Anwar, M.W.; Butt, W.H. A systematic review on the data interoperability of application layer protocols in industrial IoT. *IEEE Access* **2021**, *9*, 96528–96545. [CrossRef]
63. Gleim, L.; Pennekamp, J.; Liebenberg, M.; Buchsbaum, M.; Niemietz, P.; Knappe, S.; Epple, A.; Storms, S.; Trauth, D.; Bergs, T.; et al. FactDAG: Formalizing data interoperability in an internet of production. *IEEE Internet Things J.* **2020**, *7*, 3243–3253. [CrossRef]
64. Satti, F.A.; Ali, T.; Hussain, J.; Khan, W.A.; Khattak, A.M.; Lee, S. Ubiquitous Health Profile (UHP): A big data curation platform for supporting health data interoperability. *Computing* **2020**, *102*, 2409–2444. [CrossRef]
65. Utkucu, D.; Sözer, H. Interoperability and data exchange within BIM platform to evaluate building energy performance and indoor comfort. *Autom. Constr.* **2020**, *116*, 103225. [CrossRef]
66. Davidson, G.; Van der Net, M.; Viskin, T.; Jayaraman, E. Aligning Actions and Pledges in CPG: Making Your ESG Tech Investment Count, Accenture. 2022. Available online: <https://www.accenture.com/content/dam/accenture/anal/industry/consumer-goods-and-services/document/Accenture-CPG-SustainabilityPOV-V2.pdf> (accessed on 1 July 2024).
67. Lee, S.U.; Fernando, N.; Lee, K.; Schneider, J.G. A survey of energy concerns for software engineering. *J. Syst. Softw.* **2024**, *210*, 111944. [CrossRef]
68. Yukhno, A.S. ICT governance and ESG factors: A new agenda for the boards of directors. In *Industry 4.0: Fighting Climate Change in the Economy of the Future*; Springer International Publishing: Cham, Switzerland, 2022; pp. 39–50.
69. Solaimani, S.; Dabestani, R.; Harrison-Prentice, T.; Ellis, E.; Kerr, M.; Choudhury, A.; Bakhshi, N. Exploration and prioritisation of critical success factors in adoption of artificial intelligence: A mixed-methods study. *Int. J. Bus. Inf. Syst.* **2024**, *45*, 429–453. [CrossRef]

70. Monk, A.; Rook, D. Resilience as an Analytical Filter for ESG Data. In *Sustainability, Technology, and Finance*; Routledge: London, UK, 2022; pp. 141–161.
71. Ketter, W.; Padmanabhan, B.; Pant, G.; Raghu, T.S. Special issue editorial: Addressing societal challenges through analytics: An ESG ICE framework and research agenda. *J. Assoc. Inf. Syst.* **2020**, *21*, 9. [CrossRef]
72. Triantafyllou, A.; Jimenez JA, P.; Torres AD, R.; Lagkas, T.; Rantos, K.; Sarigiannidis, P. The challenges of privacy and access control as key perspectives for the future electric smart grid. *IEEE Open J. Commun. Soc.* **2020**, *1*, 1934–1960. [CrossRef]
73. Kim, H.; Quan, Y.J.; Jung, G.; Lee, K.W.; Jeong, S.; Yun, W.J.; Park, S.; Ahn, S.H. Smart factory transformation using Industry 4.0 toward ESG perspective: A critical review and future direction. *Int. J. Precis. Eng. Manuf. -Smart Technol.* **2023**, *1*, 165–185. [CrossRef]
74. Shackelford, S.; Raymond, A.; McCrory, M.A.; Bonime-Blanc, A. Cyber Silent Spring: Leveraging ESG+ T Frameworks and Trustmarks to Better Inform Investors and Consumers about the Sustainability, Cybersecurity, and Privacy of Internet-Connected Devices. *Kelley Sch. Bus. Res. Pap.* **2023**, *25*, 505. [CrossRef]
75. Jiang, Y.; Syn, T. Online privacy policy disclosure: An empirical investigation. *J. Comput. Inf. Syst.* **2023**, *63*, 663–680. [CrossRef]
76. Klein, A.; Manini, R.; Shi, Y. Across the pond: How US firms' boards of directors adapted to the passage of the general data protection regulation. *Contemp. Account. Res.* **2022**, *39*, 199–233. [CrossRef]
77. Mateo Tudela, F.; Bermejo Higuera, J.R.; Bermejo Higuera, J.; Sicilia Montalvo, J.A.; Argyros, M.I. On combining static, dynamic and interactive analysis security testing tools to improve owasp top ten security vulnerability detection in web applications. *Appl. Sci.* **2020**, *10*, 9119. [CrossRef]
78. Byström, N.; Gustafsson, R.; Lipiäinen, N. *Fostering Sustainable Finance and Corporate Sustainability by Means of Well Operating Informational Infrastructures*; Aalto University: Espoo, Finland, 2023.
79. Becchetti, L.; Bobbio, E.; Prizia, F.; Semplici, L. Going deeper into the S of ESG: A relational approach to the definition of social responsibility. *Sustainability* **2022**, *14*, 9668. [CrossRef]
80. Houser, K.A. Can AI solve the diversity problem in the tech industry: Mitigating noise and bias in employment decision-making. *Stanford Technol. Law Rev.* **2019**, *22*, 290.
81. Lee MS, A.; Singh, J. The landscape and gaps in open source fairness toolkits. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, Online, 8–13 May 2021; pp. 1–13.
82. HLEG (The High-Level Expert Group on Artificial Intelligence). Ethics Guidelines for Trustworthy AI. European Commission. 2019. Available online: <https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai> (accessed on 1 July 2024).
83. Adadi, A.; Berrada, M. Peeking inside the black box: A survey on explainable artificial intelligence (XAI). *IEEE Access* **2018**, *6*, 52138–52160. [CrossRef]
84. Vishwarupe, V.; Joshi, P.M.; Mathias, N.; Maheshwari, S.; Mhaisalkar, S.; Pawar, V. Explainable AI and interpretable machine learning: A case study in perspective. *Procedia Comput. Sci.* **2022**, *204*, 869–876. [CrossRef]
85. Floridi, L.; Cows, J.; Beltrametti, M.; Chatila, R.; Chazerand, P.; Dignum, V.; Luetge, C.; Madelin, R.; Pagallo, U.; Rossi, F.; et al. AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations. *Minds Mach.* **2018**, *28*, 689–707. [CrossRef] [PubMed]
86. Pratap, K.; Predovich, B.; Mandy, C. *Magic Quadrant for IT Risk Management*; Gartner Inc.: Stamford, CT, USA, 2020.
87. Abidin, A.Z. The influence of digital leadership and digital collaboration on the digital skill of manufacturing managers in Tangerang. *Int. J. Artif. Intell. Res.* **2023**, *6*, 1–8. [CrossRef]
88. Neubert, M.J.; Carlson, D.S.; Kacmar, K.M.; Roberts, J.A.; Chonko, L.B. The virtuous influence of ethical leadership behavior: Evidence from the field. *J. Bus. Ethics* **2009**, *90*, 157–170. [CrossRef]
89. Zahari, A.I.; Said, J.; Muhamad, N.; Ramly, S.M. Ethical culture and leadership for sustainability and governance in public sector organisations within the ESG framework. *J. Open Innov. Technol. Mark. Complex.* **2024**, *10*, 100219. [CrossRef]
90. Dignum, V.; Baldoni, M.; Baroglio, C.; Caon, M.; Chatila, R.; Dennis, L.; Génova, G.; Haim, G.; Kließ, M.S.; Lopez-Sanchez, M.; et al. Ethics by design. In *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society*; Association for Computing Machinery: New York, NY, USA, 2018. [CrossRef]
91. Epley, N.; Kumar, A. How to design an ethical organization. *Harv. Bus. Rev.* **2019**, *97*, 144–150.
92. Kohlegger, M.; Maier, R.; Thalmann, S. Understanding maturity models: Results of a structured content analysis. In Proceedings of the I-KNOW '09 and ISEMANICS '09, Graz, Austria, 2–4 September 2009; pp. 51–60.
93. Correia, E.; Carvalho, H.; Azevedo, S.G.; Govindan, K. Maturity models in supply chain sustainability: A systematic literature review. *Sustainability* **2017**, *9*, 64. [CrossRef]
94. Cruz, C.A.; Matos, F. ESG maturity: A software framework for the challenges of ESG data in investment. *Sustainability* **2023**, *15*, 2610. [CrossRef]
95. Sari, Y.; Hidayatno, A.; Suzianti, A.; Hartono, M.; Susanto, H. A corporate sustainability maturity model for readiness assessment: A three-step development strategy. *Int. J. Product. Perform. Manag.* **2021**, *70*, 1162–1186. [CrossRef]
96. Kwilinski, A.; Lyulyov, O.; Pimonenko, T. Unlocking sustainable value through digital transformation: An examination of ESG performance. *Information* **2023**, *14*, 444. [CrossRef]
97. Fang, M.; Nie, H.; Shen, X. Can enterprise digitization improve ESG performance? *Econ. Model.* **2023**, *118*, 106101. [CrossRef]

98. Aguiar, J.; Pereira, R.; Braga Vasconcelos, J.; Bianchi, I. An overlapless incident management maturity model for multi-framework assessment (ITIL, COBIT, CMMI-SVC). *Interdiscip. J. Inf. Knowl. Manag.* **2018**, *13*, 137–163. [\[CrossRef\]](#)
99. De Santana, E.D.S.; Nunes, É.D.O.; Passos, D.C.; Santos, L.B. SMM: A maturity model of smart cities based on sustainability indicators of the ISO 37122. *Int. J. Adv. Eng. Res. Sci.* **2019**, *6*, 13–20. [\[CrossRef\]](#)
100. Stern, H.J. Better executive bonus plans for environmental, social and corporate governance (ESG). *J. Total Reward*. 2020. Available online: <https://www.obermatt.com/00/media/2020-10-01-JRNL-2020-4Q-Better-Executive-Bonus-Plans-for-ESG-Hermann-Stern.pdf> (accessed on 1 July 2024).
101. Annesi, N.; Battaglia, M.; Ceglia, I.; Mercuri, F. Navigating paradoxes: Building a sustainable strategy for an integrated ESG corporate governance. *Manag. Decis.* **2024**, *ahead-of-print*.
102. Liao, H.T.; Pan, C.L.; Zhang, Y. Collaborating on ESG consulting, reporting, and communicating education: Using partner maps for capability building design. *Front. Environ. Sci.* **2023**, *11*, 1119011. [\[CrossRef\]](#)
103. Momeni, E.; Fraenkel, C.; Kiss, P.; Burgmann, A. ESG Tracker: Unbiased and Explainable ESG Profile from Real-time Data. In *Proceedings of the International AAAI Conference on Web and Social Media, Virtual*, 7–10 June 2021; Volume 15, pp. 1094–1096.
104. Liu, I.; Wongsosaputro, M. Compliance redefined: Using GenAI to navigate a complex regulatory landscape with reduced risks and costs. *J. Digit. Bank.* **2024**, *8*, 313–322.
105. Otto, B.; Wende, K.; Schmidt, A.; Osl, P. Towards a framework for corporate data quality management. In *Proceedings of the 18th Australasian Conference on Information Systems (ACIS 2007)*; University of Southern Queensland: Toowoomba, Australia, 2007.
106. Ahmadi, T.; Solaimani, S. Past and future of demand forecasting models. In *Influencing Customer Demand*, 1st ed.; Hemmati, M., Sajadieh, M., Eds.; CRC Press: Boca Raton, FL, USA, 2021; pp. 253–271.
107. Anjaria, K. Enhancing sustainability integration in Sustainable Enterprise Resource Planning (S-ERP) system: Application of Transaction Cost Theory and case study analysis. *Int. J. Inf. Manag. Data Insights* **2024**, *4*, 100243. [\[CrossRef\]](#)
108. Vandevenne, N.; Van Riel, J.; Poels, G. Green Enterprise Architecture (GREAN)—Leveraging EA for Environmentally Sustainable Digital Transformation. *Sustainability* **2023**, *15*, 14342. [\[CrossRef\]](#)
109. Veenstra, E.M.; Ellemers, N. ESG indicators as organizational performance goals: Do rating agencies encourage a holistic approach? *Sustainability* **2020**, *12*, 10228. [\[CrossRef\]](#)
110. Minkinen, M.; Niukkanen, A.; Mäntymäki, M. What about investors? ESG analyses as tools for ethics-based AI auditing. *AI Soc.* **2024**, *39*, 329–343. [\[CrossRef\]](#)
111. Rasuli, B.; Alipour-Hafezi, M.; Solaimani, S. Analyzing National Electronic Theses and Dissertations programs from business model perspective: Cross-case analysis. *Online Inf. Rev.* **2018**, *42*, 250–267. [\[CrossRef\]](#)
112. Barros, V.; Matos, P.V.; Sarmiento, J.M.; Vieira, P.R. ESG performance and firms’ business and geographical diversification: An empirical approach. *J. Bus. Res.* **2024**, *172*, 114392. [\[CrossRef\]](#)
113. Solaimani, S.; Bouwman, H.; Secomandi, F. Critical design issues for the development of Smart Home technologies. *J. Des. Res.* **2013**, *11*, 72–90. [\[CrossRef\]](#)
114. Aldowaish, A.; Kokuryo, J.; Almazyad, O.; Goi, H.C. How to Manage Conflicts in the Process of ESG Integration? A Case of a Japanese Firm. *Sustainability* **2024**, *16*, 3391. [\[CrossRef\]](#)

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