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Digital Maturity and ESG Integration: A Longitudinal Study of Technology Adoption Trends

Rashadul Islam Samrat[1]*, Md Rasel Ul Alam[2], Md Shahadat Hossain Shishir[3],

[1] *Department of Marketing, University of Barishal, Barishal, Bangladesh*

[2] *Department of Computer and Information Sciences, University of the Cumberlands, Kentucky, USA.*

[3] *Department of Computer Science and Engineering, World University of Bangladesh, Dhaka, Bangladesh*

**Corresponding author: samrat.meazi1@gmail.com*

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Abstract

Digital technologies are reshaping how organizations sense opportunities, allocate resources, and account for their environmental, social, and governance (ESG) obligations, yet the empirical literature linking firm-level digital maturity to ESG integration remains fragmented, cross-sectional, and geographically concentrated. Most existing studies rely on single-country, single-period panels predominantly of Chinese A-share listed firms and operationalize digital transformation through binary or text-frequency proxies rather than multidimensional maturity constructs, leaving open the question of how digital maturity and ESG integration co-evolve over time and across institutional contexts. This paper addresses this gap by developing a longitudinal, multidimensional research design for examining the digital maturity-ESG integration relationship and the technology-adoption trends that underlie it. Grounded in the Dynamic Capabilities View, the Technology-Organization-Environment framework, and stakeholder and legitimacy theories, the study proposes an integrative conceptual model in which digital maturity affects environmental, social, and governance performance both directly and indirectly, through information transparency, green innovation, and internal governance mechanisms, with regulatory stringency, industry digital intensity, and ownership structure acting as boundary conditions. A multi-wave panel methodology is specified, comprising a composite Digital Maturity Index across six dimensions, an ESG composite score disaggregated into environmental, social, and governance sub-pillars, and an estimation strategy combining fixed-effects panel regression, dynamic generalized method of moments, and cross-lagged panel modelling with instrumental-variable and propensity-score-matching robustness checks. Because the study is presented as a methodological and theoretical contribution rather than a completed empirical investigation, all quantitative illustrations are explicitly labelled as synthetic or proposed rather than as observed findings. The paper contributes a reusable measurement framework, a mediation-moderation model suitable for replication across regions and industries, and an evaluation protocol capable of distinguishing genuine digital-maturity effects from confounding firm-level and institutional factors. Practical implications for managers designing digital transformation roadmaps and for policymakers shaping sustainability-disclosure regimes are discussed, together with the limitations of the proposed design and directions for future longitudinal and cross-country research.

1. Introduction

Over the past decade, digital technologies—including cloud computing, advanced analytics, the Internet of Things, and increasingly artificial intelligence—have moved from peripheral IT investments to central determinants of organizational strategy. In parallel, environmental, social, and governance (ESG) considerations have shifted from voluntary corporate social responsibility disclosures toward mandatory or quasi-mandatory reporting regimes in many jurisdictions. Although these two transformations are frequently discussed together, they are rarely examined with the methodological rigor required to understand their dynamic and multidimensional relationship. A growing body of empirical research has investigated whether corporate digital transformation (DT) improves ESG performance, with much of the evidence relying on panels of Chinese A-share listed firms and text-frequency-based DT proxies derived from annual reports. Xie et al. (2024) found that digital transformation exerts a significantly positive effect on the ESG performance of

Chinese-listed enterprises, operating through information transparency, green innovation, and internal-control mechanisms, with the effect being more pronounced among state-owned enterprises and firms located in less digitally developed western regions. Complementary studies have reported convergent findings using different mediators and samples. Fang et al. (2023) identified goodwill and agency costs as channels through which enterprise digitization improves ESG performance, while Wang and Esperança (2023) showed that digital transformation raises ESG performance among Chinese small and medium-sized enterprises through market-performance and digital-innovation-culture pathways. Other research has examined the reverse relationship, finding that ESG performance can itself accelerate subsequent digital transformation through improved governance and reduced financing constraints. Together, these studies establish an important empirical association between digital transformation and ESG outcomes, while also indicating that the relationship may operate through multiple organizational and governance mechanisms rather than through technology adoption alone.

Despite this accumulating evidence, three structural limitations recur across the literature. First, nearly all large-sample empirical studies draw on Chinese listed-firm panels, which restricts the external validity of their findings to institutional contexts characterized by concentrated state ownership, a specific ESG-rating ecosystem, such as Sino-Securities and CSMAR, and rapidly evolving digital-economy policy. Second, digital transformation is typically operationalized as a unidimensional intensity index—commonly a word-frequency count of digital-technology keywords in annual reports—rather than as a multidimensional maturity construct that simultaneously captures strategic, technological, cultural, organizational, and governance readiness. Such an intensity measure may indicate the extent to which firms discuss digital technologies without necessarily demonstrating whether those technologies have been embedded into organizational capabilities, decision processes, data infrastructures, workforce practices, and governance arrangements. Third, although the underlying theoretical claim is developmental—that firms progress through stages of digital capability that cumulatively reshape sustainability practices—the dominant empirical designs remain effectively cross-sectional or short-panel, relying on fixed-effects regressions on annual observations rather than genuinely longitudinal, multi-wave designs capable of tracing trajectories, lagged effects, and co-evolution over time. Consequently, the existing evidence provides limited insight into whether increases in digital maturity precede improvements in ESG integration, whether ESG improvements subsequently reinforce digital development, and how these processes evolve under changing institutional conditions.

The central research problem addressed in this paper is therefore the absence of a validated, multidimensional, and longitudinally oriented framework for examining how digital maturity—as opposed to a narrow digital-transformation intensity proxy—shapes the trajectory of ESG integration within organizations over time, and how this relationship is conditioned by mediating governance mechanisms and moderating institutional factors across different regulatory and industry contexts. Addressing this problem requires moving beyond the assumption that digital transformation represents a single measurable intensity and instead conceptualizing digital maturity as an organizational capability that develops across interconnected dimensions. It also requires treating ESG integration not merely as a static performance outcome but as an evolving organizational process influenced by information transparency, innovation capabilities, governance efficiency, institutional pressures, and resource constraints. A longitudinal perspective is particularly important because digital maturity investments may require time to produce measurable organizational and sustainability effects, while governance improvements and ESG pressures may simultaneously influence subsequent technology investments.

Three specific research gaps consequently motivate this study. The first is a construct gap. Existing DT-ESG studies operationalize digital transformation narrowly, typically through textual frequency counts, whereas the digital-maturity literature has independently developed richer, multidimensional constructs spanning strategy, technology infrastructure, data and analytics, culture and people, governance, and customer experience without systematically connecting these dimensions to ESG outcomes. This separation creates a conceptual disconnect between what firms possess as digital capabilities and how those capabilities are translated into sustainability-oriented organizational outcomes. The second is a temporal gap. The majority of DT-ESG studies employ panel fixed-effects models on annual firm-year data without an explicit longitudinal design that models trajectories, lagged co-evolution, or stage transitions, despite both digital maturity and ESG integration being inherently developmental and path-dependent processes. Treating these constructs primarily as contemporaneous annual measures can obscure delayed effects, feedback relationships, and cumulative capability-building processes. The third is a contextual gap. The empirical base is overwhelmingly drawn from a single national context, limiting the generalizability of mediation and moderation findings and leaving unanswered how regulatory stringency, industry digital intensity, and ownership structure condition the digital maturity–ESG relationship outside that context. These gaps collectively indicate the need for a framework that integrates multidimensional measurement, longitudinal analysis, organizational mechanisms, and contextual contingencies within a unified research design.

Closing these gaps matters academically because it clarifies whether the positive DT-ESG associations reported in single-country panel studies reflect a general capability-building mechanism consistent with the Dynamic Capabilities View or whether they are, in part, artifacts of the specific institutional and measurement choices common in that literature. A multidimensional approach can clarify whether particular dimensions of digital maturity contribute differently to ESG integration and whether their effects emerge through identifiable governance mechanisms. It also allows the study to examine whether digital capability accumulation creates organizational conditions for improved sustainability performance rather than merely correlating with ESG outcomes at a particular point in time. From a practical perspective, the research addresses the absence of a validated, multidimensional maturity instrument that managers could use to assess and sequence digital investment decisions in ways that support ESG objectives. Such an instrument could help distinguish technology acquisition from deeper organizational transformation by evaluating whether digital capabilities are sufficiently embedded in strategy, infrastructure, data practices, organizational culture, and governance. The issue is also relevant to regulators and standard-setters designing sustainability-disclosure regimes, because a stronger evidence base extending beyond a single jurisdiction's ESG-rating ecosystem can provide a more robust understanding of how institutional requirements interact with organizational digital capabilities.

Against this background, the paper pursues five objectives. First, it synthesizes and critically evaluates the digital-transformation/digital-maturity and ESG-integration literatures thematically rather than chronologically, with particular attention to their conceptual assumptions, measurement approaches, causal mechanisms, and empirical limitations. Second, it develops an integrative theoretical framework linking digital maturity to ESG integration through mediating governance mechanisms and moderating institutional conditions. Third, it specifies a multidimensional Digital Maturity Index and a corresponding ESG composite measurement scheme suitable for longitudinal application. Fourth, it designs a multi-wave panel methodology, including an estimation strategy and robustness protocol, capable of testing the proposed relationships while addressing potential endogeneity, reverse causality, and omitted-variable concerns. Fifth, it articulates an evaluation framework illustrated with clearly labelled synthetic data that can subsequently be populated with real longitudinal data in future empirical work. The explicit separation between proposed analytical procedures and demonstrated empirical evidence is intended to ensure methodological transparency and prevent synthetic illustrations from being interpreted as observed findings.

These objectives lead to four research questions. RQ1 asks: How does firm-level digital maturity, conceptualized as a multidimensional construct, relate to the trajectory of ESG integration over time? RQ2 asks: Through which governance mechanisms—including information transparency, green innovation, and internal control or governance efficiency—does digital maturity influence ESG performance? RQ3 asks: How do institutional and firm-level conditions, including regulatory stringency, industry digital intensity, ownership structure, and economic policy uncertainty, moderate the digital maturity–ESG relationship? RQ4 asks: What longitudinal research design and estimation strategy can most credibly identify the direction and dynamics of the digital maturity–ESG relationship while addressing reverse causality and omitted-variable concerns? Collectively, these questions frame digital maturity and ESG integration as interconnected organizational processes rather than isolated technological and sustainability variables, while recognizing that their relationship may vary across firms, industries, institutional environments, and time periods.

The paper makes several contributions to the literature. First, it provides a thematic literature synthesis that connects the previously separate digital-maturity-model literature and the DT-ESG empirical literature, thereby addressing the conceptual separation between digital capability development and sustainability performance. Second, it develops an integrative conceptual framework combining the Dynamic Capabilities View, the Technology-Organization-Environment framework, and stakeholder and legitimacy theory to explain how digital capabilities may be transformed into ESG-related organizational outcomes under varying institutional conditions. Third, it proposes a reusable, multidimensional Digital Maturity Index specification and an ESG composite measurement scheme that can support longitudinal research across firms and contexts. Fourth, it provides a longitudinal methodological design—including model equations, estimation strategy, and robustness procedures—that future researchers can populate with primary or secondary panel data while explicitly addressing potential threats to causal inference. Fifth, it establishes an evaluation framework illustrated with synthetic data and clearly distinguishes proposed analytical outputs from empirical findings. This distinction is particularly important because the present framework is designed as a methodological and conceptual foundation for future empirical validation rather than as a claim of completed longitudinal estimation. Finally, by integrating measurement, theory, temporal design, and contextual moderation, the framework provides a basis for examining whether digital maturity operates as a durable organizational capability through which firms progressively strengthen ESG integration.

The remainder of the paper is organized as follows. Section 2 reviews the literature thematically, focusing on digital

transformation, digital maturity, ESG integration, governance mechanisms, and contextual influences. Section 3 develops the theoretical and conceptual framework underlying the proposed relationships. Section 4 states the research hypotheses derived from the framework. Section 5 specifies the proposed methodology, datasets, measurement procedures, and mathematical models, including the longitudinal estimation and robustness strategy. Section 6 presents the proposed Digital-Maturity-ESG Integration Framework and its architecture. Section 7 describes the evaluation framework and presents illustrative or synthetic results, with a clear distinction between simulated outputs and future empirical findings. Section 8 discusses interpretation, explainability, ethics, and robustness considerations associated with the proposed analytical framework. Section 9 discusses the study's limitations, including measurement constraints, contextual generalizability, potential identification challenges, and the absence of completed empirical validation. Finally, Section 10 concludes the paper by synthesizing the principal theoretical and methodological implications and outlining directions for future longitudinal research.

2. Literature Review

This review is organized thematically around four strands of scholarship: (i) digital transformation and its effect on corporate ESG performance; (ii) digital maturity models and their conceptualization; (iii) theoretical foundations of technology adoption and ESG disclosure; and (iv) methodological approaches to longitudinal panel analysis in this domain.

2.1 Digital Transformation and Corporate ESG Performance

The empirical literature linking digital transformation to ESG performance has expanded rapidly since 2022, almost entirely using Chinese A-share listed-firm panels. Xie et al. (2024) analyzed 28,152 firm-year observations from 2013-2022 and found that digital transformation improves ESG performance through information transparency, green innovation, and internal control, with common institutional ownership amplifying and subjective economic-policy-uncertainty perceptions dampening the relationship. Using a similar A-share sample spanning 2012-2021, related work reported that green innovation and media attention partially mediate the digital transformation-ESG relationship, and that the effect weakens under higher environmental uncertainty.

In the manufacturing sector specifically, digital transformation has been shown to enhance ESG performance primarily by improving company transparency, although a performance-expectation gap following declining firm performance can impede this promotional effect. Fang et al. (2023) demonstrated that goodwill and corporate agency costs mediate the digitization-ESG relationship using economic-modelling techniques, while Wang and Esperança (2023) focused on small and medium-sized enterprises, finding that digital transformation raises both market and ESG performance, with digital-innovation culture moderating the effect. A further study examining the inverse causal direction found that a one-standard-deviation increase in ESG performance is associated with a meaningfully higher subsequent degree of digital transformation, operating through improved corporate governance and eased financing constraints — underscoring that the digital maturity-ESG relationship may be genuinely bidirectional rather than strictly recursive.

Taken together, this literature converges on a positive, mechanism-explicit association between digital transformation and ESG performance, but it is methodologically homogeneous: virtually all studies use ordinary least squares or two-stage least squares panel regressions on Chinese listed-firm data, measure digital transformation via annual-report text-frequency indices, and test mediation using either the traditional three-step approach or an instrumental-variable causal mediation model. This homogeneity is itself informative — it suggests the field has matured in its identification strategy for a single national context, while leaving both construct validity (multidimensional maturity versus intensity proxy) and external validity (single-country panels) comparatively underexplored.

2.2 Digital Maturity: Conceptualization and Measurement

A parallel and largely separate literature has developed multidimensional digital maturity models for organizational assessment. Senna et al. (2023) synthesized 55 digital maturity models published between 2016 and 2022 and, grounding their synthesis in the Technology-Organization-Environment (TOE) framework, empirically validated an integrated Industry 4.0 maturity model across 24 manufacturing companies. Notably,

their review found that existing maturity models had systematically underweighted the environmental dimension relative to technology and organization dimensions — a finding directly relevant to the digital maturity-ESG integration question, since it implies that conventional maturity instruments may not adequately capture the sustainability-relevant aspects of digital capability.

Beyond the Industry 4.0 context, digital maturity has been conceptualized across strategy, leadership, business-model, people, culture, governance, and technology dimensions, and practitioner frameworks — such as those developed by large consulting and technology firms — commonly stage organizations along a continuum from fragmented, analogue activity toward integrated, adaptive digital capability. This staged conceptualization is theoretically compatible with the Dynamic Capabilities View discussed in Section 3, in that later maturity stages correspond to a firm's accumulated capacity to sense, seize, and reconfigure resources in response to a changing environment, including the sustainability-related expectations of stakeholders.

2.3 Theoretical Foundations: Technology Adoption and ESG Disclosure Motives

The theoretical grounding of ESG-disclosure and sustainability-performance research draws principally on stakeholder theory and legitimacy theory. Stakeholder theory holds that firms should act in ways consistent with the expectations of the full range of parties affected by their operations, not solely shareholders, and that sustainability disclosure functions as a relationship-building mechanism with these stakeholders.

Legitimacy theory, which Gray et al. (1995) argued overlaps substantially with stakeholder theory, frames ESG reporting as a device by which organizations seek to maintain a societally accepted "license to operate" by aligning disclosed behavior with prevailing social norms and expectations. Deegan (2002) similarly proposed that firms use disclosure to manage stakeholder perceptions and to demonstrate conformity with stakeholder expectations, particularly following events that threaten organizational legitimacy.

On the technology-adoption side, the Technology-Organization-Environment framework, originally developed by Tornatzky and Fleischer (1990), explains innovation adoption as jointly determined by technological characteristics, internal organizational context, and external environmental pressures — a structure well suited to explaining why digital maturity differs systematically across regulatory and industry environments. Complementing this, the Dynamic Capabilities View, developed by Teece et al. (1997) and elaborated by Teece (2007), conceptualizes firm-level capability as comprising sensing, seizing, and reconfiguring processes; digital transformation research has increasingly used this lens to explain how firms build the capacity to reconfigure resources under conditions of technological disruption.

Building on this, Helfat and Raubitschek (2018) emphasized that dynamic and integrative capabilities are particularly consequential in digital-platform-based ecosystems, where the pace of environmental change places a preium on a firm's capacity for continuous reconfiguration — a claim with direct relevance to why more digitally mature firms might be expected to adapt more readily to evolving ESG-disclosure and sustainability-performance expectations. This perspective further suggests that digital maturity is shaped by the interaction between technological capabilities, organizational readiness, and the capacity to respond to changing external requirements. Organizations with stronger dynamic capabilities may be better positioned to integrate emerging digital technologies with sustainability-oriented processes and reporting practices. The combined TOE and Dynamic Capabilities perspectives therefore provide a complementary theoretical basis for explaining both the adoption and adaptive evolution of digital technologies.

Together, these lenses support the expectation that sustained digital maturity can enhance an organization's ability to respond systematically to evolving ESG expectations and broader environmental pressures.

2.4 Governance Mechanisms and Boundary Conditions

Several governance-related constructs recur as mediators or antecedents relevant to the digital maturity-ESG relationship.

Information transparency, conceptualized following Lang et al. (2012) as the ease with which external users can access reliable firm information, has been shown to correlate with firm performance and is theorized to translate digital capability into higher perceived ESG quality by improving external assessability of a firm's practices. Li et al. (2018) found that ESG disclosure affects firm value partly through governance channels such as CEO power, underscoring those governance quality and disclosure are intertwined. Ownership-related moderators have also received attention: Dyck et al. (2019) and Chen et al. (2020) both found that institutional shareholders exert pressure that increases corporate social responsibility engagement, suggesting that ownership concentration and type are plausible moderators of any digital maturity-ESG relationship. Firm size is a further robust covariate: Drempetic et al. (2020) showed that firm size systematically influences ESG scores independent of underlying sustainability performance, a methodological caution directly relevant to the control-variable specification in Section 5.

2.5 Methodological Approaches to Mediation and Endogeneity

Methodologically, the DT-ESG literature has progressively moved away from the traditional three-step mediation approach of Preacher and Hayes (2008), which is vulnerable to endogeneity, toward instrumental-variable causal mediation models such as that proposed by Dippel et al. (2020), which construct time-varying instruments (for example, historical infrastructure data interacted with contemporary technology-diffusion proxies) to identify mediating pathways more credibly. This methodological trajectory directly informs the estimation strategy proposed in Section 5, which combines fixed-effects and instrumental-variable approaches with propensity-score matching and lagged-effect specifications. This combined strategy is intended to strengthen causal inference by addressing both observable and unobservable sources of confounding within the proposed analytical framework.

2.6 Literature Comparison Table

Table 1: summarizes representative studies across the two core strands of literature, highlighting method, context, key finding, and the specific limitation that motivates the present study's design choices.

Study	Year	Method	Dataset/Context	Key Finding	Research Gap Addressed Here
Xie, Zhu, & Zhao	2024	OLS; IV 2SLS causal mediation; moderation	28,152 Chinese A-share firm-years, 2013-2022	DT improves ESG via transparency, green innovation, internal control; moderated by common institutional ownership and policy uncertainty	Single-country panel; DT measured via text-frequency, not multidimensional maturity
Fang, Nie, & Shen	2023	Panel regression, mediation analysis	Chinese listed firms	Goodwill and agency costs mediate digitization-ESG link	Narrow mediator set; no longitudinal trajectory modelling
Wang & Esperança	2023	Panel regression, moderated mediation	Chinese SMEs	DT improves market and ESG performance via innovation culture	SME-specific; single-country; cross-sectional framing of a developmental process
Senna, Barros, Bonnin Roca, & Azevedo	2023	Systematic literature review; focus groups; empirical validation (n=24 firms)	55 synthesized maturity models; manufacturing sector	TOE-grounded multidimensional maturity model; environment dimension underweighted in prior models	Not linked to ESG outcomes; manufacturing-only validation sample
Dippel, Ferrara, & Heblich	2020	IV-based causal mediation methodology	Methodological (Stata implementation)	Provides credible mediation identification under endogeneity	Methodological tool, not applied longitudinally to digital maturity constructs
Drempetic, Klein, & Zwergel	2020	Panel regression	Global ESG-rated firms	Firm size systematically biases ESG scores	Highlights need for size controls; not integrated with digital-maturity research

3. Theoretical and Conceptual Framework

The proposed framework integrates four theoretical perspectives, each explaining a distinct segment of the digital maturity-ESG integration pathway (Figure 1).

3.1 Dynamic Capabilities View

The Dynamic Capabilities View, developed by Teece et al. (1997) and refined by Teece (2007), conceptualizes competitive advantage as arising from a firm's capacity to sense opportunities and threats, seize them through resource mobilization, and reconfigure tangible and intangible assets accordingly. Within this framework, digital maturity is theorized as an accumulated dynamic capability: more digitally mature firms possess superior sensing capacity (e.g., real-time environmental and social-risk monitoring), superior seizing capacity (e.g., faster deployment of sustainability-related process changes), and superior reconfiguring capacity (e.g., restructuring supply chains or governance processes in response to stakeholder pressure). This capability-based perspective therefore provides a theoretical explanation for why digital maturity may strengthen firms' ability to translate emerging sustainability pressures into timely organizational and strategic responses. Digital maturity can therefore be understood as an organizational mechanism through which firms continuously renew their capabilities in response to changing sustainability demands. Advanced digital infrastructures can improve the timeliness, accuracy, and integration of information required for sustainability-oriented decision-making. These capabilities may also enhance coordination among internal functions and external stakeholders involved in ESG-related activities. Greater digital maturity can facilitate the identification of emerging sustainability risks before they develop into substantial operational or reputational challenges. It may further support the rapid allocation of financial, technological, and human resources toward sustainability priorities.

3.2 Technology-Organization-Environment Framework

The TOE framework, originally proposed by Tornatzky and Fleischer (1990) and applied to digital maturity modelling by Senna et al. (2023), explains why the pace and shape of digital-capability accumulation vary systematically with technological characteristics (e.g., compatibility, complexity), organizational context (e.g., firm size, slack resources, leadership commitment), and external environment (e.g., regulatory stringency, industry digital intensity, competitive pressure). This framework supplies the moderating layer of the proposed model.

3.3 Stakeholder Theory and Legitimacy Theory

Stakeholder theory, as articulated by Freeman (1984), and legitimacy theory, as elaborated by Gray et al. (1995) and Deegan (2002), jointly explain why digitally enabled transparency and governance improvements translate into observable ESG outcomes: firms use enhanced information-processing capacity to identify and respond to stakeholder expectations, and they disclose the results in ways calibrated to maintain societal legitimacy. These theories justify treating information transparency and governance efficiency as mediating mechanisms rather than as outcomes in their own right.

3.4 Integrated Conceptual Model

Figure 1 depicts the integrated conceptual model. Digital maturity — a composite construct spanning strategy, technology infrastructure, data and analytics, culture and people, governance, and customer experience — is theorized to affect ESG integration (environmental, social, and governance sub-performance) both directly and indirectly through three mediating mechanisms: information transparency, green innovation, and internal control/governance efficiency. Regulatory stringency, industry digital intensity, firm size/ownership, and economic policy uncertainty are theorized as moderating conditions. Because both constructs are developmental, the model's outcome of interest is not a single cross-sectional association but the longitudinal trajectory of co-evolution between digital maturity and ESG integration over successive observation waves.

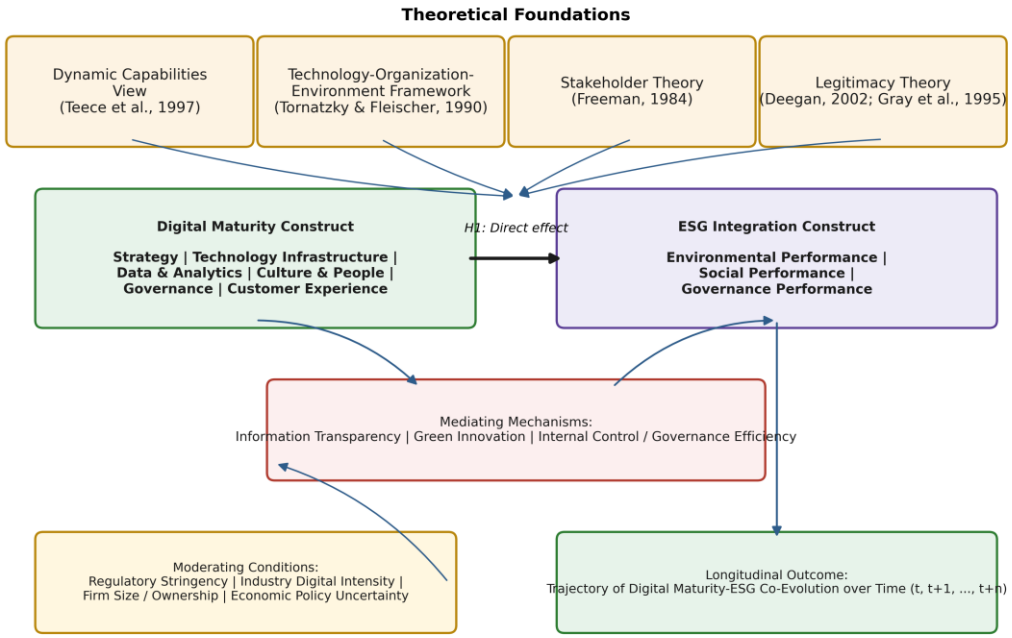

Figure 1: Integrated theoretical and conceptual framework linking digital maturity to ESG integration through mediating governance mechanisms and moderating institutional conditions.

3.5 Digital Maturity Progression Continuum

Consistent with the staged conceptualization common in the digital-maturity literature, Figure 2 depicts digital maturity as a five-stage continuum, from analogue/fragmented activity through digitized operations, digital coordination, digital integration, and finally adaptive digital maturity. This staged view underlies the longitudinal design in Section 5, in which firms are expected to occupy different, potentially shifting, positions along this continuum across observation waves. The continuum reflects a gradual transition from isolated technology use toward increasingly integrated and adaptive organizational capabilities. Each stage represents a distinct level of technological integration, coordination, and organizational readiness rather than a purely technological upgrade. The analogue/fragmented stage is characterized by limited digital infrastructure, disconnected processes, and predominantly manual information flows. Digitized operations introduce digital tools into individual activities while leaving broader organizational processes relatively independent. Digital coordination represents greater connectivity among functions, enabling information and workflows to move more consistently across organizational boundaries. Digital integration extends this connectivity by aligning digital platforms, data resources, and business processes into a more coherent operating environment. Adaptive digital maturity represents the most advanced stage, in which organizations continuously adjust technologies, processes, and capabilities in response to changing internal and external conditions. Movement across stages is not necessarily linear, as firms may advance rapidly in some dimensions while remaining less mature in others. The framework therefore allows digital maturity to be examined as a multidimensional and evolving organizational condition rather than as a fixed classification. This longitudinal perspective provides a basis for examining whether changes in digital maturity are associated with corresponding changes in organizational capabilities and ESG-related outcomes over time. The staged model also provides a common reference point for comparing digital transformation trajectories across firms and observation periods. Differences in stage progression may reflect variation in technological investment, managerial capabilities, organizational learning, and external pressures. The framework therefore permits firms to exhibit uneven maturity profiles when development occurs at different rates across technological and organizational dimensions. Such variation is particularly relevant for longitudinal analysis.

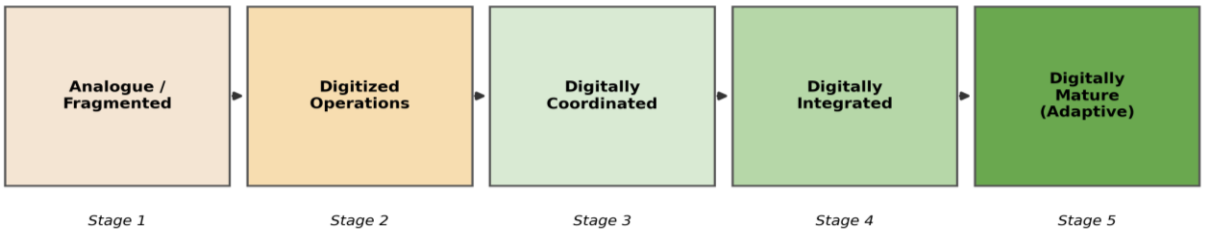

Figure 2: Digital maturity progression continuum (conceptual staging adapted from the digital-maturity-model literature).

4. Research Questions and Hypotheses

Derived from the conceptual framework in Section 3 and the research questions in Section 1.6, the following hypotheses are proposed for empirical testing in future longitudinal work:

H1: Firm-level digital maturity is positively associated with subsequent ESG integration, controlling for firm size, leverage, profitability, ownership concentration, and firm age.

H2: Information transparency partially mediates the relationship between digital maturity and ESG integration.

H3: Green innovation partially mediates the relationship between digital maturity and ESG integration.

H4: Internal control and governance efficiency partially mediate the relationship between digital maturity and ESG integration.

H5: Regulatory stringency positively moderates the digital maturity-ESG integration relationship, such that the relationship is stronger in more stringent regulatory environments.

H6: Industry digital intensity and ownership structure (e.g., state versus private ownership) produce heterogeneous digital maturity-ESG effects across subsamples.

H7: The digital maturity-ESG integration relationship exhibits lagged, bidirectional dynamics such that prior ESG integration also positively predicts subsequent digital maturity investment, consistent with a co-evolutionary rather than strictly recursive process.

5. Proposed Methodology

Because primary longitudinal data collection was outside the scope of this paper, this section specifies a complete, reproducible methodological design intended for future empirical application, rather than reporting completed data analysis. All datasets described below are proposed/recommended sources; no claim is made that data collection has occurred.

5.1 Research Design

A multi-wave longitudinal panel design is proposed, with annual observations collected over a minimum of eight to ten consecutive years to allow lagged-effect and trajectory analysis. The unit of analysis is the firm-year. Figure 3 depicts the seven-step research design, from sampling through interpretation

5.2 Data Collection and Proposed Datasets

Table 2 lists proposed data sources spanning digital maturity assessment and ESG performance measurement. Where firm-level digital maturity surveys are unavailable, a validated multidimensional proxy constructed from annual-report text analysis, technology-patent filings, and IT-capital-expenditure ratios is recommended as a substitute, following the general approach used for text-based digital-transformation indices in the reviewed literature, extended to a multidimensional structure consistent with the digital-maturity-model literature. The proposed multidimensional proxy is intended to capture both the observable intensity of digital investment and the broader organizational emphasis on digital transformation. Annual-report text analysis can provide evidence of strategic digital orientation, while patent activity and IT-capital-expenditure ratios can capture complementary indicators of technological development and resource commitment. Combining these indicators may reduce reliance on any single proxy and provide a more comprehensive representation of firm-level digital maturity. The resulting index should be constructed using transparent and reproducible coding procedures, with normalization and weighting rules specified before empirical estimation. Where sufficient observations are available, alternative proxy specifications should be tested to examine whether the estimated relationship between digital

maturity and ESG outcomes is robust to measurement choices. The ESG measures should likewise be harmonized across firms and observation periods to improve comparability and minimize inconsistencies arising from differences in reporting practices. Potential differences in industry characteristics, regulatory environments, firm size, and reporting quality should be incorporated into the empirical design because these factors may systematically influence both digital maturity and ESG performance. Temporal alignment between digital-maturity indicators and ESG outcomes is also important because technology investments may require time to generate measurable organizational and sustainability effects. Future validation should therefore examine lagged specifications and alternative measurement windows to assess the temporal stability of the proposed relationships.

Table 2: Proposed Data Sources, Measurement Constructs, and Selection Rationale

Dataset (Proposed)	Source	Approx. Scope	Key Features	Target Construct	Reason for Selection
Corporate digital maturity survey panel	Primary survey instrument (recommended, e.g., adapted TOE-based instrument)	Multi-industry, multi-country firm sample	Strategy, technology, data, culture, governance, customer-experience items	Digital Maturity Index	Provides multidimensional construct validity absent from text-frequency proxies
Annual report textual corpus	Company annual/sustainability reports	Firm-year panel, 8-10 years	Keyword-frequency indices for digital-technology adoption	Digital Maturity Index (secondary/validation)	Enables large-sample longitudinal coverage where survey data are unavailable
ESG rating database	Commercial ESG data providers (e.g., Refinitiv, Bloomberg, MSCI, or regional equivalents)	Firm-year panel matched to maturity sample	E, S, G sub-pillar scores and composite ESG score	ESG Integration (dependent variable)	Independently verified, widely used, comparable ESG scoring methodology
Financial statement database	Standard financial databases (e.g., Compustat, CSMAR, Refinitiv)	Firm-year panel	Size, leverage, profitability, ownership structure	Control variables	Standard covariates shown to influence ESG scores independent of sustainability
Regulatory and institutional indices	National/regional regulatory-stringency indices; industry classification codes	Country/industry-year	ESG disclosure mandates; industry digital-intensity indicators	Moderating variables	Enables test of institutional and industry heterogeneity (H5, H6)

5.3 Construct Operationalization

Digital Maturity Index (DMI)

The Digital Maturity Index is proposed as a weighted composite across six dimensions: (1) Strategy and leadership commitment, (2) Technology infrastructure, (3) Data and analytics capability, (4) Culture and people/digital skills, (5) Governance of digital risk, and (6) Customer/stakeholder experience. Each dimension is scored on a 0-100 scale via survey items or, where unavailable, text-based proxy indicators, and the composite is computed as a weighted mean:

$$DMI_{\mathrm{it}} = \Sigma_{\mathrm{k}} w_{\mathrm{k}} \cdot D_{\mathrm{k,\,it}} \qquad \text{(Equation 1)}$$

where $D_{k,it}$ is the standardized score of dimension k for firm i at time t, and w_k is the dimension weight, calibrated via exploratory factor analysis or, absent primary data, set to equal weights ($w_k = 1/6$) as a transparent default.

ESG Composite Score

Following standard ESG-rating construction and consistent with prior digital transformation-ESG studies, the ESG composite is defined as:

$$ESG_{\mathrm{it}} = \alpha_{\mathrm{e}} \cdot E_{\mathrm{it}} + \alpha_{\mathrm{s}} \cdot S_{\mathrm{it}} + \alpha_{\mathrm{m}} \cdot G_{\mathrm{it}} \text{ (Equation 2)}$$

where E, S, and G denote the environmental, social, and governance sub-pillar scores, and α_e, α_s, α_m are provider-specific

or researcher-specified weights (commonly equal weights of one-third each).

5.4 Mathematical Modelling: Estimation Equations

The baseline longitudinal fixed-effects model tests H1:

$$ESG_{it} = \beta_0 + \beta_1 DMI_{i,t-1} + \beta_2 Size_{it} + \beta_3 Lev_{it} + \beta_4 ROA_{it} + \beta_5 FirmAge_{it} + \beta_6 Own_{it} + Industry_i + Year_t + \varepsilon_{it}$$ (Equation 3)

where DMI is lagged by one period to mitigate reverse-causality concerns, and Industry and Year fixed effects absorb time-invariant industry heterogeneity and common macro shocks, respectively. This specification further strengthens identification by controlling for unobserved heterogeneity and temporal variation across the panel.

For the mediation tests (H2-H4), the study proposes the instrumental-variable causal mediation approach of Dippel et al. (2020), estimated as a three-equation system:

$$DMI_{it} = \gamma_0 + \gamma_1 IV_{it} + Controls + \varepsilon_{it}$$ (Equation 4a)

$$Mediator_{it} = \delta_0 + \delta_1 \hat{DMI_{it}} + Controls + \varepsilon_{it}$$ (Equation 4b)

$$ESG_{it} = \theta_0 + \theta_1 DMI_{it} + \theta_2 \hat{Mediator_{it}} + Controls + \varepsilon_{it}$$ (Equation 4c)

where IV is a time-varying instrument constructed by interacting a historically predetermined, plausibly exogenous regional technology-infrastructure measure with contemporary digital-diffusion indicators, following the logic used in the reviewed instrumental-variable mediation literature.

For the moderation tests (H5-H6), interaction terms are added to Equation 3:

$$ESG_{it} = \beta_0 + \beta_1 DMI_{i,t-1} + \beta_2 (DMI \times Moderator)_{i,t-1} + \beta_3 Moderator_{it} + Controls + Industry_i + Year_t + \varepsilon_{it}$$ (Equation 5)

For the co-evolutionary dynamics implied by H7, a cross-lagged panel model (or dynamic system-GMM specification) is proposed:

$$DMI_{it} = \varphi_1 DMI_{i,t-1} + \varphi_2 ESG_{i,t-1} + Controls + \varepsilon_{it} (Equation 6a)$$

$$ESG_{it} = \psi_1 ESG_{i,t-1} + \psi_2 DMI_{i,t-1} + Controls + \varepsilon_{it} (Equation 6b)$$

Statistically significant cross-lagged coefficients φ_2 and ψ_2 in both directions would support a genuinely bidirectional, co-evolutionary interpretation rather than a strictly recursive one.

5.5 Validation Strategy and Robustness Protocol

The following robustness checks are specified: (i) alternative DMI construction (equal-weighted versus factor-analytic weights); (ii) alternative ESG data providers to test sensitivity to rating-agency divergence; (iii) propensity-score matching contrasting high- versus low-digital-maturity firms; (iv) instrumental-variable two-stage least squares estimation with weak-instrument diagnostics (Kleibergen-Paap LM and Wald F statistics); (v) Heckman two-stage correction for potential sample-selection bias in survey-based DMI construction; and (vi) placebo tests using randomly reassigned firm-year DMI values to verify that estimated effects are not artifacts of the estimation procedure.

5.6 Reproducibility

All proposed instruments, keyword dictionaries, variable definitions, and estimation code should be deposited in a public repository upon empirical implementation, with random seeds fixed for any bootstrap or matching procedures, and full documentation of the ESG data provider, coverage period, and industry classification scheme used. This repository should preserve a clear version history so that subsequent researchers can identify changes in instruments, code, and analytical specifications. Data-processing workflows should document missing-value treatment, outlier handling, text preprocessing, and variable transformation procedures. Where proprietary ESG data cannot be redistributed, researchers should provide detailed metadata and reproducible extraction or access instructions where legally permissible. Replication materials should include the exact model specifications, control variables, and robustness tests used in the empirical analysis. Documentation should also record software versions, package

dependencies, and computational environments required to reproduce the reported estimates. Such practices would strengthen transparency, facilitate independent replication, and improve the cumulative reliability of future ESG research. Future replication studies should also report deviations from the preregistered analytical protocol and provide clear justifications for any methodological changes. Independent researchers should be able to trace each reported finding from the analytical code to the corresponding data source and variable definition. Version-controlled repositories should distinguish exploratory analyses from the final specifications used to generate reported results. Analytical scripts should include automated checks for data integrity, variable ranges, sample restrictions, and unexpected changes in observation counts. Where feasible, replication packages should include synthetic or anonymized test data that allow researchers to verify the computational workflow without exposing restricted information. All derived datasets should retain documented links to their original sources and clearly defined transformation steps. Researchers should also archive preregistration records, analysis plans, and registered hypotheses alongside the final analytical materials. Any post hoc analyses should be explicitly identified as exploratory rather than presented as part of the confirmatory analysis. Sensitivity analyses should use documented alternative specifications to assess whether substantive conclusions depend on particular modelling assumptions. Repository documentation should provide sufficient instructions for recreating tables, figures, descriptive statistics, and regression outputs from the available materials. Where computationally intensive procedures are used, researchers should report the required hardware resources and approximate execution requirements.

6. Proposed Digital Maturity-ESG Integration Framework

Building on Sections 3 and 5, this section names and specifies the proposed framework as a self-contained architecture suitable for future empirical deployment. This specification also establishes a clear basis for consistent implementation, evaluation, and reproducibility in subsequent empirical studies.

The Digital Maturity-ESG Integration (DM-EI) Framework

1. Input: firm-year records combining survey-based or text-derived digital maturity indicators, ESG rating data, financial statement variables, and institutional/regulatory context indicators.

2. Data processing: missing-data imputation, winsorization of continuous variables at the 1st and 99th percentiles, standardization of sub-indices, and one-period lagging of predictor variables.

3. Core methodology: multidimensional construction of the Digital Maturity Index (Equation 1) and ESG composite (Equation 2).

4. Model/algorithm: panel fixed-effects regression (Equation 3), instrumental-variable causal mediation (Equations 4a-4c), moderated regression (Equation 5), and cross-lagged dynamic panel modelling (Equations 6a-6b).

5. Optimization: instrument selection and weak-instrument diagnostics; factor-analytic weight calibration for the DMI where primary survey data permit.6. Evaluation: goodness-of-fit statistics, mediation effect-size decomposition (direct versus indirect effects), heterogeneity/subgroup analysis, and out-of-sample trajectory validation on a held-out panel subset.

7. Explainability: decomposition of the DMI into dimension-level contributions to observed ESG associations, and mediator-specific effect decomposition, to support managerial interpretation (Section 8.1).

8. Governance: pre-registration of hypotheses and model specifications before data access, and transparent reporting of all robustness checks regardless of outcome.

9. Output: (a) a validated Digital Maturity Index instrument; (b) empirical estimates of direct, mediated, and moderated digital maturity-ESG relationships; (c) a firm/industry-level trajectory classification distinguishing early-stage, transitional, and mature digital-ESG integration profiles; and (d) practical guidance for sequencing digital investment to support ESG objectives.

7. Evaluation Metrics

Table 3: Statistical Metrics, Analytical Methods, and Hypothesis Testing Framework

Metric	Type	Applies To	Interpretation
Regression coefficient (β_1) and standard error	Panel regression	H1 (direct effect)	Sign, magnitude, and significance of DMI on ESG composite
Average direct and indirect effect (ADE / ACME)	Causal mediation decomposition	H2-H4 (mediation)	Proportion of total DMI-ESG effect operating through each mediator
Interaction coefficient significance	Moderated regression	H5-H6 (moderation)	Whether institutional/industry context conditions the DMI-ESG relationship
Cross-lagged path coefficients (φ_2, ψ_2)	Cross-lagged panel / dynamic GMM	H7 (co-evolution)	Evidence of bidirectional versus unidirectional dynamics
Kleibergen-Paap LM / Wald F statistic	Weak-instrument diagnostic	IV robustness	Instrument relevance and strength
Standardized mean difference (post-matching)	Balance diagnostic	PSM robustness	Covariate balance between matched high-/low-maturity groups
R^2 / within-R^2	Model fit	All specifications	Proportion of within-firm ESG variance explained

7. 1 Evaluation Framework and Illustrative Results

Table 4 specifies the evaluation metrics proposed for each hypothesis. Because no primary longitudinal dataset was collected for this paper, no empirical results are reported. Figure 4 instead presents an illustrative, entirely synthetic pair of trajectories — explicitly generated for demonstration of the evaluation framework only — contrasting a hypothetical high-digital-maturity cohort against a hypothetical low-digital-maturity cohort on both the Digital Maturity Index and the ESG composite score. These synthetic series are not derived from any real firm, dataset, or prior study, and no substantive conclusion should be drawn from their shape beyond illustrating how the proposed evaluation protocol would visualize cohort divergence once real longitudinal data are collected. The proposed trajectories are designed to illustrate how longitudinal analysis could capture changes in digital maturity and ESG performance across observation periods. The Digital Maturity Index provides a structured representation of changes in firms' technological and organizational capabilities over time. The ESG composite score similarly provides an aggregated representation of sustainability-related performance that can be examined alongside digital transformation trajectories. Future empirical analysis could estimate within-firm changes and between-cohort differences while controlling for relevant firm-level and time-varying confounding factors. Lagged specifications could further examine whether changes in digital maturity precede subsequent changes in ESG performance rather than merely occurring contemporaneously. Robustness checks could compare alternative index constructions, cohort definitions, observation windows, and model specifications to assess the stability of estimated relationships. Where sufficient longitudinal observations are available, fixed-effects models could account for unobserved time-invariant characteristics that may influence both digital maturity and ESG outcomes. Instrumental-variable or matching approaches could additionally be considered where appropriate identification strategies and valid assumptions can be established. The evaluation framework therefore provides a structured pathway for transitioning from the present conceptual demonstration to empirically testable longitudinal analysis. Any conclusions regarding the magnitude, direction, or statistical significance of the relationship should ultimately be based only on appropriately collected and validated longitudinal data.

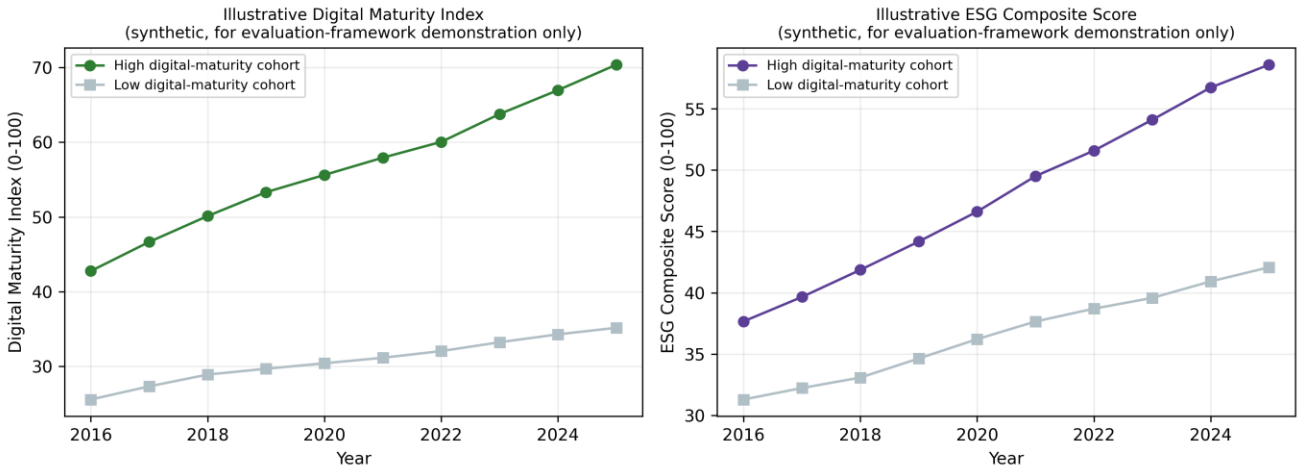

Figure 4: Illustrative synthetic trajectories (not empirical findings) demonstrating how the proposed Digital Maturity Index and ESG composite score would be visualized across a hypothetical high- versus low-digital-maturity cohort.

If populated with real panel data, the proposed framework would report: (i) baseline fixed-effects estimates of Equation 3 with associated confidence intervals; (ii) mediation decomposition tables reporting average direct and indirect effects with bootstrap confidence intervals; (iii) moderation results reported as marginal effects plots across the range of each moderator; and (iv) cross-lagged path diagrams with standardized coefficients and model-fit indices (e.g., CFI, RMSEA) for the dynamic panel specification. None of these outputs are simulated in this paper beyond the single illustrative chart in Figure 4, consistent with the research-integrity requirement that illustrative material be clearly distinguished from empirical findings.

8. Discussion

8.1 Interpretation of the Proposed Framework

The proposed framework predicts that digital maturity's effect on ESG integration is neither immediate nor purely direct: consistent with the reviewed literature, the framework expects a substantial share of the total effect to operate through information-transparency, green-innovation, and internal-control channels rather than through a direct technology-to-outcome pathway. This has a practical implication even prior to empirical validation: organizations seeking ESG gains from digital investment should prioritize the specific capabilities — data governance, disclosure automation, and analytics-enabled internal control — that the mediation literature identifies as the actual transmission channels, rather than treating digital investment in general as a sufficient condition for ESG improvement.

8.2 Explainability and Interpretability Considerations

Because the Digital Maturity Index is a weighted composite across six dimensions, dimension-level decomposition (analogous to a Shapley-value or feature-importance style attribution) is recommended once empirical data are available, so that the relative contribution of, for example, governance-of-digital-risk versus technology-infrastructure to the overall DMI-ESG association can be isolated. This form of local and global interpretability is particularly important for practitioner adoption, since managers are more likely to act on a framework that identifies which specific maturity dimension to prioritize rather than a single aggregate coefficient. A limitation of this approach is that composite-index decomposition can be sensitive to correlated sub-dimensions, and factor-analytic weighting (rather than equal weighting) should be reported alongside any decomposition to allow readers to assess robustness.

8.3 Ethics, Governance, and Regulatory Considerations

Any empirical deployment of the proposed framework raises several governance considerations. First, firm-level digital maturity survey data may reveal commercially sensitive information about internal technology architecture; data-

collection protocols should include anonymization and aggregation safeguards. Second, ESG rating data are known to diverge substantially across providers, a measurement-validity concern that should be addressed through the multi-provider robustness check specified in Section 5.5 rather than reliance on a single rating agency. Third, regulatory context varies by jurisdiction; researchers applying this framework outside the jurisdictions covered in the reviewed literature should verify which ESG-disclosure regime applies to their sample and adjust the regulatory-stringency moderator accordingly. Fourth, any managerial application of framework outputs to investment or personnel decisions should be accompanied by human oversight, given the composite and probabilistic nature of the underlying estimates.

8.4 Robustness and Validity Considerations

Internal validity is threatened primarily by reverse causality (firms with stronger ESG performance may find it easier to invest in digital capability) and by omitted-variable bias (unobserved managerial quality could drive both digital maturity and ESG performance). The instrumental-variable and cross-lagged specifications in Section 5.4 are designed specifically to address these threats, but their credibility depends on instrument validity, which must be empirically tested (not assumed) once real instruments are selected for a given context. External validity is threatened by the current literature's concentration in Chinese listed-firm panels; the multi-country data-collection recommendation in Table 2 is intended to directly address this threat, though it substantially raises the practical cost and complexity of empirical implementation.

9. Limitations

This paper has the following limitations, stated transparently rather than minimized. First, no primary or secondary empirical data were analyzed; all quantitative material beyond the literature synthesis is either a proposed specification or an explicitly labelled synthetic illustration, and the hypotheses in Section 4 therefore remain untested. Second, the proposed Digital Maturity Index, while grounded in the reviewed maturity-model literature, has not itself been psychometrically validated (e.g., via confirmatory factor analysis) and would require such validation before large-sample deployment. Third, the reviewed empirical literature that motivates the framework is concentrated in a single national context (China) and a specific ESG-rating ecosystem, which constrains the confidence with which the proposed relationships can be assumed to generalize internationally prior to empirical testing. Fourth, the proposed instrumental variables described in Section 5.4 are illustrative of an identification strategy used in the reviewed literature and would require context-specific validation (relevance and exclusion-restriction testing) for any new empirical setting. Fifth, computational and data-access constraints — particularly the cost of assembling a multi-country, multi-year digital-maturity survey panel matched to independently sourced ESG ratings — represent a substantial practical barrier to full implementation of the proposed design. Sixth, reproducibility of any future empirical application depends on data-provider licensing terms, which may restrict public deposition of the underlying ESG and financial datasets even where code and derived indices can be shared

10. Future Research Directions

Building directly on the limitations above, five specific directions are proposed. First, cross-country replication of the proposed longitudinal design using matched samples from at least two additional regulatory regimes (for example, the European Union's Corporate Sustainability Reporting Directive context and a common-law jurisdiction) would directly test the external-validity concern raised in Section 8.4. Second, psychometric validation of the proposed Digital Maturity Index, via confirmatory factor analysis on primary survey data from a pilot sample, should precede any large-sample deployment. Third, extension of the cross-lagged specification in Equations 6a-6b to a full dynamic structural equation model spanning more than two waves would allow direct testing of non-linear or threshold effects in the digital maturity-ESG trajectory, addressing the linearity limitation noted in comparable prior work. Fourth, given the growing role of generative and agentic artificial intelligence within the technology-infrastructure

dimension of digital maturity, future iterations of the framework should examine whether AI-specific capability (as distinct from general digitalization) exerts a differentiated effect on ESG integration, particularly on the governance sub-pillar. Fifth, privacy-preserving federated approaches to multi-firm digital-maturity data collection could reduce the disclosure burden identified in Section 8.3 while still enabling the multi-country panel construction recommended above.

11. Conclusion

This paper set out to address a specific and well-defined gap in the digital transformation-ESG literature: the absence of a multidimensional, longitudinally oriented framework for examining how digital maturity relates to ESG integration over time, beyond the largely single-country, cross-sectional evidence base that currently dominates the field. Returning to the research questions posed in Section 1.6, the paper has (RQ1-RQ2) synthesized theoretical grounds, drawn from the Dynamic Capabilities View, the Technology-Organization-Environment framework, and stakeholder/legitimacy theory, for expecting digital maturity to affect ESG integration both directly and through information-transparency, green-innovation, and governance-efficiency mechanisms; (RQ3) specified regulatory stringency, industry digital intensity, ownership structure, and economic policy uncertainty as plausible moderating conditions; and (RQ4) proposed a complete longitudinal methodology — including a multidimensional Digital Maturity Index, an ESG composite measurement scheme, panel and cross-lagged estimation equations, and an instrumental-variable and matching-based robustness protocol — capable of testing these relationships credibly once populated with real data.

The paper's contribution is therefore methodological and theoretical rather than empirical: it provides a reusable measurement and estimation architecture, explicitly distinguishing proposed specifications and synthetic illustrations from tested findings, that future researchers can deploy across national contexts currently underrepresented in the literature. Practically, the framework offers organizations a more granular basis than a single digital-transformation intensity score for sequencing digital investment toward specific governance mechanisms shown, in prior single-country research, to mediate ESG gains. The central limitation of the present contribution — that its hypotheses remain untested pending primary data collection — is also its primary invitation to future research: cross-country, multi-wave application of the proposed Digital Maturity-ESG Integration Framework represents a direct and tractable next step for the field.

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