

Corporate life cycle and sustainability disclosure in 10-K filings: average signaling, local legitimacy

Li Yang

UQ Business School, The University of Queensland, Brisbane, Australia

Abstract

Purpose – This study examines how firm life-cycle stages shape sustainability disclosure behavior and investigates whether competing disclosure logics, signaling theory and legitimacy theory, operate differently across stages of corporate development.

Design/methodology/approach – Using a sample of US listed firms from 2009 to 2019, we analyze sustainability-related language embedded in mandatory 10-K filings. Firm life-cycle stages are proxied using both retained earnings to total assets (RE/TA) and cash-flow-based classifications. Sustainability disclosure intensity is measured through textual analysis of 10-K reports, while sustainability performance is captured using ESG scores. We estimate baseline regressions with industry and year fixed effects and conduct robustness analyses, including alternative life-cycle proxies, propensity score matching, and heteroskedasticity-consistent standard errors.

Findings – The results show that mature firms exhibit higher sustainability disclosure intensity, consistent with signaling theory: firms with stronger sustainability performance disclose more to credibly convey their quality. However, further analysis reveals meaningful heterogeneity across life-cycle stages. Growth-stage firms display relatively higher sustainability disclosure despite weaker sustainability performance, a pattern consistent with legitimacy-driven communication. Sensitivity analyses based on cash-flow life-cycle classifications further indicate that while legitimacy considerations dominate in specific stage contrasts, signaling incentives prevail at the aggregate level.

Practical implications – The findings suggest that sustainability disclosure should be interpreted considering firms' life-cycle positions. Similar disclosure levels may reflect different underlying motivations and economic fundamentals, which has implications for investors, regulators, and other stakeholders.

Originality/value – This study integrates firm life-cycle theory with disclosure theories and shows that signaling and legitimacy operate jointly but unevenly across stages of corporate development, offering a dynamic perspective on sustainability disclosure behavior.

Keywords Firm life cycle, Sustainability disclosure, Signaling theory, Legitimacy theory

Paper type Research article

1. Introduction

Sustainability disclosure has become a routine input into how firms are evaluated by capital market participants, regulators, and other stakeholders. Prior research shows that sustainability-related disclosures affect firm valuation, cost of capital, and investor behavior (Dhaliwal *et al.*, 2011; Ioannou and Serafeim, 2012; Grewal *et al.*, 2020). As sustainability performance is increasingly viewed as financially material (Eccles *et al.*, 2014; Ferrer *et al.*, 2020), firms face growing pressure not only to engage in sustainable activities, but also to communicate them credibly. This pressure is further intensified by evidence that firms with strong growth prospects benefit from sustainability disclosure through enhanced market performance (Presley *et al.*, 2025). However, as firms increasingly expand their sustainability disclosures, concerns about greenwashing have also emerged (Free *et al.*, 2024), raising uncertainty about the credibility of such disclosures and the underlying motives driving them.



Against this backdrop, a central question arises: when firms disclose sustainability information, are they primarily revealing underlying strength or managing perceived vulnerability (Clarkson *et al.*, 2008; Herbohn *et al.*, 2014; Hummel and Schlick, 2016)? In the disclosure literature, this question maps naturally onto two competing theoretical lenses. Under signaling theory, voluntary disclosure is costly and therefore informative; firms with superior underlying quality disclose more to credibly distinguish themselves from lower-quality peers (Verrecchia, 1983; Dye, 1985). In contrast, legitimacy theory views disclosure as a strategic response to external scrutiny, whereby firms facing legitimacy threats increase disclosure to preserve social acceptance rather than to signal superior performance (Shocker and Sethi, 1973; O'Donovan, 2002; Clarkson *et al.*, 2008). Empirical evidence supports both perspectives, but results remain mixed, suggesting that disclosure incentives are context dependent. A key distinction between the two theories lies in their underlying assumptions about the relation between disclosure and firm quality. Signaling theory predicts a positive association, whereby higher-quality firms disclose more to separate themselves from lower-quality peers. In contrast, legitimacy theory does not require such alignment and may even predict a negative or non-monotonic relation, as firms with weaker underlying performance have stronger incentives to disclose to manage external perceptions. Thus, while both theories can explain increased disclosure, they imply fundamentally different interpretations of the same empirical pattern.

This paper argues that the corporate life cycle provides a systematic context through which these competing disclosure motives can be reconciled. The firm life cycle reflects more than a descriptive classification of development stages. It captures persistent differences in resource endowments, organizational capabilities, strategic priorities, and stakeholder relationships (Penrose, 1995; Helfat and Peteraf, 2003; Dickinson, 2011). These differences shape not only firms' sustainability performance, but also their ability and incentives to disclose sustainability-related information. Firms at different life-cycle stages face distinct constraints in financing sustainability initiatives, measuring and verifying outcomes, and bearing the proprietary and litigation costs associated with disclosure (Clarkson *et al.*, 2011; Hasan and Habib, 2017).

From a signaling perspective, firms with stronger sustainability performance, typically more mature firms with accumulated resources and organizational slack, have incentives to disclose sustainability information to reduce information asymmetry and convert performance advantages into market value (Verrecchia, 1983; Clarkson *et al.*, 2008). From a legitimacy perspective, firms with weaker sustainability performance, often those in non-mature or transitional stages, may rely more heavily on disclosure to manage stakeholder perceptions and mitigate legitimacy concerns (O'Donovan, 2002; Beddewela and Fairbrass, 2016). Importantly, these incentives need not be mutually exclusive, and their relative importance may vary systematically across the life cycle.

We examine sustainability disclosure embedded in annual 10-K filings, rather than stand-alone CSR or sustainability reports. This choice offers several advantages. First, 10-K filings are subject to SEC oversight and legal liability, which constrains opportunistic or purely symbolic disclosure (Cannon *et al.*, 2019). Second, 10-Ks follow a highly standardized format, enhancing comparability across firms and reducing discretion in presentation. Third, sustainability-related content in 10-K filings reflects issues that managers consider financially material to investors, rather than aspirational narratives aimed primarily at reputational audiences. Prior studies show that sustainability disclosure in mandatory filings differs systematically from voluntary CSR reporting in both tone and content (Cannon *et al.*, 2019), making the 10-K setting particularly suitable for examining strategic disclosure behavior.

The core empirical question of this study is therefore straightforward: does sustainability disclosure vary across the corporate life cycle, and if so, which disclosure theory better explains the observed pattern? Importantly, we do not treat the answer as binary. Instead, our evidence suggests a structured reconciliation. When firm maturity is proxied using retained

earnings measures (DeAngelo *et al.*, 2006), sustainability disclosure increases with maturity in broad specifications, consistent with signaling theory. However, when attention shifts to alternative life-cycle classifications and adjacent stage comparisons, particularly around the growth–maturity boundary, disclosure differences attenuate or reverse. Firms in growth stages often disclose at levels comparable to, or exceeding, those of mature firms, despite exhibiting weaker sustainability performance. This pattern is consistent with legitimacy-driven disclosure incentives aimed at securing stakeholder support during periods of strategic expansion (Jawahar and McLaughlin, 2001; Hasan and Habib, 2017). These findings suggest that sustainability disclosure does not carry a uniform strategic meaning across firms. Rather, the same disclosure practice may function as a quality signal for some firms and as a legitimacy device for others, depending on where the firm is situated in its life cycle. The contribution of this paper is therefore not to adjudicate between signaling and legitimacy theories, but to show how each operates within different segments of the life-cycle distribution.

This study makes three contributions to the sustainability disclosure literature. First, it provides a novel life-cycle-based reconciliation of competing disclosure theories (signaling and legitimacy), demonstrating that signaling describes the average relationship between maturity and disclosure, while legitimacy explains local deviations around the growth–maturity boundary. This integration of life-cycle theory with sustainability disclosure in mandatory filings represents a dynamic perspective previously underexplored in the literature. Second, it extends the sustainability disclosure literature by focusing on 10-K filings, where disclosure is costlier and more constrained than in voluntary sustainability reporting. Third, it highlights the importance of life-cycle measurement: alternative proxies capture different dimensions of maturity and lead to distinct theoretical interpretations of disclosure behavior. Practically, our findings highlight that sustainability disclosure is not uniformly informative: its interpretation depends critically on firms' life-cycle stages, with identical disclosure intensity potentially signaling underlying strength or legitimacy-seeking behavior.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on sustainability performance, disclosure theories, and firm life cycle, and develops the hypotheses. Section 3 describes the data, variable measurement, and empirical design. Section 4 presents the main empirical results and robustness tests. Section 5 concludes with implications and directions for future research.

2. Literature review and hypotheses development

2.1 Literature on sustainability disclosure

The literature on sustainability disclosure has evolved into several distinct strands, reflecting the growing strategic importance of non-financial information in global markets. The first strand focuses on the determinants and consequences of sustainability disclosure, emphasizing its role in addressing the escalating demands from both product and capital markets. On the one hand, as stakeholders increasingly prioritize social and environmental impacts, disclosure has become a critical tool for building consumer trust and brand reputation (Mckinsey, 2023); firms with higher disclosure levels often experience stronger consumer engagement and reduced reputational risks (Ioannou and Serafeim, 2012; Kim and Lyon, 2015; Leonelli *et al.*, 2025). On the other hand, capital market participants increasingly view sustainability transparency as an indicator of long-term resilience and strategic foresight. Consequently, high-quality sustainability disclosures are associated with significant capital market benefits, including a lower cost of capital (Dhaliwal *et al.*, 2011, 2014; You *et al.*, 2024), improved valuations (Grewal *et al.*, 2020), and enhanced investor confidence (Naughton *et al.*, 2018). Notably, Hu *et al.* (2025) demonstrate that in emerging markets like China, sustainability reports possess potent signaling power that directly shapes investment decisions.

The second strand examines the relationship between actual sustainability performance and disclosure quality, yielding mixed empirical results. While signaling theory suggests a positive association where superior performers disclose more to distinguish themselves

(Clarkson *et al.*, 2008; Herbohn *et al.*, 2014), other studies document weak or negative links. This suggests that some firms may employ disclosure as a symbolic tool for legitimacy management rather than substantive accountability (Clarkson *et al.*, 2008; Hummel and Schlick, 2016). This inconsistency leads to a “disclosure gap”, where despite increasing institutional pressure, a significant portion of firms still provide inadequate or fragmented information, resulting in persistent information asymmetry. A third strand highlights the role of institutional and contextual factors, such as the dichotomy between mandatory and voluntary disclosure regimes (Kalkanci and Plambeck, 2020). Within this context, Eccles *et al.* (2014) find that “high-sustainability” firms differ fundamentally from their peers by developing superior organizational processes for measuring and reporting non-financial data, which ultimately translates into stronger long-term financial performance.

Despite these insights, existing research often treats firms as homogeneous entities, overlooking how internal resource constraints and strategic priorities shift over time. While the literature underscores the general signaling potential of sustainability disclosure, it fails to fully explain why firms exhibit such heterogeneous disclosure behaviors under similar market pressures. Our study extends this literature by introducing firm life-cycle theory as a systematic contextual moderator to explain these variations.

2.2 Firm life cycle, sustainability performance, and the disclosure puzzle

How, then, does the firm life cycle explain variations in corporate sustainability disclosure? A growing body of literature suggests that sustainability performance varies systematically across the firm life cycle. Life-cycle theory and related organizational evolution work emphasize that firms’ resource endowments, strategic priorities, and operating constraints change predictably as they move from early-stage expansion to maturity and, eventually, decline (Miller and Friesen, 1984; Agarwal and Gort, 2002; Dickinson, 2011). Consistent with the resource-based view and its dynamic extensions, firms accumulate and reconfigure resources and capabilities over time, implying that later-stage firms are more likely to possess the organizational routines and managerial capabilities required to support sustained non-financial investments (Wernerfelt, 1984; Barney, 1991; Grant, 1991; Peteraf, 1993; Helfat and Peteraf, 2003; Adner and Helfat, 2003).

In the sustainability domain, prior evidence indicates that mature firms generally exhibit stronger sustainability performance than non-mature firms, reflecting accumulated financial slack, more stable cash flows, and more developed governance and reporting infrastructures (Hasan and Habib, 2017; Diebecker *et al.*, 2017; Al-Hadi *et al.*, 2017; Artiach *et al.*, 2010). For example, Hasan and Habib (2017) document that life-cycle position is associated with CSR engagement through organizational financial resources, while Diebecker *et al.* (2017) show that sustainability performance evolves over the life cycle and is strengthened by free cash flows in later stages. Related work further links life-cycle stages to financing frictions and the cost of equity, reinforcing the notion that resource constraints are stage dependent and economically consequential (Hasan *et al.*, 2015; Hasan and Cheung, 2018).

If sustainability performance were the sole driver of sustainability disclosure, these patterns would imply a monotonic increase in disclosure with maturity. Yet disclosure is not a mechanical reflection of underlying outcomes. Rather, disclosure is a strategic choice that trades off potential capital-market benefits against proprietary, litigation, and reputational costs, and this trade-off can vary by organizational context (Verrecchia, 1983; Dye, 1985). As a result, a central puzzle remains: when firms communicate sustainability information, are they primarily revealing strength or managing vulnerability?

2.3 Signaling versus legitimacy: competing predictions for sustainability disclosure

Two core theoretical lenses yield contrasting predictions.

Under signaling theory, credible disclosure is costly and therefore informative: higher-quality firms are more willing to disclose to separate from lower-quality peers when

information asymmetry is present (Spence, 1973; Verrecchia, 1983; Dye, 1985). Applied to sustainability, this logic predicts a positive relation between sustainability performance and sustainability disclosure. Firms with superior sustainability outcomes can convert these outcomes into stakeholder confidence and capital-market benefits via disclosure, particularly when disclosure can function as a meaningful signal of organizational quality and long-run value creation (Dhaliwal *et al.*, 2011; Grewal *et al.*, 2020; Lo and Sheu, 2007). The “signal” channel is also consistent with evidence that sustainability-related activities and reputation can affect external assessments such as credit ratings and broader stakeholder responses (Attig *et al.*, 2013; Fombrun and Shanley, 1990; Cowan and Guzman, 2020; Turban and Greening, 1997). In this view, weaker performers may strategically remain relatively silent to avoid drawing attention to deficiencies, allowing markets to pool them with average firms by default (Verrecchia, 1983).

In contrast, legitimacy and institutional perspectives emphasize that firms seek alignment with societal expectations and respond strategically when legitimacy is threatened (Shocker and Sethi, 1973; Campbell, 2007). When external scrutiny intensifies, firms may expand sustainability disclosure to manage perceptions and protect their “license to operate,” even if underlying performance is uneven (Beddewela and Fairbrass, 2016; DiMaggio *et al.*, 2000; Scott, 1995). This perspective is consistent with concerns that sustainability disclosure can include symbolic elements (e.g. greenwashing versus brownwashing), implying that disclosure may be used defensively rather than purely to reveal strength (Kim and Lyon, 2015). Importantly, the environmental disclosure literature also highlights that disclosure strategies can reflect cost–benefit considerations and stakeholder pressure rather than underlying performance alone (Cormier and Magnan, 1997, 1999; Hughes *et al.*, 2001; Clarkson *et al.*, 2008).

2.4 Why the life cycle matters for disclosure incentives

A life-cycle lens helps reconcile these competing predictions by recognizing that disclosure incentives evolve with resource constraints, strategic priorities, and stakeholder dependence across stages (Jawahar and McLaughlin, 2001; Dickinson, 2011; Sirmon *et al.*, 2010). Mature firms are typically characterized by accumulated organizational resources and more routinised control and reporting systems, which increase both the capacity to invest in sustainability initiatives and the ability to document outcomes credibly (Hasan and Habib, 2017; Clarkson *et al.*, 2011; Helfat and Peteraf, 2003). They may therefore be more likely to rely on disclosure as a signal, reinforcing differentiation and credibility with capital-market participants (Dhaliwal *et al.*, 2011; Grewal *et al.*, 2020; Clarkson *et al.*, 2011). Moreover, established firms often operate with more stable stakeholder relationships and reputational capital, reducing the need for purely defensive communication while increasing the benefits of value-relevant disclosure (Fombrun and Shanley, 1990; Freeman, 2010; Freeman *et al.*, 2007).

Growth-stage firms, however, occupy a more ambiguous position. While their sustainability performance may lag mature firms on average (Hasan and Habib, 2017; Diebecker *et al.*, 2017), growth firms are frequently more reliant on external finance and reputation building, and therefore may face heightened incentives to communicate sustainability initiatives proactively to strengthen stakeholder relationships during critical transition periods (Jawahar and McLaughlin, 2001; Hasan *et al.*, 2015). At the same time, organizational change and strategic expansion can increase scrutiny and legitimacy risk, making disclosure a plausible tool for managing perceptions, particularly when outcomes are still developing (Campbell, 2007; Beddewela and Fairbrass, 2016; Kim and Lyon, 2015). This framework implies that signaling and legitimacy need not be mutually exclusive: the average maturity–disclosure relationship may reflect signaling, while local contrasts, especially around the growth–maturity boundary, may reveal legitimacy-driven disclosure incentives.

2.5 Hypotheses development

Building on the above discussion, we develop two hypotheses that allow the data to adjudicate between these competing mechanisms. First, drawing on signaling theory and prior evidence that mature firms exhibit stronger sustainability performance, we expect sustainability disclosure to increase with firm maturity on average:

- H1. (Average signaling effect).** Firms at a mature life-cycle stage exhibit higher levels of sustainability disclosure in 10-K filings than firms at less mature stages.

Second, recognizing that growth-stage firms may face distinct legitimacy pressures and stronger incentives to manage stakeholder perceptions, we allow for local deviations from this average pattern:

- H2. (Local legitimacy effect).** In specific life-cycle contrasts, particularly between growth and mature firms, sustainability disclosure may not increase monotonically with maturity and may exhibit patterns consistent with legitimacy-driven disclosure.

Together, these hypotheses frame sustainability disclosure not as evidence for a single dominant theory, but as the outcome of shifting strategic incentives across the firm life cycle. This perspective allows signaling and legitimacy to coexist in a structured and empirically testable manner, rather than as mutually exclusive explanations.

3. Data, measures, and empirical design

3.1 Sample construction and data sources

Table 1 summarizes the sample selection procedure and the industry distribution of the final sample. The sample consists of US publicly listed firms for which financial data, sustainability performance measures, and textual disclosures from annual 10-K filings are jointly available from 2009 to 2019. Financial statement variables are obtained from standard Compustat sources. Sustainability performance is measured using firm-level ESG scores provided by Sustainalytics, which capture firms' exposure to and management of environmental, social, and governance risks. Sustainability disclosure measures are constructed from firm-level 10-K

Table 1. Industry composition for the study sample

Panel A: Data and sample		
Description	Total number of the observations	
Corporate sustainability performance sample	27,068	
Less		
Matching with SEC archives	(22,262)	
Final sample	4,806	
Panel B: Industrial distribution of the sample		
Industry	Count	%
Industrials	929	19.3%
Consumer discretionary	770	16.0%
Information technology	742	15.4%
Health care	560	11.7%
Energy	491	10.2%
Materials	405	8.4%
Real estate	364	7.6%
Consumer staples	351	7.3%
Communication services	195	4.0%
Total	4,806	100%

filings retrieved from the SEC's EDGAR database. The sample period spans multiple years, allowing the analysis to exploit both cross-sectional variation across firms and intertemporal variation within firms. We focus on firm-year observations with non-missing values for life-cycle proxies, sustainability performance scores, sustainability disclosure measures, and core financial controls. Observations from the financial and utilities sectors are excluded due to their distinct regulatory environment and reporting structure. Standard data-cleaning procedures are applied, including winsorization of continuous variables at conventional percentiles to mitigate the influence of extreme values.

Importantly, the analysis does not rely on voluntary stand-alone sustainability or CSR reports. Instead, it focuses exclusively on sustainability-related language embedded in mandatory 10-K filings. This design choice reflects the study's core objective: to observe sustainability disclosure in a setting where managerial statements are subject to legal liability, auditing processes, and reputational discipline, thereby sharpening inference about the economic meaning of disclosure.

3.2 Measuring sustainability disclosure

Sustainability disclosure is measured using textual analysis of 10-K filings. Following prior disclosure studies (Cannon *et al.*, 2019), we construct a dictionary-based measure that captures sustainability-related language across environmental, social, and governance dimensions, with the full list of keywords reported in Appendix. For each firm-year, we count the frequency of sustainability-related keywords appearing in the 10-K and scale this count by total word count to control for document length. The resulting measure reflects the intensity of sustainability-related disclosure within a firm's mandatory financial filing.

This approach has two advantages in the context of the present study. First, it allows for consistent measurement across firms and years within a highly standardized reporting format. Second, because 10-K filings are written primarily for capital market audiences, sustainability language in this setting is more likely to reflect deliberate communication choices rather than symbolic or purely promotional narratives. While dictionary-based methods do not capture tone or nuance, they are well suited for testing broad theoretical predictions about disclosure intensity across life-cycle stages.

3.3 Measuring firm life cycle

A central premise of the paper is that life-cycle measurement is not innocuous. Different proxies capture different aspects of organizational maturity, and these differences can shape empirical conclusions. Accordingly, we employ two widely used but conceptually distinct approaches to measuring firm life cycle.

3.3.1 Retained earnings-based maturity (RE/TA). Following DeAngelo *et al.* (2006), we use the ratio of retained earnings to total assets (RE/TA) as a continuous proxy for firm maturity. Higher values indicate a greater reliance on internally generated capital and, by extension, a more mature operating and financing structure. This measure is particularly suitable for testing signaling-based predictions because it maps smoothly onto a gradient of internal resource accumulation. Firms with higher RE/TA are, on average, less dependent on external financing and better positioned to sustain long-term investments, including investments in sustainability systems and reporting infrastructure. In the empirical analysis, RE/TA serves as the primary life-cycle proxy in baseline specifications. Its continuous nature facilitates interpretation of average disclosure patterns across the life-cycle spectrum.

3.3.2 Cash-flow pattern classification. As a complementary approach, we also classify firms into discrete life-cycle stages using the sign patterns of operating, investing, and financing cash flows, following Dickinson (2011). This method assigns firm-years to categories such as growth, maturity, and decline based on observable financing and investment behavior. While widely adopted in the literature, this classification captures a different conceptual dimension of life cycle. It emphasizes cash-flow dynamics and financing needs rather than accumulated resources. As a result, firms near stage boundaries, particularly between growth and maturity,

may shift categories even when underlying capabilities evolve more gradually. We exploit this feature rather than treat it as a weakness. If sustainability disclosure reflects strategic responses to changing external pressures, rather than purely accumulated capacity, differences across discrete stages may reveal patterns that are obscured in continuous maturity measures.

3.4 Empirical specification

The baseline empirical model relates sustainability disclosure intensity to firm life cycle and control variables:

$$\begin{aligned}
 ESG_disc_{i,t} = & \beta_0 + \beta_1 Lc_{i,t} + \beta_2 ESG_score_{i,t} + \beta_3 Size_{i,t} + \beta_4 Roa_{i,t} + \beta_5 Lev_{i,t} + \beta_6 Age_{i,t} \\
 & + \beta_7 Pbv_{i,t} + \beta_8 Rd_{i,t} + \beta_9 Gmi_{i,t} + IndustryFE + YearFE + \varepsilon_{i,t}
 \end{aligned}
 \tag{1}$$

The dependent variable, $ESG_disc_{i,t}$, measures the intensity of sustainability-related disclosure embedded in firm i 's annual 10-K filing in year t . Our key explanatory variable, $Lc_{i,t}$, captures firm life-cycle position and is constructed using alternative proxies following [DeAngelo et al. \(2006\)](#) and [Dickinson \(2011\)](#). The coefficient of interest, β_1 , reflects whether sustainability disclosure systematically varies with life-cycle stage.

Following prior research regarding corporate lifecycle and corporate sustainability disclosure ([Hasan and Habib, 2017](#); [Cannon et al., 2019](#)), We include firm-level sustainability performance ($ESG_score_{i,t}$) to disentangle disclosure behavior from underlying sustainability outcomes and to mitigate concerns that disclosure merely reflects performance differences. Additional control variables capture firm size, profitability, leverage, firm age, growth opportunities, R&D intensity, and margin characteristics, consistent with prior disclosure and sustainability literature. Detailed definitions and measurement methods for all primary variables are presented in Appendix [Table A1](#). All regressions include industry and year fixed effects to account for time-invariant industry characteristics and common temporal shocks. Standard errors are clustered at the firm level unless otherwise stated.

This baseline specification allows us to assess whether sustainability disclosure varies with firm maturity on average, while holding constant observable firm characteristics and sustainability performance. Subsequent analyses exploit alternative life-cycle definitions, matched samples, and robustness checks to explore whether the disclosure–life-cycle relation exhibits heterogeneity across specific stage contrasts.

4. Main empirical results

4.1 Descriptive statistics and correlation matrix

Panel A of [Table 2](#) reports descriptive statistics for the 4,806 firm-year observations included in the final sample. The mean value of sustainability disclosure intensity ($ESG_disc_{i,t}$) is 3.027, indicating that, on average, firms include approximately 3.0 sustainability-related keywords per 10,000 words in their annual 10-K filings. The relatively large standard deviation of 3.764 suggests substantial cross-sectional variation in sustainability disclosure practices across firms. The distribution is highly dispersed, with some firms reporting no sustainability-related language in their filings, while others report up to 21.058 keywords per 10,000 words, highlighting pronounced heterogeneity in disclosure behavior. The summary statistics for the remaining variables are broadly consistent with the characteristics of firms across different life-cycle stages documented in earlier analyses based on the full sample. As the sample in this chapter is restricted to US-listed firms with available 10-K filings, average firm size, profitability (ROA), and competition-related measures are modestly higher than those observed in the broader global sample, reflecting the relatively mature institutional and capital market environment of the United States.

Table 2. Descriptive statistics

Panel A: Descriptive statistics							
Variables	Mean	Std	Min	25%	50%	75%	Max
ESG_disc	3.027	3.674	0.000	0.694	1.754	3.994	21.058
Lc (RE/TA)	0.280	0.392	−1.218	0.048	0.294	0.497	1.354
Lc (Maturity)	0.883	0.321	0.000	1.000	1.000	1.000	1.000
Size	16441.571	29009.398	594.310	3175.898	6328.137	15468.263	184555.550
Roa	6.315	5.189	−10.252	3.178	5.734	8.896	22.801
Lev	1.078	1.719	0.000	0.305	0.623	1.137	12.832
Age	63.866	46.765	3.000	26.000	48.000	98.000	202.850
Pbv	4.269	4.885	0.000	1.751	2.884	4.782	33.811
Rd	0.022	0.043	0.000	0.000	0.000	0.024	0.208
Gm	0.451	0.227	0.037	0.272	0.422	0.623	0.990
ESG_score	56.002	8,756	33.000	49.000	55.000	62.000	90.570

Panel B: Descriptive statistics of sustainability disclosure levels on 5 stages							
Stages	Min	25%	Medium	75%	Max	Mean	No.
Introduction	0.000	0.718	1.673	3.678	18.541	3.172	89
Growth	0.000	1.059	2.339	4.771	21.257	3.535	1,199
Mature	0.000	0.682	1.864	4.072	21.257	3.178	3047
Shake-out	0.000	0.851	1.693	3.489	18.656	2.664	411
Decline	0.000	0.959	1.874	3.327	14.946	2.553	60

Note(s): Variable definitions are in the [Appendix](#)

Panel B of [Table 2](#) presents average sustainability disclosure intensity across the five life-cycle stages. Two descriptive patterns are noteworthy. First, firms in the growth and maturity stages exhibit higher average levels of sustainability disclosure than firms in other stages. Second, growth-stage firms display, on average, slightly higher disclosure intensity than mature firms. While these descriptive differences are not intended to establish causal relationships, they provide preliminary evidence that sustainability disclosure does not increase monotonically with firm maturity. This non-monotonic pattern motivates the subsequent multivariate analyses, which examine whether the observed differences are robust to controls and whether they align more closely with signaling or legitimacy-based interpretations of disclosure behavior.

[Table 3](#) reports the Pearson correlation matrix for the 4,806 firm-year observations included in the analysis. Sustainability disclosure intensity ($ESG_disc_{i,t}$) is positively and significantly correlated with the retained earnings-to-total assets ratio (RE/TA), suggesting that firms with higher accumulated internal resources tend to exhibit higher levels of sustainability-related disclosure. By contrast, the simple correlation between $ESG_disc_{i,t}$ and the maturity indicator based on the [Dickinson \(2011\)](#) classification is not statistically significant. The correlation between RE/TA and the maturity indicator is positive and significant, indicating that the two life-cycle proxies capture related but not identical dimensions of firm development. This pattern is consistent with prior studies that emphasize differences in how alternative life-cycle measures reflect firm maturity and financial viability.

Importantly, except for the correlation between firm size (Size) and R&D intensity (Rd), all pairwise correlation coefficients are below 0.5, suggesting that multicollinearity is unlikely to pose a serious concern for the multivariate analyses. These results indicate that the explanatory variables exhibit sufficient independent variation to support subsequent regression analysis.

4.2 Baseline results: firm life cycle and sustainability disclosure

[Table 4](#) presents baseline regressions examining the association between firm life cycle, sustainability performance, and sustainability disclosure using two alternative life-cycle

Table 3. Pearson correlation matrix

	ESG_disc	Size	Roa	Lev	Age	Pbv	Rd	Gm	ESG_score	Lc (RE/TA)	Lc (Maturity)
<i>ESG_disc</i>	1.000										
<i>Size</i>	−0.055***	1.000									
<i>Roa</i>	−0.076***	−0.024	1.000								
<i>Lev</i>	−0.011	−0.003	−0.023	1.000							
<i>Age</i>	0.055***	0.161***	0.078***	−0.003	1.000						
<i>Pbv</i>	−0.099***	−0.028	0.299***	0.062***	0.020	1.000					
<i>Rd</i>	−0.114***	0.550***	0.078***	−0.005	0.007	0.084***	1.000				
<i>Gm</i>	−0.174***	0.018	0.086***	−0.004	−0.260***	0.112***	0.163***	1.000			
<i>ESG_score</i>	0.022	0.298***	0.044**	−0.002	0.208***	−0.009	0.250***	−0.081***	1.000		
<i>Lc (RE/TA)</i>	0.048**	0.047**	0.497***	−0.028	0.278***	0.013	0.033*	−0.099***	0.156***	1.000	
<i>Lc (Maturity)</i>	−0.012	0.017	0.292***	−0.024	0.105***	0.050***	0.043**	−0.069***	0.085***	0.243***	1.000

Note(s): Variable definitions are in the [Appendix](#). Robust *t*-statistics in brackets

*, **, *** represent significance levels at 10%, 5%, and 1%, respectively

Table 4. Results for firm lifecycle and sustainability disclosure

Variables	DeAngelo <i>et al.</i> (2006) (I) ESG_score	DeAngelo <i>et al.</i> (2006) (II) ESG_disc	Dickinson (2011) (III) ESG_score	Dickinson (2011) (IV) ESG_disc
Intercept	40.772*** [49.045]	0.814** [2.483]	39.965*** [47.223]	0.689** [2.051]
Lc	2.9726*** [8.501]	0.589*** [3.297]	0.929*** [3.859]	0.162 [1.154]
ESG_score	—	0.010** [2.194]	—	0.012*** [2.605]
Size	0.000** [20.623]	−0.000** [−2.496]	0.000*** [20.790]	−0.000** [−2.503]
Roa	0.046* [1.686]	−0.029*** [−3.449]	0.126*** [4.915]	−0.022*** [−2.764]
Lev	0.525*** [6.821]	−0.038 [−1.586]	0.430*** [5.625]	−0.046*** [−1.975]
Age	0.027*** [9.838]	−0.004*** [−5.199]	0.031*** [11.658]	−0.004*** [−4.821]
Pbv	−0.165*** [−5.761]	−0.005 [−0.509]	−0.175*** [−6.075]	−0.006 [−0.649]
Rd	31.590*** [8.758]	−6.110*** [−5.473]	29.660*** [8.184]	−6.572*** [−5.931]
Gm	−4.401*** [−7.022]	−0.294 [−1.328]	−4.267*** [−6.761]	−0.280 [−1.261]
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	4,806	4,806	4,806	4,806
Adjusted R ²	0.261	0.184	0.252	0.182

Note(s): Variable definitions are in the [Appendix](#). Robust *t*-statistics in brackets
*, **, *** represent significance levels at 10%, 5%, and 1%, respectively

measures: retained earnings to total assets (DeAngelo *et al.*, 2006) and cash flow patterns (Dickinson, 2011). Columns (I) and (III) focus on sustainability performance, while columns (II) and (IV) examine sustainability disclosure.

Consistent with prior research (Hasan and Habib, 2017; Diebecker *et al.*, 2017), firm maturity is positively and significantly associated with sustainability performance across both classifications. In columns (I) and (III), the coefficient on Lc is positive at the 1% level, indicating that mature firms systematically exhibit stronger sustainability outcomes regardless of whether life cycle is proxied by accumulated retained earnings or cash flow profiles. This consistency suggests that the link between firm maturity and sustainability performance reflects underlying structural advantages rather than measurement artefacts.

The disclosure results are more nuanced. When life cycle is measured using RE/TA, column (II) shows a positive and significant association between maturity and sustainability disclosure, consistent with disclosure functioning as a signal of underlying sustainability strength. In contrast, when life cycle is classified using cash flow patterns, the coefficient on Lc in column (IV) becomes statistically insignificant, despite the continued strong association between maturity and sustainability performance in column (III). This divergence indicates that superior sustainability performance does not uniformly translate into higher disclosure intensity, particularly around stages where firms may be transitioning between growth and maturity.

The behavior of control variables in the disclosure regressions further supports this interpretation. Firm size is negatively associated with disclosure intensity in both columns (II) and (IV), suggesting that sustainability language in 10-K filings does not simply scale with organizational size. Profitability (ROA) and leverage exhibit negative coefficients, indicating that firms under weaker financial conditions tend to disclose more extensively, consistent with disclosure being used strategically rather than purely reflectively. R&D intensity is also negatively associated with disclosure, implying that innovative firms may prioritize substantive investment over communicative emphasis. These patterns reinforce the view that sustainability disclosure responds to incentive structures and strategic considerations beyond underlying performance alone.

Taken together, Table 4 establishes two stylized facts that motivate the subsequent analyses. First, mature firms consistently outperform non-mature firms in sustainability performance, in line with existing literature. Second, the relationship between maturity and sustainability disclosure is conditional on how life-cycle stages are defined, suggesting that disclosure may reflect signaling on average but legitimacy-driven incentives in specific stage comparisons. The sensitivity analyses therefore explore these local contrasts in greater detail.

4.3 Additional analyses and sensitivity tests

Table 5 reports the transition matrix of firms across lifecycle stages based on the Dickinson (2011) classification. A salient feature of the matrix is the pronounced mobility between the growth and maturity stages. Transitions from growth to maturity and from maturity back to growth are substantially more frequent than transitions involving other stages, such as introduction, shake-out, or decline. This pattern highlights that the boundary between growth and maturity is highly dynamic rather than static, and that firms around this boundary are more likely to experience strategic and operational reconfiguration. Such dynamics motivate a closer examination of disclosure behavior in this local region of the life cycle, where incentives and constraints may differ from those implied by a monotonic stage ordering.

4.3.1 *Local evidence consistent with legitimacy-driven disclosure.* Table 6 presents sensitivity analyses that explicitly exploit this dynamic. Column (I) focuses on sustainability

Table 5. Transition matrix between lifecycles stages

	Introduction	Growth	Maturity	Shake-out	Decline
Introduction	22	16	18	6	11
Growth	13	405	514	49	5
Maturity	11	543	1,854	183	7
Shake-out	5	78	194	71	9
Decline	12	8	10	5	11

Table 6. Results for the sensitivity analysis

Variables	Dickinson (2011) – G (I) ESG_score	Dickinson (2011) – G (II) ESG_disc	Dickinson (2011) – M&G (III) ESG_disc
Intercept	40.766*** [48.725]	0.856*** [2.753]	0.701** [2.183]
Lc	–1.310*** [–4.995]	0.153* [1.919]	0.267** [2.488]
ESG_score	–	0.012*** [2.696]	0.011*** [2.602]
Size	0.000*** [20.777]	–0.000** [–2.390]	–0.000** [–2.401]
Roa	0.135*** [5.377]	–0.018** [–2.356]	–0.024*** [–3.039]
Lev	0.434*** [5.684]	–0.045* [–1.914]	–0.042* [–1.797]
Age	0.031*** [11.547]	–0.004*** [–4.744]	–0.004*** [–4.859]
Pbv	–0.176*** [–6.118]	–0.007 [–0.832]	–0.007 [–0.781]
Rd	28.736*** [7.921]	–6.432*** [–5.799]	–6.395*** [–5.767]
Gm	–4.111*** [–6.505]	–0.441** [–2.286]	–0.435** [–2.259]
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,806	4,806	4,806
Adjusted R ²	0.183	0.183	0.183

Note(s): Variable definitions are in the Appendix. Robust *t*-statistics in brackets
*, **, *** represent significance levels at 10%, 5%, and 1%, respectively

performance. The coefficient on *Lc* is negative and statistically significant, indicating that firms classified as being in the growth stage exhibit lower sustainability performance relative to firms in other stages. This result is consistent with the notion that growth-stage firms face tighter resource constraints and have not yet accumulated the organizational capabilities required to deliver strong sustainability outcomes.

Column (II) shifts attention to sustainability disclosure. In contrast to the performance result, the coefficient on *Lc* becomes positive and marginally significant. This suggests that growth-stage firms, despite weaker sustainability performance, engage in relatively higher levels of sustainability disclosure compared to firms in other lifecycle stages. This divergence between performance and disclosure is consistent with a legitimacy-based interpretation, whereby growth-stage firms use disclosure strategically to manage stakeholder perceptions, strengthen external relationships, and secure continued access to resources during a critical transition phase.

4.3.2 Reinforcement of the average signaling pattern. In column (III) of [Table 6](#), growth and maturity firms are combined into a single reference group and compared against firms in the remaining lifecycle stages. The results show that this combined group exhibits significantly higher levels of sustainability disclosure. This finding indicates that firms located in the central phases of the lifecycle, where organizational scale, visibility, and stakeholder scrutiny are greatest, tend to disclose more extensively than firms in peripheral stages such as introduction or decline. Importantly, when viewed in conjunction with the transition patterns documented in [Table 5](#), this result suggests that the [Dickinson \(2011\)](#) classification captures a broader signaling structure at the aggregate level, even though local deviations arise around the growth–maturity boundary.

Taken together, the sensitivity analyses reinforce the paper’s central argument. On average, sustainability disclosure patterns are broadly consistent with signaling theory, particularly when firms are grouped according to their position within the core lifecycle stages. However, when attention is restricted to the highly dynamic transition between growth and maturity, disclosure behavior departs from underlying performance in a manner consistent with legitimacy-driven communication. These findings indicate that signaling and legitimacy are not competing explanations applied uniformly across the lifecycle, but rather operate at different levels of aggregation and in different strategic contexts. Therefore, in the practical use of corporate sustainability disclosures, it is important to consider the heterogeneity in disclosure incentives across firms at different stages of the life cycle.

4.4 Robustness tests

4.4.1 Alternative life-cycle proxies. As a first robustness check, we employ alternative proxies for firm life cycle based on retained earnings (*RE/TA*) and cash-flow patterns ([DeAngelo et al., 2006](#); [Dickinson, 2011](#)). Across both proxies, the results for sustainability performance are highly consistent with prior evidence: mature firms exhibit significantly stronger sustainability performance, in line with [Hasan and Habib \(2017\)](#) and [Diebecker et al. \(2017\)](#). This confirms that the life-cycle–performance relation is robust to alternative classifications. When turning to sustainability disclosure, the two proxies reveal distinct but complementary patterns. Using the *RE/TA* measure, firm maturity is positively and significantly associated with sustainability disclosure, consistent with signaling theory: firms with stronger sustainability performance disclose more to credibly communicate their quality to external stakeholders.

By contrast, the cash-flow-based classification provides finer stage-level insight. Growth-stage firms do not exhibit superior sustainability performance and, in some specifications, display weaker performance. Nevertheless, these firms engage in slightly higher levels of sustainability disclosure relative to other non-mature stages. This divergence between performance and disclosure is consistent with legitimacy theory, suggesting that growth-stage firms use disclosure strategically to build reputation and secure stakeholder support during a

critical transitional phase. Importantly, this local legitimacy pattern does not overturn the broader signaling interpretation. When firms in favorable life-cycle stages, namely growth and maturity, are grouped together, their disclosure levels remain significantly higher than those of firms in shake-out or decline stages. Overall, the alternative life-cycle proxies reinforce the study's central conclusion: signaling theory characterizes the average disclosure pattern across the life cycle, while legitimacy theory explains stage-specific deviations, particularly during the growth phase.

4.4.2 HC3 standard errors. To address concerns about potential heteroskedasticity, we re-estimate the disclosure regressions using HC3 standard errors. The results, reported in [Table 7](#), remain highly consistent with the baseline findings and continue to support both [Hypothesis 1](#) and [Hypothesis 2](#).

In Column (I), using the RE/TA-based life-cycle proxy of [DeAngelo et al. \(2006\)](#), firm maturity remains positively and significantly associated with sustainability disclosure under HC3 standard errors. This result further supports [Hypothesis 1](#), indicating that, on average, more mature firms engage in higher levels of sustainability disclosure, consistent with disclosure functioning as a signal of superior underlying sustainability capacity. Column (II) applies [Dickinson's \(2011\)](#) cash-flow-based classification and focuses on growth-stage firms. The coefficient on the growth-stage indicator remains positive and statistically significant, suggesting that growth firms disclose more sustainability information than firms in other life-cycle stages. Combined with earlier evidence that growth firms do not exhibit superior sustainability performance, this pattern provides additional support for [Hypothesis 2](#) and is consistent with a legitimacy-based interpretation of disclosure behavior in the growth stage. In Column (III), growth-stage and mature firms are grouped together to represent firms in relatively favorable life-cycle phases. The combined indicator remains significantly positive under HC3 standard errors, reinforcing [Hypothesis 1](#) at an aggregate level. Even when heteroskedasticity is accounted for, firms in “healthy” life-cycle stages disclose more sustainability information than firms in more constrained stages.

Overall, the HC3 results strengthen the paper's central conclusion: while sustainability disclosure exhibits an average pattern consistent with signaling theory, legitimacy considerations play a meaningful role in shaping disclosure behavior at specific life-cycle stages.

Table 7. Results for using HC3 standard errors

Variables	DeAngelo et al. (2006) (I) ESG_disc	Dickinson (2011) – G (II) ESG_disc	Dickinson (2011)– M&G (III) ESG_disc
Intercept	0.980*** [3.484]	0.856*** [2.753]	0.701*** [2.456]
Lc	0.221** [2.099]	0.153** [1.978]	0.267*** [2.980]
ESG_score	0.010** [2.364]	0.012*** [2.709]	0.011*** [2.625]
Size	–0.000*** [–3.437]	–0.000*** [–3.419]	–0.000*** [–3.418]
Roa	–0.027*** [–3.854]	–0.018** [–2.757]	–0.023*** [–3.551]
Lev	–0.034* [–1.835]	–0.045* [–2.456]	–0.042** [–2.301]
Age	–0.004*** [–5.101]	–0.004*** [–4.645]	–0.004*** [–4.772]
Pbv	–0.007 [–0.810]	–0.007 [–0.902]	–0.007 [–0.849]
Rd	–6.401*** [–7.851]	–6.432*** [–7.871]	–6.396*** [–7.776]
Gm	–0.419*** [–2.560]	–0.441*** [–2.696]	–0.434*** [–2.664]
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,806	4,806	4,806
Adjusted R ²	0.183	0.183	0.183

Note(s): Variable definitions are in the [Appendix](#). Robust *t*-statistics in brackets

*, **, *** represent significance levels at 10%, 5%, and 1%, respectively

4.4.3 *Propensity score matching.* Propensity score matching (PSM) is employed to further examine whether the coexistence of signaling, and legitimacy interpretations persists when firms are compared on a more balanced basis. By matching firms on observable characteristics, including size, profitability, leverage, age, growth opportunities, R&D intensity, governance-related controls, and sustainability performance, we reduce concerns that the baseline results are driven by systematic differences in firm fundamentals rather than life-cycle positioning.

Column (I) of Table 8 reports PSM results based on the DeAngelo *et al.* (2006) life-cycle proxy. Consistent with the baseline findings, firm maturity remains positively and significantly associated with sustainability disclosure intensity after matching. This result suggests that mature firms continue to disclose more sustainability-related information even when compared with otherwise similar firms, reinforcing Hypothesis 1 and supporting an average signaling interpretation in which disclosure reflects stronger underlying sustainability capability.

Columns (II) and (III) present results based on the Dickinson (2011) cash-flow classification. In Column (II), growth-stage firms exhibit a modest but statistically significant increase in sustainability disclosure relative to other life-cycle stages, despite no corresponding advantage in sustainability performance. This pattern is consistent with Hypothesis 2 and aligns with a local legitimacy interpretation, whereby growth firms, facing heightened financing needs and reputational pressures, appear more inclined to use disclosure strategically to secure stakeholder support.

Importantly, Column (III) shows that when growth and maturity stages are combined to capture broadly viable life-cycle phases, disclosure intensity remains significantly higher than in contractionary stages. This finding indicates that, at a more aggregated level, sustainability disclosure continues to track life-cycle strength, thereby reaffirming the overall signaling interpretation. Taken together, the PSM results demonstrate that the empirical tension between signaling and legitimacy is not an artifact of observable firm differences but reflects a systematic life-cycle structure: signaling dominates on average, while legitimacy emerges in specific local contrasts, particularly around the growth–maturity boundary.

Table 8. Results for propensity score matching

	DeAngelo <i>et al.</i> (2006) (I) ESG_disc	Dickinson (2011) – G (II) ESG_disc	Dickinson (2011) – M&G (III) ESG_disc
Intercept	1.2143*** [3.721]	1.673*** [7.869]	0.406 [1.010]
Lc	0.297*** [4.497]	0.093** [1.965]	0.258*** [2.735]
ESG_socre	–0.001 [–0.202]	0.003 [0.957]	0.005 [0.889]
Size	–0.000*** [–2.728]	–0.000*** [–4.792]	–0.000*** [–2.770]
Roa	–0.051*** [–6.304]	–0.003 [–0.587]	–0.007 [–0.704]
Lev	0.004 [0.125]	–0.058*** [–3.642]	–0.052** [–2.026]
Age	–0.003*** [–4.210]	–0.006*** [–10.166]	0.001 [0.644]
Pbv	–0.011 [–1.063]	–0.028*** [–4.532]	0.006 [0.553]
Rd	–5.065*** [–4.276]	–7.395*** [–9.529]	–3.813*** [–3.146]
Gm	–0.067 [–0.338]	–0.717*** [–5.514]	–0.557** [–2.321]
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Adjusted R ²	0.183	0.218	0.193

Note(s): Variable definitions are in the Appendix. Robust *t*-statistics in brackets
*, **, *** represent significance levels at 10%, 5%, and 1%, respectively

5. Conclusion

This study examines how firm life-cycle stages shape sustainability disclosure behavior, with particular attention to the competing roles of signaling and legitimacy. Using US listed firms and sustainability-related language embedded in mandatory 10-K filings, we document a robust positive association between firm maturity and sustainability disclosure intensity. Across alternative life-cycle proxies, firms at more advanced stages of development tend to disclose more sustainability information, consistent with signaling theory: firms with stronger sustainability performance and organizational capacity use disclosure to credibly convey their underlying quality to stakeholders.

Importantly, our results reveal substantial heterogeneity across life-cycle stages that cannot be captured by a single disclosure logic. While mature firms' disclosure behavior aligns closely with signaling incentives, growth-stage firms exhibit relatively higher sustainability disclosure despite weaker sustainability performance. This pattern suggests that sustainability disclosure among growth firms is more consistent with legitimacy-seeking motives, reflecting their heightened need to build reputation, strengthen stakeholder relationships, and secure external resources during a critical transition phase. Sensitivity analyses based on cash-flow life-cycle classifications further reinforce this interpretation, indicating that legitimacy theory operates locally within specific life-cycle contrasts, whereas signaling theory dominates in the aggregate.

These findings remain robust across a comprehensive set of robustness tests designed to address potential measurement, selection, and estimation concerns. First, we employ alternative life-cycle proxies, including the retained earnings to total assets (RE/TA) measure and the cash-flow pattern approach. The results are consistent across both specifications, suggesting that the observed average signaling effect is not driven by the choice of proxy and is robust to different operationalizations of firm life cycle. Second, we adopt heteroskedasticity-consistent (HC3) standard errors to account for potential heteroskedasticity in the error terms. The statistical significance of the main coefficients remains unchanged, indicating that our inferences are not sensitive to heteroskedasticity concerns. Third, we implement propensity score matching (PSM) to mitigate potential selection bias arising from systematic differences between firms at different life-cycle stages. The matched-sample analysis yields qualitatively similar results, reinforcing the generalizability of our findings. Collectively, the evidence suggests that sustainability disclosure is shaped by a dynamic interaction between firm development and disclosure incentives.

This study makes three important contributions to the sustainability disclosure literature. First, and most notably, it integrates firm life-cycle theory with signaling and legitimacy theories to provide a dynamic reconciliation: signaling theory best describes the average maturity–disclosure relationship, whereas legitimacy theory explains meaningful local deviations, particularly during the growth stage. This life-cycle perspective offers a novel lens through which the mixed evidence on sustainability disclosure can be understood. Second, unlike most prior studies that rely on voluntary CSR or stand-alone ESG reports, we focus on sustainability-related language in mandatory 10-K filings, a setting characterized by higher legal liability and greater investor orientation. Third, we demonstrate the sensitivity of empirical inferences to life-cycle measurement choices, underscoring the importance of carefully selecting and interpreting alternative proxies.

Practically, the results suggest that sustainability disclosure in 10-K filings should be interpreted through a life-cycle lens. For investors, similar disclosure intensity may signal underlying quality in mature firms but reflect legitimacy-seeking in growth-stage firms, implying different valuation implications. For analysts, incorporating life-cycle information may improve the interpretation of disclosure signals and the accuracy of forecasts. For regulators, the findings suggest that uniform disclosure requirements may have heterogeneous effects across firms, highlighting the potential value of life-cycle-sensitive disclosure guidance.

Future research could extend this framework in several promising directions. For instance, it would be valuable to investigate whether life-cycle-driven disclosure patterns translate into differential capital-market outcomes, such as cost of capital, analyst forecast accuracy, or stock price informativeness. Researchers may also examine the generalizability of these findings in international settings with varying institutional pressures or explore how life-cycle stage moderates the market reaction to sustainability disclosures. Finally, combining textual analysis with alternative sustainability performance measures (e.g. actual environmental or social incidents) could further enrich our understanding of the disclosure–performance nexus across the corporate life cycle.

Acknowledgments

The author would like to thank Professor Kathleen Herbohn and Professor Peter Clarkson for their helpful comments and feedback on earlier versions of this manuscript. The author also extends gratitude to the Editor-in-Chief and the anonymous reviewers for their constructive comments.

Appendix

Table A1. Explanation of variables

Variable	Explanation
<i>Dependent variables</i>	
<i>ESG_score</i>	a sustainability performance measure, proxied by overall ESG rating given by Morningstar Sustainabilitycs
<i>ESG_disc</i>	a sustainability disclosure measure, proxied by the ratio of overall sustainability keywords to the total number of words in the 10-K report
<i>Independent variables</i>	
<i>Lc (RE/TA)</i>	a firm lifecycle measure, proxied by the ratio of retained earnings to total assets
<i>Lc (Maturity)</i>	a firm lifecycle measure, dummy variable, which equals to 1 if in mature stage, and 0 otherwise
<i>Lc (Growth)</i>	a firm lifecycle measure, dummy variable, which equals to 1 if in growth stage, and 0 otherwise
<i>Lc (Maturity&Growth)</i>	a firm lifecycle measure, dummy variable, which equals to 1 if in mature stage or growth stage, and 0 otherwise
<i>Size</i>	a firm size measure, proxied by total assets (millions of USD)
<i>Roa</i>	a profitability measure, proxied by return on assets
<i>Lev</i>	a leverage ratio measure, proxied by the ratio of total debt to total equity
<i>Age</i>	a firm age measure, proxied by years in existence
<i>Pbv</i>	a firm growth measure, proxied by price/book value ratio
<i>Rd</i>	an innovation intensity measure, proxied by the ratio of R&D expense to total assets
<i>Gm</i>	a profitability measure, proxied by gross profit margin

The sustainability keywords include:

Philanthropy (18): altruism, altruist, altruistic, charitable, charities, charity, community giving, corporate giving, corporate political activities, corporate political activity, employee volunteer effort, employee volunteer program, philanthropic, philanthropist, philanthropy, social campaign, social object, volunteerism.

Business Practice (155): age discrimination, alternative trade, animal ethics, atmospheric pollution, beneficial reuse, biodiversity, biological diversity, biomass energy, biomass fuel, biomimicry, bribery and corruption, business and society, business ethics, business in the community, carbon capture, carbon cost, carbon dioxide emission, carbon disclosure, carbon emission, carbon footprint, carpooling, cause

marketing, cause related marketing, CERES, climate change, climatic change, common good, community activism, conscious consumption, conservation, consumer activism, consumer protection, consumerism, contamination, deceptive advertising, declaration of human right, design for environment, discrimination, eco efficiency, ecological community, ecological economy, ecological footprint, ecology, energy from biomass, environmental accounting, environmental audit, environmental economics, environmental ethics, environmental impact analysis, environmental impact assessment, environmental law, environmental legislation, environmental management, environmental marketing, environmental performance, environmental protection agency, environmental risk, environmental rule, environmentalist, environmentally responsible, environs, ethical action, ethical business, ethical leadership, ethical policy, ethical sourcing, ethical trading initiative, ethics education, exploitation, fair trade, false advertising, forest stewardship council, free choice, free speech, freedom of expression, freedom of speech, friends of the earth, FTSE4good index, gender balance, gender equality, gender equity, global environmental, global warming, green business, green chemistry, green jobs, green marketing, greenhouse effect, greenhouse gas, greenwashing, hazardous, health and safety, health and social care, health value, human ecology, human right, illegal employment, inclusive business, Kyoto protocol, living wage, local community, marketing ethics, microlending, minimum wage, nondiscrimination, offshoring, ozone layer, pollution, poverty, preservation, racism, recycling, renewable energies, renewable energy, resource efficiency, responsible business, responsible consumption, responsible investment, responsible investor, responsible leadership, responsible management, responsible practice, responsible supply chain, ride sharing, rightsizing, social acceptance, social advertising, social auditing, social benefit, social collaboration, social contract, social control, social cost, social dialogue, social enterprise, social entrepreneur, social innovation, social investment, social justice, social movement, social promotion, social reporting, social risk, socially responsible, sustainable innovation, sustainable investment, sustainable leadership, sustainable marketing, sustainable site development, sustainable workplace, vanpooling, waste management, waste reclamation, work life balance, world commission on environment.

Product (18): clean technologies, clean technology, consumer product safety, dangerous product, eco design, eco-design, eco-innovation, green building, green design, green technologies, green technology, ISO14001, local food, locally grown, organic, regional food, sustainable design, sustainable production.

General (28): accountability 1,000, corporate accountability, corporate citizenship, corporate social and environmental responsibilities, corporate social and environmental responsibility, CSR, DJSI, Dow Jones Sustainability Index, global reporting initiative, good corporate practice, integrated reporting, ISO 26000, responsible care, social accountability, social responsibilities, social responsibility, socially sustainable, sustainability, sustainable business, sustainable firm, sustainable corporation, sustainable development, sustainable enterprise, sustainable organization, sustainable tourism, sustainable use of resource, triple bottom, World Business Council for Sustainable Development.

References

- Adner, R. and Helfat, C.E. (2003), "Corporate effects and dynamic managerial capabilities", *Strategic Management Journal*, Vol. 24 No. 10, pp. 1011-1025, doi: [10.1002/smj.331](https://doi.org/10.1002/smj.331).
- Agarwal, R. and Gort, M. (2002), "Firm and product life cycles and firm survival", *American Economic Review*, Vol. 92 No. 2, doi: [10.1257/000282802320189221](https://doi.org/10.1257/000282802320189221).
- Al-Hadi, A., Chatterjee, B., Yafthian, A., Taylor, G. and Monzur Hasan, M. (2017), "Corporate social responsibility performance, financial distress and firm life cycle: evidence from Australia", *Accounting and Finance*, Vol. 59 No. 2, pp. 961-989, doi: [10.1111/acfi.12277](https://doi.org/10.1111/acfi.12277).
- Artiach, T., Lee, D., Nelson, D. and Walker, J. (2010), "The determinants of corporate sustainability performance", *Accounting and Finance*, Vol. 50 No. 1, pp. 31-51, doi: [10.1111/j.1467-629x.2009.00315.x](https://doi.org/10.1111/j.1467-629x.2009.00315.x).
- Attig, N., El Ghouli, S., Guedhami, O. and Suh, J. (2013), "Corporate social responsibility and credit ratings", *Journal of Business Ethics*, Vol. 117 No. 4, pp. 679-694, doi: [10.1007/s10551-013-1714-2](https://doi.org/10.1007/s10551-013-1714-2).
- Barney, J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17 No. 1, pp. 99-120, doi: [10.1177/014920639101700108](https://doi.org/10.1177/014920639101700108).
- Beddewela, E. and Fairbrass, J. (2016), "Seeking legitimacy through CSR: institutional pressures. And corporate responses of multinationals in Sri Lanka", *Journal of Business Ethics*, Vol. 136 No. 3, pp. 503-522, doi: [10.1007/s10551-014-2478-z](https://doi.org/10.1007/s10551-014-2478-z), available at: <https://www.jstor.org/stable/24736145>

- Campbell, J.L. (2007), "Why would corporations behave in socially responsible ways? An institutional theory of corporate social responsibility", *Academy of Management Review*, Vol. 32 No. 3, pp. 946-967, doi: [10.2307/20159343](https://doi.org/10.2307/20159343).
- Cannon, J.N., Ling, Z., Wang, Q. and Watanabe, O.V. (2019), "10-K disclosure of corporate social. Responsibility and firms' competitive advantages", *European Accounting Review*, Vol. 29 No. 1, pp. 1-29, doi: [10.1080/09638180.2019.1670223](https://doi.org/10.1080/09638180.2019.1670223).
- Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. (2008), "Revisiting the relation between environmental performance and environmental disclosure: an empirical analysis", *Accounting, Organizations and Society*, Vol. 33 Nos 4-5, pp. 303-327, doi: [10.1016/j.aos.2007.05.003](https://doi.org/10.1016/j.aos.2007.05.003).
- Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. (2011), "Does it really pay to be green? Determinants and consequences of proactive environmental strategies", *Journal of Accounting and Public Policy*, Vol. 30 No. 2, pp. 122-144, doi: [10.1016/j.jaccpubpol.2010.09.013](https://doi.org/10.1016/j.jaccpubpol.2010.09.013).
- Cormier, D. and Magnan, M. (1997), "Investors' assessment of implicit environmental liabilities: an empirical investigation", *Journal of Accounting and Public Policy*, Vol. 16 No. 2, pp. 215-241, doi: [10.1016/s0278-4254\(97\)00002-1](https://doi.org/10.1016/s0278-4254(97)00002-1)
- Cormier, D. and Magnan, M. (1999), "Corporate environmental disclosure strategies: determinants, costs and benefits", *Journal of Accounting, Auditing and Finance*, Vol. 14 No. 4, pp. 429-451, doi: [10.1177/0148558x9901400403](https://doi.org/10.1177/0148558x9901400403).
- Cowan, K. and Guzman, F. (2020), "How CSR reputation, sustainability signals, and country-of-origin sustainability reputation contribute to corporate brand performance: an exploratory study", *Journal of Business Research*, Vol. 117 No. 1, pp. 683-693, doi: [10.1016/j.jbusres.2018.11.017](https://doi.org/10.1016/j.jbusres.2018.11.017).
- DeAngelo, H., DeAngelo, L. and Stulz, R. (2006), "Dividend policy and the earned/contributed. capital mix: a test of the life-cycle theory", *Journal of Financial Economics*, Vol. 81 No. 2, pp. 227-254, doi: [10.1016/j.jfineco.2005.07.005](https://doi.org/10.1016/j.jfineco.2005.07.005).
- Dhaliwal, D.S., Li, O.Z., Tsang, A. and Yang, Y.G. (2011), "Voluntary nonfinancial disclosure and the cost of equity capital: the initiation of corporate social responsibility reporting", *The Accounting Review*, Vol. 86 No. 1, pp. 59-100, doi: [10.2308/accr.00000005](https://doi.org/10.2308/accr.00000005).
- Dhaliwal, D., Li, O.Z., Tsang, A. and Yang, Y.G. (2014), "Corporate social responsibility disclosure. and the cost of equity capital: the roles of stakeholder orientation and financial transparency", *Journal of Accounting and Public Policy*, Vol. 33 No. 4, pp. 328-355, doi: [10.1016/j.jaccpubpol.2014.04.006](https://doi.org/10.1016/j.jaccpubpol.2014.04.006).
- Dickinson, V. (2011), "Cash flow patterns as a proxy for firm life cycle", *The Accounting Review*, Vol. 86 No. 6, pp. 1969-1994, doi: [10.2308/accr-10130](https://doi.org/10.2308/accr-10130), available at: <https://www.jstor.org/stable/41408043>
- Diebecker, J., Rose, C. and Sommer, F. (2017), "Corporate sustainability performance over the firm. life cycle: levels, determinants, and the impact on accounting performance", *SSRN Electronic Journal*. doi: [10.2139/ssrn.3084601](https://doi.org/10.2139/ssrn.3084601).
- DiMaggio, P.J. and Powell, W.W. (2000), "The iron cage revisited institutional isomorphism and. collective rationality in organizational fields", *Advances in Strategic Management*, Vol. 17, pp. 143-166, doi: [10.1016/s0742-3322\(00\)17011-1](https://doi.org/10.1016/s0742-3322(00)17011-1).
- Dye, R.A. (1985), "Disclosure of nonproprietary information", *Journal of Accounting Research*, Vol. 23 No. 1, pp. 123-145, doi: [10.2307/2490910](https://doi.org/10.2307/2490910).
- Eccles, R.G., Ioannou, I. and Serafeim, G. (2014), "The impact of corporate sustainability on organizational processes and performance", *Management Science*, Vol. 60 No. 11, pp. 2835-2857, doi: [10.1287/mnsc.2014.1984](https://doi.org/10.1287/mnsc.2014.1984).
- Ferrer, E., López-Arceiz, F.J. and Rio, C. (2020), "Sustainability disclosure and financial analysts' accuracy: the European case", *Business Strategy and the Environment*, Vol. 29 No. 8, pp. 2939-2952, doi: [10.1002/bse.2549](https://doi.org/10.1002/bse.2549).
- Fombrun, C. and Shanley, M. (1990), "What's in a name? Reputation building and corporate strategy", *Academy of Management Journal*, Vol. 33 No. 2, pp. 233-258, doi: [10.2307/256324](https://doi.org/10.2307/256324).
- Free, C., Jones, S. and Tremblay, M.-S. (2024), "Greenwashing and sustainability assurance: a review and call for future research", *Journal of Accounting Literature*, Vol. 47 No. 4, pp. 739-764, doi: [10.1108/jal-11-2023-0201](https://doi.org/10.1108/jal-11-2023-0201).

- Freeman, R.E. (2010), "Strategic management: a stakeholder approach", Cambridge Core, available at: <https://www.cambridge.org/core/books/strategic-management/E3CC2E2CE01497062D7603B7A8B9337F>
- Freeman, R.E., Harrison, J.S. and Wicks, A.C. (2007), *Managing for Stakeholders: Survival, Reputation, and Success*. [online] JSTOR, Yale University Press, available at: <https://www.jstor.org/stable/j.ctt1npxrg>
- Grant, R.M. (1991), "The resource-based theory of competitive advantage: implications for strategy. formulation", *California Management Review*, Vol. 133 No. 3, pp. 114-135, doi: [10.2307/41166664](https://doi.org/10.2307/41166664).
- Grewal, J., Hauptmann, C. and Serafeim, G. (2020), "Material sustainability information and stock. Price informativeness", *Journal of Business Ethics*, Vol. 171 No. 3, pp. 513-544, doi: [10.1007/s10551-020-04451-2](https://doi.org/10.1007/s10551-020-04451-2).
- Hasan, M.M., Cheung, A. and Wai-Kong (2018), "Organization capital and firm life cycle", *Journal of Corporate Finance*, Vol. 48, pp. 556-578, doi: [10.1016/j.jcorpfin.2017.12.003](https://doi.org/10.1016/j.jcorpfin.2017.12.003).
- Hasan, M.M. and Habib, A. (2017), "Corporate life cycle, organizational financial resources and. corporate social responsibility", *Journal of Contemporary Accounting and Economics*, Vol. 13 No. 1, pp. 20-36, doi: [10.1016/j.jcae.2017.01.002](https://doi.org/10.1016/j.jcae.2017.01.002).
- Hasan, M.M., Hossain, M., Cheung, A., Wai-Kong and Habib, A. (2015), "Corporate life cycle and cost of equity capital", *Journal of Contemporary Accounting and Economics*, Vol. 11 No. 1, pp. 46-60, doi: [10.1016/j.jcae.2014.12.002](https://doi.org/10.1016/j.jcae.2014.12.002).
- Helfat, C.E. and Peteraf, M.A. (2003), "The dynamic resource-based view: capability. Lifecycles", *Strategic Management Journal*, Vol. 24 No. 10, pp.997-1010, doi: [10.1002/smj.332](https://doi.org/10.1002/smj.332), available at: <https://www.jstor.org/stable/20060594>
- Herbohn, K., Walker, J. and Loo, H.Y.M. (2014), "Corporate social responsibility: the link. Between sustainability disclosure and sustainability performance", *Abacus*, Vol. 50 No. 4, pp. 422-459, doi: [10.1111/abac.12036](https://doi.org/10.1111/abac.12036).
- Hu, H., Zhang, T. and Dong, H. (2025), "The signaling power of ESG reports: how corporate sustainability disclosure shapes investment decisions in China", *International Review of Financial Analysis*, Vol. 109, 104691, doi: [10.1016/j.irfa.2025.104691](https://doi.org/10.1016/j.irfa.2025.104691).
- Hughes, S.B., Anderson, A. and Golden, S. (2001), "Corporate environmental disclosures: are they useful in determining environmental performance?", *Journal of Accounting and Public Policy*, Vol. 20 No. 3, pp. 217-240, doi: [10.1016/s0278-4254\(01\)00031-x](https://doi.org/10.1016/s0278-4254(01)00031-x).
- Hummel, K. and Schlick, C. (2016), "The relationship between sustainability performance and sustainability disclosure – reconciling voluntary disclosure theory and legitimacy theory", *Journal of Accounting and Public Policy*, Vol. 35 No. 5, pp. 455-476, doi: [10.1016/j.jaccpubpol.2016.06.001](https://doi.org/10.1016/j.jaccpubpol.2016.06.001).
- Ioannou, I. and Serafeim, G. (2012), "What drives corporate social performance? The role of nation-level institutions", *Journal of International Business Studies*, Vol. 43 No. 9, pp. 834-864, doi: [10.1057/jibs.2012.26](https://doi.org/10.1057/jibs.2012.26).
- Jawahar, I.M. and McLaughlin, G.L. (2001), "Toward a descriptive stakeholder theory: an. Organizational life cycle approach", *Academy of Management Review*, Vol. 26 No. 3, p. 397, doi: [10.2307/259184](https://doi.org/10.2307/259184).
- Kalkanci, B. and Plambeck, E.L. (2020), "Managing supplier social and environmental impacts with voluntary versus mandatory disclosure to investors", *Management Science*, Vol. 66 No. 8, pp. 3311-3328, doi: [10.1287/mnsc.2019.3382](https://doi.org/10.1287/mnsc.2019.3382).
- Kim, E.-H. and Lyon, T.P. (2015), "Greenwash vs. Brownwash: exaggeration and undue modesty in. Corporate sustainability disclosure", *Organization Science*, Vol. 26 No. 3, pp.705-723, doi: [10.1287/orsc.2014.0949](https://doi.org/10.1287/orsc.2014.0949), available at: <https://www.jstor.org/stable/43661016>
- Leonelli, S., Muhn, M., Rauter, T. and Sran, G. (2025), "How do consumers use ESG disclosure? Evidence from a randomized field experiment with everyday product purchases", *Journal of Accounting and Economics*, Vol. 81 No. 1, 101811, doi: [10.1016/j.jacceco.2025.101811](https://doi.org/10.1016/j.jacceco.2025.101811).

- Lo, S.-F. and Sheu, H.-J. (2007), "Is corporate sustainability a value-increasing strategy for business?", *Corporate Governance: An International Review*, Vol. 15 No. 2, pp. 345-358, doi: [10.1111/j.1467-8683.2007.00565.x](https://doi.org/10.1111/j.1467-8683.2007.00565.x).
- McKinsey & Company (2023), *Consumers Care about Sustainability—And Back it up with Their Wallets*, McKinsey & Company.
- Miller, D. and Friesen, P.H. (1984), "A longitudinal study of the corporate life cycle", *Management Science*, Vol. 30 No. 10, pp. 1161-1183, doi: [10.1287/mnsc.30.10.1161](https://doi.org/10.1287/mnsc.30.10.1161), available at: <https://www.jstor.org/stable/2631384>
- Naughton, J.P., Wang, C. and Yeung, I. (2018), "Investor sentiment for corporate social performance", *The Accounting Review*, Vol. 94 No. 4, pp. 401-420, doi: [10.2308/accr-52303](https://doi.org/10.2308/accr-52303).
- O'Donovan, G. (2002), "Environmental disclosures in the annual report: extending the applicability and predictive power of legitimacy theory", *Accounting, Auditing and Accountability Journal*, Vol. 15 No. 3, pp. 344-371, doi: [10.1108/09513570210435870](https://doi.org/10.1108/09513570210435870).
- Penrose, E. (1995), "The theory of the growth of the firm", *The Theory of the Growth of the Firm*. doi: [10.1093/0198289774.001.0001](https://doi.org/10.1093/0198289774.001.0001).
- Peteraf, M.A. (1993), "The cornerstones of competitive advantage: a resource-based view", *Strategic Management Journal*, Vol. 14 No. 3, pp.179-191, doi: [10.1002/smj.4250140303](https://doi.org/10.1002/smj.4250140303), available at: <https://www.jstor.org/stable/2486921>
- Presley, K.W., Zhong, Y. and Abudu, H. (2025), "The dual impact of sustainability disclosure on corporate performance: an empirical analysis of Chinese firms", *Business Strategy and the Environment*, Vol. 34 No. 6, pp. 6849-6863, doi: [10.1002/bse.4331](https://doi.org/10.1002/bse.4331).
- Scott, W.R. (1995), "Institutions and organizations. Ideas, interests and identities", *Management [online]*, Vol. 17 No. 2, p. 136.
- Shocker, A.D. and Sethi, S.P. (1973), "An approach to incorporating societal preferences in. Developing corporate action strategies", *California Management Review*, Vol. 15 No. 4, pp. 97-105, doi: [10.2307/41164466](https://doi.org/10.2307/41164466).
- Sirmon, D.G., Hitt, M.A., Ireland, R.D. and Gilbert, B.A. (2010), "Resource orchestration to create competitive advantage", *Journal of Management*, Vol. 37 No. 5, pp. 1390-1412, doi: [10.1177/0149206310385695](https://doi.org/10.1177/0149206310385695).
- Spence, M. (1973), "Job market signaling", *The Quarterly Journal of Economics*, Vol. 87 No. 3, pp. 355-374, doi: [10.2307/1882010](https://doi.org/10.2307/1882010).
- Turban, D.B. and Greening, D.W. (1997), "Corporate social performance and organizational. Attractiveness to prospective employees", *Academy of Management Journal*, Vol. 40 No. 3, pp. 658-672, doi: [10.2307/257057](https://doi.org/10.2307/257057).
- Verrecchia, R.E. (1983), "Discretionary disclosure", *Journal of Accounting and Economics*, Vol. 5, pp. 179-194, doi: [10.1016/0165-4101\(83\)90011-3](https://doi.org/10.1016/0165-4101(83)90011-3)
- Wernerfelt, B. (1984), "A resource-based view of the firm", *Strategic Management Journal*, Vol. 5 No. 2, pp. 171-180, doi: [10.1002/smj.4250050207](https://doi.org/10.1002/smj.4250050207), available at: <https://www.jstor.org/stable/2486175>
- You, X., Chen, C., Peng, K. and Li, Y. (2024), "ESG disclosure quality and cost of debt", *Emerging Markets Review*, Vol. 64, 101219, doi: [10.1016/j.ememar.2024.101219](https://doi.org/10.1016/j.ememar.2024.101219).

Further reading

- Mayntz, R. (1996), *Book Reviews: W. Richard Scott: Institutions and Organizations 1995*, Sage, Thousand Oaks, London, New Delhi, 178 pages. *Organization Studies*, Vol. 17 No. 3, pp. 539-541, doi: [10.1177/017084069601700309](https://doi.org/10.1177/017084069601700309).

Corresponding author

Li Yang can be contacted at: younglee3344@gmail.com