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The Impact of Sustainability Reporting on Manufacturer Market and Operations Performance: Five Long-term Event Studies from Signaling and Stakeholder Perspectives

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Abstract

Sustainability reporting (SR) is an important source of voluntary disclosure of sustainability information. SR can play a critical role in manufacturing firms' disclosure of their practices and strategies concerning their impacts on the natural environment and wider society, as well as how they run their business beyond mandatory disclosure. With a focus on market performance, previous studies demonstrate that SR can enhance market and financial outcomes, where a company's superiority is signaled to external stakeholders such as investors and customers. However, there is limited understanding of its broader impact on production and operations considering both internal and external stakeholders. This research conducts five event studies and regression analyses on the market and efficiency reactions to SR, using the Global Reporting Initiative (GRI) reporting data from 1999 to 2020 that comprises 1,254 firm-year observations of U.S. manufacturing firms. Our event study results indicate that SR leads to a time-lagged positive effect on performance metrics such as return on assets (ROA), labor productivity, manufacturing cost efficiency, Tobin's q , and market value, attributed to the costly signaling effect. Our regression analyses suggest that signal observability factors can amplify the effect of SR on certain performance. The findings suggest that executives should prioritize internal stakeholders, such as employees, and sustainable operations when investing in SR. While SR is originally a voluntary disclosure directed toward external stakeholders, it may also signal internal stakeholders and drive responses related to operations and productivity, constituting a reverse signaling process. This research addresses a gap in understanding the role of SR in driving financial performance and productivity within the integrated framework of stakeholder theory and signaling theory and provides managerial implications for firms' operations and production.

Keywords: Sustainability Reporting, Event Study, Empirical Research, Signaling Theory.

1. Introduction

Sustainability Reporting (SR) is a form of voluntary disclosure that serves as a form of sustainability communication to support sustainable operations. By reducing information asymmetry (Spence, 2002), fulfilling SR standards signals to stakeholders that reporting firms are capable of meeting higher standards of sustainability performance. This is known as a costly signal (Connelly *et al.*, 2011) because only resourceful firms can bear and absorb the high costs of signaling compliance with higher standards (Bird *et al.*, 2005). Typically, SR is aimed at external stakeholders like investors and shareholders (Lee and Maxfield, 2015), who use the disclosed information to interpret the legitimacy, credibility, and reputation of the reporting firms, and are expected to respond with positive market valuations (Schadewitz and Niskala, 2010). Through this signaling effect, fulfilling SR guidelines and standards can improve firm performance, such as financial and market performance (Yang *et al.*, 2021).

In stakeholder theory, SR is considered a public relations (PR) communication tool (Friske *et al.*, 2023, Verbeeten *et al.*, 2016), instrumental in managing a firm's relationships with investors and shareholders (Herremans *et al.*, 2016). However, efforts to integrate stakeholder theory with signaling theory encounter several limitations. First, the pressure for sustainability comes from external stakeholders, such as investors. SR is treated as a one-way communication between reporting firms and external stakeholders. Previous studies have used signaling theory to explain the effects of SR (e.g., Verbeeten *et al.*, 2016) and customer pressure on supply chains (Song *et al.*, 2023). A growing body of research underscores the significance of sustainability-related disclosures as determinants of investor behavior and market valuation (Eccles *et al.*, 2014, Khan *et al.*, 2016). Prior studies in the information systems section demonstrate that voluntary environmental disclosures, such as green technology adoption or carbon footprint reporting, elicit positive abnormal returns, reflecting investor appreciation for enhanced transparency and long-term risk mitigation (Nishant *et al.*, 2017). However, within the context of manufacturing firms, the operationalization of SR and its financial implications remain underexplored. Manufacturing firms face heightened scrutiny from external stakeholders, particularly investors, who regard them as proxies for operational resilience and competitive advantage (Golicic and Smith, 2013). While regulatory mandates impose baseline sustainability disclosures, voluntary SR often encompasses broader initiatives, such as circular production systems, ethical sourcing, and energy-efficient operations, which may signal operational excellence and innovation (Klassen and Vereecke, 2012). SR can be conceptualized as a strategic capability that enhances firm reputation, reduces regulatory risks, and fosters stakeholder trust—factors that collectively influence market perceptions (Hart and Dowell, 2011). Despite these theoretical linkages, empirical evidence on the market reaction to SR in the manufacturing sector remains fragmented, with limited attention to external financial market responses (Jacobs *et al.*, 2010).

Furthermore, the understanding of stakeholders could be insufficient if only external stakeholders are considered. Manufacturing firms are also under pressure from internal stakeholders (e.g., employees) regarding their sustainability practices. Stakeholder theorists have long suggested using a broader set of major stakeholders (see Friedman and Miles, 2002). Internal stakeholders, particularly non-investors like employees, are also important stakeholders who can create value for firms (Lee and Maxfield, 2015). Employees may be skeptical of the company's motivations for getting involved in sustainability initiatives led by company executives (Polman and Bhattacharya, 2016, Bhattacharya *et al.*, 2011). This can also be explained by signaling theory, whereby information asymmetries within manufacturing firms lead to legitimacy and motivation issues that affect productivity. By learning about their firms' core ideology from SR (Friske *et al.*, 2023), employees can be motivated by increasing awareness and engagement (Searcy and Buslovich, 2014). While SRs initially signal to external stakeholders, internal stakeholders may also receive signals from SRs because of their

increased legitimacy and SR-related activities. Employees can play an important role in SR-related activities. Previous interviews note that SR data collection is “a big and expensive issue for large organizations that have pretty diverse activities or operations (Searcy and Buslovich, 2014).” Employees’ collaboration is important that ensure their firms can cope with SR standards as a costly signal from activities such as certification, preparation, audit, compliance, and production of SR (Sarkis, 2001). Employees need to fulfill the practices disclosed in CSR to improve the utilization of assets and resources and reduce waste. In addition, employee legitimacy is enhanced by the recognition of positive corporate efforts to manage and disclose sustainability information.

The research gaps lead to three important questions: RQ1: Does SR lead to better market performance for manufacturing firms? RQ2: Does SR improve operational efficiency for manufacturing firms? RQ3: What are the effects of SR observability on the performance impact of manufacturing firms? Answers to these questions are critical to advance the understanding of whether and how SR, as a representative practice of narrowing the sustainability information asymmetry between manufacturing firms and their stakeholders. Based on the above integrative and expansive signaling-stakeholder perspective and proxies for observability, we examine the effects of SR on market reaction and operational efficiency. This study uses objective data from GRI reports among US manufacturing firms for the period from 1999 through 2020. We first use event studies to estimate the long-term effects of GRI reporting vs. non-reporting firms. We then use regressions to test the effects of first-time reporting, reporting frequency, and media exposure.

Our study advances both theoretical and practical knowledge in the field of operations management. First, the findings of this study indicate that SR leads to positive and significant abnormal performance, influencing both market performance and the operational efficiency of manufacturing firms. Drawing on the signaling theory, this study provides empirical evidence that SR can serve as an effective tool to communicate a firm’s sustainability efforts, thereby improving market and efficiency performance. Second, this study reveals that SR is a valuable means of communication with both external and internal stakeholders, particularly in terms of observability of sustainability issues, first reporting, frequency of reporting, and media exposure. External stakeholders, such as investors and customers, place high value on the transparency and legitimacy that proactive SR activities offer, thereby helping to mitigate sustainability-related information asymmetry. Simultaneously, internal stakeholders, including employees, recognize SR as a signal of the firm’s commitment to sustainable practices, fostering organizational trust and engagement.

Additionally, this research contributes to the signaling literature by providing empirical evidence of “reverse” signaling. Traditionally, signals originate from the sender and are directed toward the receiver to reduce information asymmetry. Most signaling processes are intentional; for instance, firms deliberately signal to external stakeholders. However, signals may also be received by unintended audiences, such as internal stakeholders. Both earlier and recent studies have emphasized the importance of exploring this possibility with in signaling theory (Connelly *et al.*, 2011; Connelly *et al.*, 2025). Although the initial signal is intended for external audiences, internal effects may arise when employees perceive and respond to the same signal. In this study, we refer to this phenomenon – where internal stakeholders respond to signals originally intended for external audiences – as “reverse signaling”. Our findings suggest that SR not only addresses external sustainability information asymmetry but also mitigates the internal information asymmetry. This represents a reversal of the original signaling direction; while SR primarily intended to signal external stakeholders, it also communicates to internal stakeholders, thereby enhancing internal engagement and improving operational outcomes.

2. Theoretical Background and Hypotheses

2.1. Sustainability Reporting

SR studies were more qualitative and conceptual in the early stages (e.g., Willis, 2003, Dando and Swift, 2003). More quantitative research using firms' financial data has been published in recent years. Based on various theories, previous studies examined the effects of SR on a range of variables, e.g., financial impacts (Chen *et al.*, 2015), reduction of pollution expenditure (Chiu *et al.*, 2017), environmental impacts such as emissions reduction (Bernard *et al.*, 2015, Song *et al.*, 2023), ESG performance (Lee and Maxfield, 2015), market value (Loh *et al.*, 2017), and profitability (Yang *et al.*, 2021). As a leading reporting standard, the GRI guidelines were first introduced in 1998 as one of the sources of SR standards. As the most cited set of guidelines (Toppinen and Korhonen-Kurki, 2013), GRI is commonly used in practice (KPMG, 2017, KPMG, 2022). These guidelines are updated periodically to reflect emerging developments in sustainability standards (GRI, 2020). GRI reporting covers environmental, social, and economic issues, and incorporates critical measures that cover multiple areas of firms (GRI, 2020). With the dimensional framework, manufacturing firms need to refer the SR indicators and therefore state the sustainability goals and actions. In Appendix 1, we present two examples of sustainability reporting (SR) from manufacturing firms: Nvidia, a high-tech and rapidly growing AI hardware company, and Ford, a well-established automotive manufacturer. As shown in the appendix table, manufacturing firms are expected to reference appropriate GRI indicators when disclosing additional sustainability information across foundation (GRI 1 series), general (GRI 2 series), environmental (GRI 3 series), and social (GRI 4 series) dimensions. By referencing specific GRI indicators, these firms articulate their sustainability goals and corresponding actions. SR guidelines also require firms to provide a disclosure index that links their practices and commitments to the GRI framework. For instance, recycling is a material topic for manufacturing firms, as it concerns a broad range of stakeholders. In response, Nvidia reported that over 90% of packaging by weight for its GPU systems is recyclable and referenced GRI 301-3 in support of this claim. The company also implemented carbon foot printing initiatives to support resale and refurbishment. Similarly, Ford set an interim goal of using 20% recycled or renewable plastics in vehicles sold in North America and Europe by 2025, and disclosed measures such as component remanufacturing and the use of recycled materials in vehicle parts, referencing GRI 301-2. Although GRI indicators are topic-specific and governance is treated as a cross-cutting foundation within the GRI framework, companies can also use GRI standards to index their sustainability commitments and governance-related goals. This allows them to respond not only to stakeholders in a SR context but also to investors who adopt an ESG-oriented perspective.

Previous research has employed various proxies to capture the effects of SR, such as whether firms have adopted a particular reporting standard (e.g., the GRI and CDP), are listed on indexes such as the Dow Jones Sustainability Indices (DJSI) or have appointed a chief sustainability officer (Robinson *et al.*, 2011, Yang *et al.*, 2019, Wiengarten *et al.*, 2017). SR may create legitimacy and elicit positive market responses from external stakeholders, such as investors and stakeholders. However, empirical findings on the impact of SR remain mixed. Some studies report that GRI reporting is associated with improved corporate social performance and increased market value (Loh *et al.*, 2017, Lee and Maxfield, 2015), while others find insignificant effects (Verbeeten *et al.*, 2016). This suggests the need to understand the conditions under which SR contributes to firm performance. External conditions, such as industry type (Bernard *et al.*, 2015), local legal systems, and enforcement (Kolk and Perego, 2010, Fernandez-Feijoo *et al.*, 2014), are shown to affect the outcomes of SR. Political ties in China can increase signal strength by fostering support from various stakeholders (Yang *et al.*,

2021). Little is known about how various stakeholders respond to SR and reporting firms, in addition to investors/shareholders who make market valuations through interpreting legitimacy.

Past studies indicate that SR improves financial performance, such as asset utilization (Yang *et al.*, 2021). However, legitimacy from external stakeholders cannot fully capture the process of improving asset utilization within firms. As such, explaining firm performance using only the external stakeholder perspective represents a significant limitation. We need to consider the cost burdens the reporting firms bear, and the many activities, including auditing, certification, TQM, procurement, and others, operational functions need to implement or modify (Sarkis, 2001). Any SR demands additional workloads to capture, consolidate, measure, assess, and analyze data related to sustainable activities and performance (Searcy and Buslovich, 2014). This explains why some firms found that GRI guidelines difficult to implement (Ferreira Quilice *et al.*, 2018).

Another issue in the existing literature is that simply measuring whether SR standards are used (or not) does not reveal the nuances of how different conditions drive the efficacy of SR. While signaling theory (Spence, 2002) has been used to explain the performance effects of SR (Robinson *et al.*, 2011, Yang *et al.*, 2019), the potential of this theory remains underappreciated. The role played by the two main characteristics of the signaling theory, i.e., signal observability and signal costs, has not been fully understood. The signaling processes involving both internal and external stakeholders have been overlooked in SR studies. This omission prevents a more complete understanding of SR's impact. We need a more comprehensive integration between signaling theory and stakeholder theory. We also need a more expansive view that considers employees (as salient internal stakeholders) who may act as both SR signal receivers and senders, along with signals from external stakeholders directed towards reporting firms. It is also important to consider operational efficiency to better understand the financial outcomes of SR.

The existing literature also highlights clues that link SR to both market and operations. Research has argued that SR plays a moderating role between enterprise risk management and business performance and integrating SR into enterprise risk management helps reduce the cost of capital by lowering information asymmetry and building stakeholder trust (Shad *et al.*, 2019), suggesting that transparent ESG reporting can lead to a lower perceived risk premium and thus cheaper financing. This notion is supported by evidence of SR reduces litigation and reputational costs, as well as anecdotal cases of firms avoiding penalties by proactively managing environmental risks disclosed in their reports. Beyond financial costs, SR encourages more frugal use of resources. By publicly committing to targets (e.g. cutting energy use or scrap rates), manufacturing firms often implement process innovations or leaner production techniques to meet those goals. Studies have noted that companies publishing sustainability reports tend to improve their resource efficiency over time, for instance, by reducing greenhouse gas emissions intensity or water usage in production. Papoutsis and Sodhi (2020) indicate that SR matters to firms' sustainability performance. With evidence of firms' improved sustainability performance, their results provide clues that SR could affect firms' internal operations and production. Empirical studies of sustainable supply management find that when manufacturers set reporting requirements for suppliers (e.g., requiring data on suppliers' energy use or certifications), it often drives those suppliers to enhance their sustainability performance. For example, an empirical study by Ageron *et al.* (2012) showed that close collaboration with suppliers on sustainability (and reporting those outcomes) led to improvements in supply continuity and reduced environmental impact in the supply chain. By incorporating supply chain metrics into SR, manufacturing firms can identify bottlenecks or risks (such as a supplier with high emissions or poor safety) and work jointly to address them, thus improving the overall sustainability and resilience of the production network. The above

literature provides clues as to how SR may affect a firm's external and internal operations and performance.

2.2. Stakeholder and Signaling Theory: An Integrated Framework

As shown in Figure 1, this study integrates stakeholder theory with signaling theory to form an integrated framework and expands the framework by considering both external and internal stakeholders. We adopt an open system perspective because internal operations and external stakeholders interact (Klassen, 1993). In an open system, internal and external stakeholders can observe and signal each other. Such signaling processes shape organizational goals and influence market response and operational efficiency.

– Figure 1 about here –

From a signaling theory perspective, SR mitigates information asymmetry between manufacturing firms and external stakeholders, thereby enhancing market performance. Investors and other external stakeholders increasingly demand transparency that extends beyond government-mandated disclosures, driven by concerns that inadequate sustainability practices may expose them to financial and reputational risks (Lo *et al.*, 2018). As a result, external stakeholders, such as buyers, now incorporate sustainability metrics into their purchasing and investment decisions (Xu *et al.*, 2021). Nevertheless, information asymmetry persists, as manufacturing firms seldom disclose comprehensive operational or sustainability data. SR addresses this gap by providing standardized, credible signals of sustainability performance, which stakeholders use to assess firm value and reduce uncertainty (Connelly *et al.*, 2011).

Employees, as critical internal stakeholders, also interpret SR signals. While societal pressures compel firms to adopt ambitious sustainability goals, employees often remain skeptical of organizational commitments due to internal information asymmetries (Rodrigo *et al.*, 2019). In practice, employers disseminate sustainability related information through formal and informal channels, such as employee training (He *et al.*, 2024) and workplace experience (Wang *et al.*, 2025). Although sustainable activities may introduce additional operational requirements, employers often anticipate that improved communication and access to sustainability information will motivate their employees and secure their support. Prior research indicates that employees' attitudes and motivations are influenced not only by internal communication but also by how their firms engage the broader external stakeholders (Glavas and Kelley, 2014). Despite the multiplicity of communication channels, SR plays a unique role by providing standardized, structured, and externally validated information regarding how the firm treats its wider stakeholders and its sustainability commitment. Therefore, SR offers benchmarks and transparency in sustainability practices, enhancing credibility and legitimacy and motivating internal stakeholders such as employees. Adhering to SR frameworks, like the Global Reporting Initiative (GRI), necessitates greater transparency in operational processes, including sustainable procurement, energy use, emissions, and supply chain management (Searcy and Buslovich, 2014). Although this heightened visibility increases operational scrutiny (Swift *et al.*, 2019), it incentivizes efficiency gains. For example, GRI compliance requires employees to systematically collect and disseminate sustainability data across departments, fostering accountability and process optimization (Wong *et al.*, 2021).

Notably, SR generates dual signaling effects. On one hand, SR reduces information asymmetry by providing credible data that investors and other external stakeholders can use to assess sustainability risks. On the other hand, SR serves as a formal channel that delivers transparent and consistent information to a broader range of stakeholders, addressing the limitations of context-dependent and fragmented informal or observational channels in

communicating the firm's sustainability achievements and commitments. The detailed content, broad stakeholder engagement, and validated nature of SR may enhance internal stakeholders' engagement in organizational sustainability initiatives, thereby motivating employees to proactively identify and implement operational improvements. As such, the comprehensive and validated signals provided by SR reinforce the alignment between employee actions and organizational objectives. Thus, we posit:

H1. Compared with non-reporting firms, manufacturing firms that produce SR reports achieve higher (a) market performance and (b) operational efficiency.

2.3 The Effects of Observability

The adoption of SR standards has frequently served as a proxy for signal quality or strength in prior studies. Similar signals of commitment to sustainability can also arise through actions such as inclusion in recognized indices (e.g., the Dow Jones Sustainability Indices) or the appointment of chief sustainability officers (Wiengarten *et al.*, 2017). However, signaling theory emphasizes that the effectiveness of signals depends not only on their inherent quality but also on their visibility to stakeholders (Connelly *et al.*, 2011). Thus, a critical but often overlooked factor is signal efficacy, which refers to how effectively signals are delivered and recognized by stakeholders. As illustrated in our conceptual framework (Figure 1), signal efficacy ensures that signals are clearly observed, processed, and interpreted correctly by internal and external stakeholders. When signals become more visible and salient, stakeholders are more likely to respond effectively. This applies in the two signal directions: (forward) signaling to external stakeholders and (reverse) signaling to internal stakeholders.

Signal efficacy depends significantly on observability, defined by Connelly *et al.* (2011, p. 45) as "the extent to which receivers notice or recognize a signal." Enhanced observability reduces information asymmetry, allowing stakeholders to better assess the firm's sustainability commitments. In our study, observability is operationalized through three measurable proxies: first-time reporting, reporting frequency, and media exposure. First-time reporting greatly enhances observability by marking a firm's explicit shift toward sustainability transparency, serving as a costly and conspicuous signal (Cuadrado-Ballesteros *et al.*, 2016). Reporting sustainability information for the first time is an observable signal that a company's attitude towards sustainability information has shifted from a positive stance to proactive action. According to signaling theory, costly signals are particularly effective in drawing attention due to their difficulty and expense, making them less likely to be mimicked by less committed firms (Connelly *et al.*, 2011). For instance, Walmart's first-time adoption of GRI reporting guidelines signaled a substantial strategic shift, gaining immediate attention from both internal stakeholders (employees and management) and external observers (investors and consumers). The visibility and novelty of this event generated heightened stakeholder scrutiny, prompting reciprocal signaling behaviors. External stakeholders conveyed their expectations clearly, pressuring the firm toward improvements in market perception and operational efficiency. Hence, aligning explicitly with signaling theory, we posit:

H2. First-time SR reporting is positively associated with manufacturing firms' abnormal (a) market performance and (b) operational efficiency due to SR.

Reporting frequency increases observability through repetitive signaling, thereby reinforcing stakeholder perceptions about the consistency and credibility of firm actions (Connelly *et al.*, 2011, Janney and Folta, 2003). Repeated reporting transmits persistent signals of commitment, establishing long-term credibility and reducing stakeholder uncertainty. Signaling theory underscores that consistency enhances stakeholders' ability to accurately interpret and trust the signals they receive (Connelly *et al.*, 2011). When firms consistently communicate their sustainability activities, they demonstrate sustained capability and intent,

triggering reciprocal signals from stakeholders who then demand continual improvements. Internal stakeholders (employees) internalize this consistent signaling as motivation, directly linking reporting frequency to improvements in operational processes. Moreover, the same signal sent multiple times can enhance message congruity and reduce confusion (Gao *et al.*, 2008). Repeating signals can reduce information asymmetry, perpetuate the signaling effects (Janney and Folta, 2006), and reinforce the same messages (Balboa and Martí, 2007). Together, a high reporting frequency produces observable signals that reach external and internal stakeholders, ultimately influencing the performance impact of SR. Thus, we posit:

H3. Reporting frequency is positively associated with manufacturing firms' abnormal (a) market performance and (b) operational efficiency due to SR.

Media exposure amplifies signal observability by expanding the signal reach and enhancing its salience across stakeholder groups (Connelly *et al.*, 2011, Gao *et al.*, 2008). Signaling theory recognizes media as critical signaling agents, capable of shaping stakeholder perceptions by reinforcing, clarifying, or even scrutinizing firm-generated signals (Wartick, 1992). Increased media coverage facilitates broader signal distribution and more diverse stakeholder engagement. Even critical or skeptical media coverage reinforces signal observability, prompting stakeholders to verify and challenge the authenticity of signals, thus increasing the overall effectiveness of SR. For example, Walmart's initial GRI report attracted critical media scrutiny, which paradoxically strengthened signal efficacy by compelling the company to substantively respond through improvements in operational practices. Both external and internal stakeholders may be aware of the firm's sustainability media coverage which could affect their perception and responses. Thus, we posit:

H4. Media exposure is positively associated with manufacturing firms' abnormal (a) market performance and (b) operational efficiency due to SR.

3. Data, Measures, and Model Specification

3.1. Data Sources and Samples

This study relies on three data sources: GRI reporting, which is the most widely adopted SR guideline¹; Compustat, which includes the financial and operational data²; and Factiva, providing information on media coverage³. We selected US manufacturing firms (SIC codes 2000 to 3999) that produced SR based on GRI standards from 1999 to 2020 because they (1) account for a large proportion of the firms that produce SR; (2) face a clear set of environmental and social regulations; (3) consume significant energy and produce pollution and waste; and (4) receive more attention from stakeholders. The main sample consists of 263 US manufacturing firms (with available GRI data) and 1254 observations. Table 1 (Panel A) summarizes the sectors, SIC codes, and number of observations.

– Table 1 about here –

The term abnormal performance (AP) is used by event studies to reflect actual deviation from expected returns or performance. In this study, we aim to evaluate the AP caused by SR. To estimate AP, we matched the sample observation with control groups. We considered the release of the SR as the event year (Year 0) and the year before (Year -1) as the base year. As such, we matched a control portfolio for each sample observation based on the market and operational performance outcome in the base year.

¹ GRI reporting: www.globalreporting.org.

² Compustat database: www.compustat.com.

³ Factiva database: www.global.factiva.com.

Consistent with existing literature (Arora *et al.*, 2020, Barber and Lyon, 1996), we adopted a multiple-step approach with progressively relaxed rules to avoid the loss of any of the sample firms (Hendricks *et al.*, 2015). First, we identified the control group, which has the same two-digit SIC and a dependent variable value within 90% to 110% of the sample firms. Second, if there were unmatched firms, we relaxed the rules to match firms with a one-digit SIC code and the dependent variable value within 90% to 110% of those of the sample firms, respectively. Third, if there were unmatched firms in the first two steps, we relaxed the rule to match control firms by the dependent variable value within 90% to 110% of that of the sample firms only. Last, if there were unmatched firms in the last three steps, we selected the matching firm with the closest performance without the rule for including the dependent variable and SIC code. We also set a rule of a factor of 50 of the total assets to control the firm size of the control group in the matching steps (Hendricks *et al.*, 2015). On average, each observation of sample firms matched with 12.16 (ROA), 7.46 (labor productivity), 21.05 (COGS/Sales), 14.70 (Tobin's q), and 5.37 (market value) observations of control firms, which is consistent with the existing literature to provide effective matching outcomes (Lo *et al.*, 2014; Orzes *et al.*, 2020). Table 1 (Panel C) summarizes the statistics for the sample and matched control groups.

3.2 Variables and Measures

Dependent variables. We collected market and operational efficiency data (dependent variables) from the Compustat database (Lo *et al.*, 2014). Data for the last two years (i.e., 2021, and 2022) were omitted to address the concern of missing data for our event study.

We measured two types of operational efficiency. Labor productivity is defined as net operating income (million USD) divided by the number of employees (Fan *et al.*, 2018). COGS/Sales ratio is measured by the bottom-line improvements in Cost of Goods Sold (COGS), including direct labor and materials costs, divided by Sales (Corbett *et al.*, 2005). We consider an additional dependent variable, ROA, which is defined as net operating income (before depreciation, interest, and taxes) divided by total assets (Lo *et al.*, 2018).

For market performance, we considered market valuation in terms of share market value, i.e., as the value of firms in the stock market (million USD), which is equal to market capitalization. We also included Tobin's q, a market measure of firm values that is forward-looking and risk-adjusted (Montgomery and Wernerfelt, 1988). Tobin's q is a financial market-based measure. Defined as the capital market value of a firm divided by the replacement value of its assets, Tobin's q incorporates a market measure of firm value.

Independent variables. To measure sustainability-related media exposure, we constructed an index based on the number of relevant news articles retrieved from the Factiva database (Eftekhari *et al.*, 2017). Specifically, the index captures overall media attention directed toward firms' sustainability practices during the event year. Instead of restricting the measurement solely to media coverage of sustainability reports, we include general sustainability-related media coverage to reflect broader stakeholder-oriented interest in corporate sustainability. This approach ensures a comprehensive and consistent measure of public attention while mitigating potential biases arising from selective media exposure and data skewness (Xu *et al.*, 2025; Zhao *et al.*, 2024). The data from the Factiva database was analyzed in the following steps. First, we searched business news in English related to the sample firms based on a keyword list in the event year. Following existing literature (e.g., Arora *et al.*, 2020), we iteratively retrieved sustainability-related news articles from Factiva using a keyword-based search strategy. News articles were included if they contained at least one of the following keywords, which reflect overall media attention on corporate sustainability: "environmental," "environment," "sustainability," "sustainable," "corporate social responsibility," "sustainability performance," "environmental disclosure," "social responsibility," "Global Reporting Initiative," "GRI," "CSR reporting," or "environmental

reporting.” Second, we measured the total number of news articles about each sample firm in the event year. Finally, we calculated the natural logarithms of the ratio of the number of sustainability-related news articles of the sample firms in the event year to the number of total news articles in the same year. Following previous studies (Liu *et al.*, 2014, Eftekhari *et al.*, 2017), we did not categorize media reports as positive or negative. Based on this setting, we controlled the interference of the variation in the trend of the number of news articles in different years. As such, the aggregate volume of sustainability-related coverages, controlled by the total number of firm-related news articles in the same year, serves as an effective proxy for the observability of sustainability information as perceived by a broader range of stakeholders.

First-time reporting is an indicator variable that takes a value of 1 if a firm conducts SR for the first time, and 0 otherwise, following the design of existing studies in the literature, to identify the first event (Xia *et al.*, 2016). This variable indicates the first report conducted by a firm, differentiating the disclosure behavior of its subsequent sustainability reporting. In the past, *reporting frequency* has been hard to measure due to a lack of data (Qiu and Kahn, 2018).

Reporting frequency is defined as the consistency of firms in producing GRI reports after their first GRI reporting. It is measured as the number of reports produced by the firm divided by the difference between the end year of the event and the year of first reporting, as follows:

$$ReportingFrequency_{it} = \begin{cases} 0, & YearEvent_{it} = FirstEvent_i \\ \frac{NumberOfEvents_{it}}{YearEvent_{it} - FirstEvent_i}, & YearEvent_{it} \neq FirstEvent_i \end{cases}$$

where i is the index of the firm and t is the index of time.

3.3 Model Specification

3.3.1 Event Study Model

To test H1, we conducted five event studies to estimate the AP between firms in the sample (i.e., GRI reporting firms) and the control group (i.e., non-GRI reporting firms). We adopted a four-year event window to measure the AP of the five dependent variables, following the existing literature on sustainability events (Wiengarten *et al.*, 2017). Specifically, the year of the event (i.e., the release of the SR) is defined as the event year (Year 0). Year -1 is defined as the base year. The first and second years after the event year are defined as Year 1 and Year 2, respectively.

The formulas for calculating the AP are shown as follows:

$$AP_{(t+i,t+j,p)} = PS_{(t+j,p)} - EP_{(t+j,p)}$$

$$EP_{(t+j,p)} = PS_{(t+i,p)} + \frac{1}{m_q} \sum_{q=1}^{m_q} (PC_{q,t+j} - PC_{q,t+i}),$$

where AP is abnormal performance; EP is expected performance; PS is performance of the sample firms; PC is average performance of the firms in the control group; t is the base year (i.e., year -1); i is the start year for comparison (i.e., -1, 0, 1); j is the end year for comparison (i.e., 0, 1, 2); p is the index of firms in the sample group (e.g., 1, 2, ...); q is the index of firms in the control group (e.g., 1, 2, ...); n is the number of firms in the sample group; and m_q is the number of firms in the control group of index q .

Although the long-term event study may be less affected by overlapping events directly, the overlapping of similar cohort events may still elevate the significance levels of the event study results (Sorescu *et al.*, 2017). For event study hypothesis testing, to avoid overlapping event windows, we restricted the events without overlapping in the estimated windows (i.e., 4 years). In other words, the first-time event and later events without overlapping are included

(MacKinlay, 1997). Because of the availability of variables, the sample is consistent, but there should be a variance among sample sizes for different dependent variables (Lo *et al.*, 2014). As a result, a restricted sample set without overlapping event windows was used for testing the event study effects (see Table 1, Panel B).

The event study tested the time-lag effects of GRI reporting relative to non-GRI reporting firms. Consistent with previous studies, we adopted Wilcoxon Signed-Rank (WSR), binomial sign (Sign), and paired t-tests to examine the differences in performance between the sample and matched control group based on the median of the sample firms (Fan *et al.*, 2018, Lo *et al.*, 2014, Zhang and Xia, 2013, Hendricks *et al.*, 2015). Additional results based on the mean were reported for reference. Following prior studies (Swift *et al.*, 2019), we consider the sign test (instead of the WSR test) as more appropriate when the data are skewed (absolute skewness greater than 1) (Cowan, 1992), to choose the main results when the statistical results are not consistent.

3.3.2 Regression Model

We use regression models to examine the effects of observability (H2–H4). The dependent variable AP is regressed against sustainability-related media exposure, reporting frequency and first-time reporting. The control variables (i.e., Industry's 3-year averaged ROA and Sample's ROA, and Firm Size) and dummy variables of year and industry fixed effects are included.

$$AP_{(i,j,p)} = \gamma_{10} + \gamma_{11}(industry_dummy_{i,p}) + \gamma_{12}(year_dummy_{i,p}) \\ + \gamma_{13}(ROA_control_{i,p}) + \gamma_{14}(industry_averaged_ROA_control_{i,p}) \\ + \gamma_{15}(media_exposure_{p,i}) + \gamma_{16}(firm_size_{i,p}) \\ + \gamma_{17}(first_time_reporting_{i,p}) + \gamma_{18}(reporting_frequency_{i,p}) + e$$

where i is the start year for comparison (i.e., -1, 0, 1); j is the end year for comparison (i.e., 0, 1, 2); and $p = 1, 2, \dots, n$ is the index of the firms in the sample group.

We adopted OLS with a setting of industry and year-fixed effects, and robust error. Additionally, we also conducted RLM for a robustness check (Longoni *et al.*, 2019, Netland *et al.*, 2021). Appendix II shows the descriptive statistics and correlation matrices for all variables.

– Table 2 about here –

4. Analysis and Results

4.1 Event Study Results (H1)

In this section, we present the results of the analysis of the event study. Table 2 shows the results of the event study. There is a significant and positive change in the ROA between Year -1 and Year 0 (median change = 0.006, $p_{WSR} = 0.002$, $p_{sign} = 0.001$). This change continues in the period of Year -1 through Year 1 (median change = 0.013, $p_{WSR} < 0.001$, $p_{sign} < 0.001$), and Year -1 through Year 2 (median change = 0.142, $p_{WSR} = 0.044$, $p_{sign} = 0.001$). So, there were increases in ROA for three years.

Row LP in Table 2 shows the results for labor productivity. During the period of Years -1 to 0, a marginal median change in labor productivity can be observed (median change = 2.346, $p_{WSR} = 0.028$, $p_{sign} = 0.054$). The trend continues during the period of Year -1 through Year 1 (median change = 5.146, $p_{WSR} = 0.003$, $p_{sign} = 0.005$). Furthermore, the results show significant labor productivity from Year -1 through Year 2 (median change = 3.230, $p_{WSR} = 0.054$, $p_{sign} = 0.022$). So, there were increases in labor productivity for three years.

Regarding COGS/Sales, the results indicate that there is a marginal median change during the period of Year -1 through year 0 (median change = -0.003, $p_{WSR} = 0.032$, $p_{sign} = 0.206$, skewness > 1). A more significant result was found during the period of Year -1 through Year 1 (median change = -0.006, $p_{WSR} = 0.001$, $p_{sign} = 0.045$). The results indicate a significant

COGS/Sales during the period of Year -1 to Year 2 (median change = -0.003, $p_{WSR} = 0.001$, $p_{sign} = 0.272$, skewness < 1). In the period of Year 1 through Year 2, the effect weakens (median change = -0.001, $p_{WSR} = 0.225$, $p_{sign} = 0.846$). So, there were marginal improvements in COGS/Sales for three years. Overall, the results show GRI reporting firms gain operational efficiency compared to non-reporting firms for one to three years, supporting H1(b).

For market value (row MV), during Year -1 through Year 1, a positive and significant median change can be observed (median change = 329.969, $p_{WSR} = 0.017$, $p_{sign} = 0.109$, skewness < 1). Likewise, in the period of Years -1 through Year 0, a marginal mean change is observed (median change = 4.469, $p_{WSR} = 0.434$, $p_{sign} = 1.000$). Significant median changes are found over the period from Year 0 through Year 1 (median change = 142.752, $p_{WSR} = 0.064$, $p_{sign} = 0.047$, skewness > 1) and marginal increases are found from Year -1 through Year 2 (median change = 363.326, $p_{WSR} = 0.041$, $p_{sign} = 0.282$, skewness < 1). Again, there were three-year improvements in market value.

For Tobin's q, the results indicate that there is a significant median change during the period of Year -1 through Year 0 (median change = 0.334, $p_{WSR} = 0.047$, $p_{sign} = 0.034$). The trend did not persist during the period of Year -1 through Year 1 (median change = -0.103, $p_{WSR} > 0.1$, $p_{sign} > 0.1$), suggesting there is a short-term effect. Overall, the results show support for H1(a).

4.2 Regression Analysis Results (H2-H4)

For regression analyses, we use industry and year-fixed effect models (Lo *et al.*, 2018). We correct the selection bias endogeneity using the Heckman two-stage model (Arora *et al.*, 2020). We adopted OLS and robust error; RLM is also used to enhance robustness (Longoni *et al.*, 2019). Tables 3 and 4 summarize the results of four models of regression analyses: Model 1 the null model (control variables included), Model 2 OLS results, Model 3 RLM results, and Model 4 Heckman two-stage model for addressing sample self-selection endogeneity.

Panel A of Table 3 shows the regression results of labor productivity. The coefficient of first-time reporting is positive and significant ($\gamma_{OLS} = 24.60$, $p = 0.0097$, $\gamma_{RLM} = 18.28$, $p < 0.001$). The coefficient of reporting frequency is positive and significant ($\gamma_{OLS} = 29.42$, $p = 0.004$, $\gamma_{RLM} = 22.40$, $p < 0.001$). Instead, the findings show an insignificant effect of sustainability-related media exposure ($\gamma_{OLS} = -1.234$, $p = 0.726$, $\gamma_{RLM} = 1.309$, $p = 0.576$).

Panel B of Table 3 shows results for COGS/Sales. There is no significant effect of first-time reporting ($\gamma_{OLS} = -0.009$, $p = 0.646$, $\gamma_{RLM} = -0.012$, $p = 0.106$), reporting frequency ($\gamma_{OLS} = 0.005$, $p = 0.826$, $\gamma_{RLM} = -0.013$, $p = 0.108$), and media exposure ($\gamma_{OLS} = -0.011$, $p = 0.347$, $\gamma_{RLM} = 0.003$, $p = 0.308$) on COGS/Sales.

– Tables 3 and 4 about here –

Panel A of Table 4 shows no significant effect of first-time reporting ($\gamma_{OLS} = 972.2$, $p = 0.734$, $\gamma_{RLM} = 2229.3$, $p = 0.219$), reporting frequency ($\gamma_{OLS} = 1073.0$, $p = 0.741$, $\gamma_{RLM} = 1815.7$, $p = 0.353$), and media exposure ($\gamma_{OLS} = -634.4$, $p = 0.610$, $\gamma_{RLM} = 414.8$, $p = 0.589$) on market value.

Panel B of Table 4 shows media exposure is insignificant in affecting Tobin's q ($\gamma_{OLS} = 0.0460$, $p = 0.337$; $\gamma_{RLM} = 0.0596$, $p = 0.171$). Instead, first-time reporting positively influences Tobin's q ($\gamma_{OLS} = 0.226$, $p = 0.022$; $\gamma_{RLM} = 0.314$, $p = 0.002$) and reporting frequency also has a positive and significant effect on Tobin's q ($\gamma_{OLS} = 0.226$, $p = 0.033$, $\gamma_{RLM} = 0.325$, $p = 0.003$).

Panel C of Table 4 shows first-time GRI reporting has a positive and significant impact on ROA ($\gamma_{OLS} = 0.0237$, $p = 0.002$; $\gamma_{RLM} = 0.0283$, $p < 0.001$), as do reporting frequency

($\gamma_{OLS} = 0.0237$, $p = 0.003$; $\gamma_{RLM} = 0.0278$, $p < 0.001$) and sustainability-related media exposure ($\gamma_{OLS} = 0.008$, $p = 0.008$, $\gamma_{RLM} = 0.008$, $p = 0.006$).

In summary, the results show first-time reporting is positively associated with labor productivity, Tobin's q and ROA, but not with market value and COGS/Sales, which partially support H2(a) and H2(b). Reporting frequency is also positively associated with labor productivity and Tobin's Q and ROA, but not with market value and COGS/Sales, which partially support H3(a) and H4(b). Instead, media exposure is only positively associated with Tobin's q and ROA, partially supporting H4(a) but rejecting H4(b).

4.3 Robustness Check and Endogenous Concern

We conducted additional analyses to check the robustness and address endogeneity. First, although event studies were conducted with matched samples and unintended factors eliminated (Ketokivi and McIntosh, 2017), we examined whether the sample and control groups were well-matched using t-test of the data for the base year. The results show no difference between the sample and matched control firms for each dependent variable ($p > 0.1$). As the data collected cross multiple years, there was a concern that the unobserved factors (e.g., inflation) may have an impact on the operating income and ultimately affect productivity. Consistent with the literature (Lo *et al.*, 2014, Swift *et al.*, 2019), based on the event study and matching setting, the influence of these unobserved factors can be mitigated as the sample group is controlled by matched control groups. In addition, year effects are controlled for in the regression model. Therefore, unobserved factors are unlikely to bias the results. Second, we report on three types of tests to understand the median and mean changes for a robustness check, which reduces the concerns of data distribution and improves robustness.

Third, in addition to OLS estimations, we conducted regression analyses using Robust Liner Regression (RLM), which enhances robustness by downgrading the influence of outliers (Longoni *et al.*, 2019, Netland *et al.*, 2021). OLS is generally adopted for the regression models to understand the factors that influence the impact caused by events (e.g., Lo *et al.*, 2014). However, OLS is sensitive to extreme data (outliers). In our regression models, we include multiple sources of datasets. For instance, the variable of labor productivity is calculated by operating income divided by the number of employees. Some companies have a smaller number of employees but have extremely high operating incomes. The solution for addressing this concern could be as simple as further trimming the data such as 1% at both the lower boundary and upper boundary. However, it causes potential bias which literature argues that the extreme data is real data and should be contained. As such, RLM (robust linear regression is suggested in this scenario) (Wang *et al.*, 2024, Rodrigues *et al.*, 2018). RLM does not simplify or remove the data points, instead, it assigns appropriate weights to observations to ensure that outliers do not have undue influence on the results, and therefore generate stable and robust estimations (Qi *et al.*, 2023). By considering these, we are motivated to report both OLS results and additional RLM results. The results show that the supported hypotheses are consistent for both OLS and RLM models, which indicates that the models are not vulnerable to the concern of extreme data points. The results are summarized in Tables 3 and 4. The RLM results show that the main effects of variables are consistent with the OLS results. All values of Variance Inflation Factors (VIFs) for our study are well below the common threshold value of 10, indicating that multicollinearity is not a serious concern for this study (Belsley, 1980, Greene, 2003).

Fourth, given that the collected sample includes events from 19 years and firms in our sample have self-selected to release their sustainability reports, it was a concern that the occurrence of events may be non-random, leading to endogeneity issues (Arora *et al.*, 2020). Sample selection bias might exist as we sample firms' GRI data that might have similar performance outcomes. Due to the non-randomness, the OLS estimation might be biased

because independent variables can be correlated with the error term in the regression model (Antonakis *et al.*, 2010). To deal with this endogeneity, we used the Heckman two-stage procedure to deal with potential sample-induced endogeneity (Heckman, 1979, Arora *et al.*, 2020, Song *et al.*, 2023). We collected the non-sample observations and performed a probit model that includes firm size, sample firm's ROA, and industry's 3-year averaged ROA to predict the likelihood of firms conducting SR to estimate the inverse Mills ratio (IMR). Incorporating the Inverse Mills Ratio (IMR) into our analysis addresses potential self-selection bias by accounting for the non-random selection of firms based on performance metrics. The primary motivation for adopting IMR is to include data from firms during non-reporting years, which cannot be observed in the context of an event study. The IMR is derived from a selection probit model to correct for sample selection bias, which, in our context, is the probability of a firm being included in the sample given its performance characteristics. In our model, the dependent variable is coded as "1" if a firm produces a sustainability report in the year; otherwise, it is coded as "0". Several factors may influence the probability of SR. Manufacturing firms with larger capacities (assets) might be more proactive in reporting their sustainability efforts. Firms with better financial performance records (previous ROA might be more inclined to produce SRs. Additionally, manufacturing firms in growing industries (industry's 3-year averaged ROA) might be more likely to engage in SR. Therefore, we include variables such as the firm's total assets (logged) in the previous year, the firm's Return on Assets (ROA) in the previous year, and the industry's three-year average ROA. In the probit model, we also control for year and industry dummy variables. Both results of the regression models with and without IMR are shown in Tables 3 and 4, providing additional robustness by addressing the self-sample selection endogeneity for event studies (Lo *et al.*, 2018).

In summary, the event study results indicate that SR leads to positive and significant abnormal financial performance, as reflected in measures such as Return on Assets (ROA), Market Value (MV), and Tobin's Q (TQ). This suggests that manufacturing firms engaging in SR can signal to investors by mitigating information asymmetry related to sustainability. Additionally, SR is shown to positively and significantly influence abnormal operational efficiency, as measured by Labor Productivity (LP) and Manufacturing Cost Efficiency (MCE). This effect may be attributed to reverse signaling, whereby SR communicates to employees, who are internal stakeholders.

Further analysis of the observability effects of SR on abnormal performance reveals mixed results. First-time reporting and reporting frequency both positively and significantly affect abnormal ROA, LP, and TQ, supporting the hypotheses that the decision to initiate SR and the frequency of reporting can enhance efficiency in various ways. The effect on abnormal MCE is not significant, suggesting that cost-related efficiency may not be impacted by SR's observability. Moreover, the influence on TQ is positive and significant, whereas the effect on MV is not, indicating that the decision to report and sustained reporting efforts primarily shape the market's expectations regarding future returns on investment rather than immediate market perception (i.e., MV). On the other hand, sustainability-related media exposure has a positive and significant impact on abnormal ROA performance. This suggests that media exposure related to sustainability can influence a firm's overall performance, though its effect on specific operational improvements is less evident.

5. Discussions and Implications

5.1 Theoretical Implications

Our study contributes to the literature on SR by addressing two issues. First, most SR studies focus on external stakeholders and suggest that fulfilling SR standards can enhance the valuation of reporting firms (Yang *et al.*, 2021). Studies that integrate stakeholder theory with

the signaling perspective (Herremans *et al.*, 2016) considered only investors and shareholders, not internal stakeholders, especially employees. With a focus on operations and production, our findings suggest that SR signals both external and internal stakeholders in terms of sustainability. Our integrative and expansive framework broadens the signaling and stakeholder perspectives so that we gain a fuller understanding of the signaling processes, the roles of employees, the possibility of reverse signaling, and the effects of SR on operational efficiency. Also, past SR studies from a signaling perspective considered signal strength (costly signals) but ignored the need to check signal efficacy. We show that different proxies of signal efficacy (observability) can influence financial performance and operational efficiency enhancement in different ways.

Our study contributes to the application of signaling and stakeholder theory in understanding the SR effects. While the main literature considers quality and strength of SR signals only affect market valuations made by investors or shareholders, we show that three proxies of observability cannot improve market values. Our findings question this assumption. The market is not the only signal receiver. Investors could have observed the first-time reporting and responded through market valuation with a “costly signal” demanding greater labor productivity. In response to the call from Connelly *et al.* (2011, 2025), this study advances the understanding of unintended signaling by providing evidence that SRs, although produced by firms to communicate with external stakeholders, can also signal and motivate internal stakeholders, illustrating a “reverse signaling” process. This finding also explains why SR could improve ROA, labor productivity, and Tobin’s q. While operating income depends on the market (positive responses from customers) income, the improvement in productivity suggests signals from SR could affect internal stakeholders, especially employees. This further supports the incorporation of internal stakeholders in our integrative and expansive framework, and that SR can directly affect employees’ motivation or their ability to generate operating incomes. Rather than using stakeholder theory (Lee and Maxfield, 2015) or signaling theory (Yang *et al.*, 2021) in a narrow way, we justify the need for a more expansive framework (Figure 1) to explain the different effects of SR.

The integration of signaling theory with stakeholder theory also reveals the bi-directional signals learnt by external and internal stakeholders. A highlight of our contribution includes the empirical evidence of the concept of reverse signaling. Reverse signaling is demonstrated by the positive and significant effects of SR observability (first-time reporting and reporting frequency). The findings suggest that inward signals drive the operational functions and improve operational efficiency. Although we focus on SR literature, this study offers novel theoretical implications to sustainable operations literature and stakeholder governance literature. The results indicate that internal and external stakeholders could engage in the “forward” and “reverse” signaling processes through increasing observability or transparency. While we know transparency matters for accountability (Panwar and Suddaby, 2021), the integrative framework links sustainable operations to corporate and stakeholder governance (through SR). Operational functions play important roles in the processes of stakeholder governance and accountability (Wong *et al.*, 2021) and corporate governance (Ching and Gerab, 2017). While sustainable operations literature offers insights on implementing audits, certifications, and sustainable operations practices, there is a lack of theories to incorporate stakeholder pressures to explain how operations functions use feedback from the market to set goals and how they contribute to broader stakeholder governance by signaling to external stakeholders. A more comprehensive understanding of sustainable operations should incorporate reporting (disclosure) and interactions between operational employees with external stakeholders (through various means of signaling efforts or quality).

Moreover, the study contributes to the argument that signal strength or a costly signal requires an important condition as signal efficacy. We show observability proxies to capture

how effectively signals are sent by signalers. From measuring whether a firm uses a specific SR standard or index, the SR literature may use the three observability proxies. Our findings suggest media exposure is a proxy that largely facilitates signaling to external stakeholders, while more theoretical advancement could be achieved using first-time reporting and reporting frequency to understand the effects of SR on employees and other internal stakeholders.

Finally, our research enriches the sustainable operations and production literature. Our empirical evidence shows that SR offers important signaling effects on manufacturing firms' performance. The existing stream of literature on sustainable operations and production has revealed important events that affect firms' performance, such as Diversity, Equity, and Inclusion Commitment announcements (Li *et al.*, 2024), Occupational Health and Safety Management certification (Lo *et al.*, 2014), sustainability executives' appointments (Arora *et al.*, 2020), and sustainability incidents (Lo *et al.*, 2018). Our findings suggest that SR plays an important role in manufacturing firms' operations and profitability, which contributes to the understanding of sustainability information disclosure and transparency.

5.2 Implications for Practice

Our results highlight that the benefits of SR are not limited to market performance alone, and that SR is not just a PR exercise, but is an effective tool for improving operational efficiency. Hence, we recommend not treating SR as just a stakeholder communication tool; it is a tool for driving both profitability and productivity. SR should be an integral part of sustainable operations because it engages external and internal stakeholders by releasing additional sustainability information that addresses information asymmetry. Manufacturing firms should view SR as an ongoing interaction with external and internal stakeholders. By recognizing pressures to improve sustainability performance (Luo and Bhattacharya, 2006) by listening to shareholders (Flammer, 2015) and shareholder activism (Flammer *et al.*, 2019), internal stakeholders such as employees of the firms who are involved in SR reporting can use such insights and pressures to drive operational efficiency and market performance. The implication for practice is that a firm should involve employees and recruit important stakeholders, such as suppliers, as contributors in the preparation of SR (rather than as a PR exercise) because they will learn to improve asset and labor utilization while meeting sustainability requirements.

Our findings provide insights into the sustainable operations of manufacturing companies. First, we suggest that manufacturing firms adopt sustainability standards like the SR guidelines because it is not only a powerful way to differentiate a firm's underlying quality from its competitors: first-time SR also acts as a burning platform, driving the "reverse" signal and motivational effects that increase efforts to increase transparency, accountability, and sustainable operations. Although manufacturing firms are concerned about scrutiny caused by additional information provided and sustainability transparency, our results provide empirical evidence that SR can gain positive outcomes in financial and operational ways. Second, the positive effect of SR relies on consistent effort as frequency reporting. The findings of reporting frequency highlight the need to produce consistent signals for increasing observability and improving performance as expected by the external stakeholders and internal stakeholders. Lastly, our results also suggest that top executives should not put all their attention into share market valuation and also pay attention to the media's amplification effect. There is no harm in cooperating with the media to enhance the observability of SR; we do not find significant effects on either market response or operational efficiency. Although media and shareholders might scrutinize practices based on the released sustainability information in the reports, media exposure appears to drive an extent of signaling effect on market performance.

5.3 Limitations and Future Research

As with all studies, this study has several limitations. First, even though our additional analyses address the potential endogeneity caused by sample selection, our dataset covers only publicly traded manufacturing firms in the US with available SR data. It remains to be established whether our findings can be generalized to small and medium enterprises (SMEs) that are not listed, capable of meeting SR requirements, or operating in other contexts. Future studies might consider combining different methods (i.e., surveys, interviews, case studies, simulation, etc.) to collect the operations data of SMEs that may not be available in the current data set. Second, this study is premised on signaling theory, which only considers positive signals to reduce information asymmetry, but we cannot account for mechanisms such as honesty and reliability perceptions (Connelly *et al.*, 2011). As SRs contain rich unstructured text, future research could leverage advanced analytical techniques, such as natural language processing and data mining, to systematically monitor and evaluate the ambitious sustainability goals and implementation strategies disclosed by manufacturing firms. While this study focuses on a general media exposure index that captures overall attention to corporate sustainability, future work may further benefit from analyzing individual SRs and media coverage at the document level using these advanced methods. Such analyses would offer deeper insights into how different stakeholders respond to sustainability initiatives and their outcomes over the long term. Third, this study focuses on the effects on the performance. Future research may consider exploring motives for conducting sustainability reports, thereby generating insights into the drivers of SR. Fourth, future research might wish to examine how SR reporting may drive the implementation of sustainability practices, especially how signal observability due to SR and other forms of SR encourages employees of reporting firms to initiate sustainability practices in their operations. Considering the negative consequences of sustainability incidents, the combined roles of SR and other environmental management standards and practices deserve future study. Fifth, because sustainable development practices and reporting require resources, the competition for reporting can become a survival game where participants enter and exit. It is worth exploring the impacts of sustainable development from a resource-based perspective, considering company size. Finally, in addition to examining the long-term impacts of sustainability reporting (SR), future research could explore short-term event studies to better understand how SR influences immediate operational outcomes. For example, it would be valuable to investigate key issues faced by manufacturing firms, such as inventory management and operational cycles (Lo *et al.*, 2009), during the implementation and utilization of SR practices.

6. Conclusion

Our study enhances the understanding of SR by integrating signaling theory with stakeholder theory, offering a more comprehensive framework that highlights its effects on both external and internal stakeholders. Focusing on production economics, using data from U.S. manufacturing firms, our results provide empirical evidence that SR leads to both a positive market reaction and operational improvements. With the theoretical foundations of signaling theory, these findings suggest that SR not only signals external stakeholders but also signals internal stakeholders in a reverse manner, beyond the original purpose of SR activities. Furthermore, our results reveal that the observability of SR, first-time reporting, reporting frequency, and sustainability-related media exposure play key roles in the signaling process. From a practical perspective, the results indicate that manufacturing firms can enhance both market and operational performance through SR. The findings show that transparent sustainability, as a result of SR, can be both practical and beneficial by addressing investors' concerns and engaging employees in building legitimacy. This finding provides empirical

insights that how manufacturing firms should align their sustainability practices with their employees and motivate them by addressing their skepticism and creating a sustainable business (Polman and Bhattacharya, 2016). The effects of observability factors suggest that manufacturing firms can benefit from the decision to begin SR. While increased sustainability transparency may attract more attention from a broader range of stakeholders, which causes manufacturer firms' concerns about criticism, continuous reporting, and exposure are important for driving long-term performance outcomes.

REFERENCE

- AGERON, B., GUNASEKARAN, A. & SPALANZANI, A. 2012. Sustainable supply management: An empirical study. *International Journal of Production Economics*, 140, 168-182.
- ANTONAKIS, J., BENDAHAN, S., JACQUART, P. & LALIVE, R. 2010. On making causal claims: A review and recommendations. *The Leadership Quarterly*, 21, 1086-1120.
- ARORA, P., HORA, M., SINGHAL, V. & SUBRAMANIAN, R. 2020. When do appointments of corporate sustainability executives affect shareholder value? *Journal of Operations Management*, 66, 464-487.
- BALBOA, M. & MARTÍ, J. 2007. Factors that determine the reputation of private equity managers in developing markets. *Journal of Business Venturing*, 22, 453-480.
- BARBER, B. M. & LYON, J. D. 1996. Detecting abnormal operating performance: The empirical power and specification of test statistics. *Journal of Financial Economics*, 41, 359-399.
- BELSLEY, D. A. 1980. On the efficient computation of the nonlinear full-information maximum-likelihood estimator. *Journal of Econometrics*, 14, 203-225.
- BERNARD, S., ABDELGADIR, S. & BELKHIR, L. 2015. Does GRI reporting impact environmental sustainability? An industry-specific analysis of CO2 emissions performance between reporting and non-reporting companies. *Journal of Sustainable Development*, 8, 190-205.
- BHATTACHARYA, C., SEN, S. & KORSCHUN, D. 2011. *Leveraging corporate responsibility: The stakeholder route to maximizing business and social value*, Cambridge University Press.
- BIRD, R. B., SMITH, E., ALVARD, M., CHIBNIK, M., CRONK, L., GIORDANI, L., HAGEN, E., HAMMERSTEIN, P. & NEIMAN, F. 2005. Signaling theory, strategic interaction, and symbolic capital. *Current Anthropology*, 46, 221-248.
- CHEN, L., FELDMANN, A. & TANG, O. 2015. The relationship between disclosures of corporate social performance and financial performance: Evidences from GRI reports in manufacturing industry. *International Journal of Production Economics*, 170, 445-456.
- CHING, H. Y. & GERAB, F. 2017. Sustainability reports in Brazil through the lens of signaling, legitimacy and stakeholder theories. *Social Responsibility Journal*, 13, 95-110.
- CHIU, S.-C., LIN, H.-C. & WANG, C.-S. 2017. The Impact of Investments in Pollution Reduction on Shareholder Wealth: Evidence from Taiwanese Manufacturing Companies. *Corporate Social Responsibility and Environmental Management*, 24, 676-691.
- CONNELLY, B. L., CERTO, S. T., IRELAND, R. D. & REUTZEL, C. R. 2011. Signaling theory: A review and assessment. *Journal of Management*, 37, 39-67.
- CONNELLY, B. L., CERTO, S. T., REUTZEL, C. R., DESJARDINE, M. R. & ZHOU, Y. S. 2025. Signaling theory: state of the theory and its future. *Journal of Management*, 51, 24-61.

- CORBETT, C. J., MONTES-SANCHO, M. J. & KIRSCH, D. A. 2005. The Financial Impact of ISO 9000 Certification in the United States: An Empirical Analysis. *Management Science*, 51, 1046-1059.
- COWAN, A. R. 1992. Nonparametric event study tests. *Review of Quantitative Finance and Accounting*, 2, 343-358.
- CUADRADO-BALLESTEROS, B., GARCIA-SANCHEZ, I.-M. & FERRERO, J. M. 2016. How are corporate disclosures related to the cost of capital? The fundamental role of information asymmetry. *Management Decision*, 54, 1669-1701.
- DANDO, N. & SWIFT, T. 2003. Transparency and assurance minding the credibility gap. *Journal of Business Ethics*, 44, 195-200.
- ECCLES, R. G., IOANNOU, I. & SERAFEIM, G. 2014. The impact of corporate sustainability on organizational processes and performance. *Management Science*, 60, 2835-2857.
- EFTEKHAR, M., LI, H., VAN WASSENHOVE, L. N. & WEBSTER, S. 2017. The role of media exposure on coordination in the humanitarian setting. *Production and Operations Management*, 26, 802-816.
- FAN, D., LO, C. K. Y., YEUNG, A. C. L. & CHENG, T. C. E. 2018. The impact of corporate label change on long-term labor productivity. *Journal of Business Research*, 86, 96-108.
- FERNANDEZ-FEIJOO, B., ROMERO, S. & RUIZ, S. 2014. Effect of Stakeholders' Pressure on Transparency of Sustainability Reports within the GRI Framework. *Journal of Business Ethics*, 122, 53-63.
- FERREIRA QUILICE, T., ORANGES CEZARINO, L., FERNANDES RODRIGUES ALVES, M., BARTOCCI LIBONI, L. & FERREIRA CALDANA, A. C. 2018. Positive and negative aspects of GRI reporting as perceived by Brazilian organizations. *Environmental Quality Management*, 27, 19-30.
- FLAMMER, C. 2015. Does Corporate Social Responsibility Lead to Superior Financial Performance? A Regression Discontinuity Approach. *Management Science*, 61, 2549-2568.
- FLAMMER, C., TOFFEL, M. W. & VISWANATHAN, K. 2019. Shareholder Activism and Firms' Voluntary Disclosure of Climate Change Risks. *Available at SSRN*.
- FRIEDMAN, A. L. & MILES, S. 2002. Developing Stakeholder Theory. *Journal of Management Studies*, 39, 1-21.
- FRISKE, W., HOELSCHER, S. A. & NIKOLOV, A. N. 2023. The impact of voluntary sustainability reporting on firm value: Insights from signaling theory. *Journal of the Academy of Marketing Science*, 51, 372-392.
- GAO, H., DARROCH, J., MATHER, D. & MACGREGOR, A. 2008. Signaling corporate strategy in IPO communication: A study of biotechnology IPOs on the NASDAQ. *The Journal of Business Communication* (1973), 45, 3-30.
- GLAVAS, A. & KELLEY, K. 2014. The effects of perceived corporate social responsibility on employee attitudes. *Business Ethics Quarterly*, 24, 165-202.
- GOLICIC, S. L. & SMITH, C. D. 2013. A meta-analysis of environmentally sustainable supply chain management practices and firm performance. *Journal of Supply Chain Management*, 49, 78-95.
- GREENE, W. H. 2003. *Econometric analysis*, Pearson Education India.
- GRI. 2020. *GRI's history* [Online]. Available: <https://www.globalreporting.org/about-gri/mission-history/> [Accessed 18 Mar 2019].
- HART, S. L. & DOWELL, G. 2011. Invited editorial: A natural-resource-based view of the firm: Fifteen years after. *Journal of Management*, 37, 1464-1479.

- HE, H., YE, Y. & HUO, B. 2024. Can employee training facilitate production repurposing in crises? An ability-motivation-opportunity perspective. *International Journal of Production Economics*, 278, 109444.
- HECKMAN, J. J. 1979. Sample selection bias as a specification error. *Econometrica: Journal of the Econometric Society*, 153-161.
- HENDRICKS, K. B., HORA, M. & SINGHAL, V. R. 2015. An Empirical Investigation on the Appointments of Supply Chain and Operations Management Executives. *Management Science*, 61, 1562-1583.
- HERREMANS, I. M., NAZARI, J. A. & MAHMOUDIAN, F. 2016. Stakeholder Relationships, Engagement, and Sustainability Reporting. *Journal of Business Ethics*, 138, 417-435.
- JACOBS, B. W., SINGHAL, V. R. & SUBRAMANIAN, R. 2010. An empirical investigation of environmental performance and the market value of the firm. *Journal of Operations Management*, 28, 430-441.
- JANNEY, J. J. & FOLTA, T. B. 2003. Signaling through private equity placements and its impact on the valuation of biotechnology firms. *Journal of Business Venturing*, 18, 361-380.
- JANNEY, J. J. & FOLTA, T. B. 2006. Moderating effects of investor experience on the signaling value of private equity placements. *Journal of Business Venturing*, 21, 27-44.
- KETOKIVI, M. & MCINTOSH, C. N. 2017. Addressing the endogeneity dilemma in operations management research: Theoretical, empirical, and pragmatic considerations. *Journal of Operations Management*, 52, 1-14.
- KHAN, M., SERAFEIM, G. & YOON, A. 2016. Corporate sustainability: First evidence on materiality. *The Accounting Review*, 91, 1697-1724.
- KLASSEN, R. D. 1993. The integration of environmental issues into manufacturing. *Production and Inventory Management Journal*, 34, 82.
- KLASSEN, R. D. & VEREECKE, A. 2012. Social issues in supply chains: Capabilities link responsibility, risk (opportunity), and performance. *International Journal of Production Economics*, 140, 103-115.
- KOLK, A. & PEREGO, P. 2010. Determinants of the adoption of sustainability assurance statements: An international investigation. *Business strategy and the environment*, 19, 182-198.
- KPMG 2017. The KPMG Survey of Corporate Responsibility Reporting.
- KPMG 2022. KPMG Survey of Sustainability Reporting.
- LEE, J. & MAXFIELD, S. 2015. Doing Well by Reporting Good: Reporting Corporate Responsibility and Corporate Performance. *Business and Society Review*, 120, 577-606.
- LI, F., LO, C. K., TANG, C. S. & ZHOU, P. 2024. Will diversity, equity, and inclusion commitment improve manufacturing firms' market performance? A signaling theory perspective on DEI announcements. *Production and Operations Management*, 34(3), 331-342.
- LIU, L. X., SHERMAN, A. E. & ZHANG, Y. 2014. The long-run role of the media: Evidence from initial public offerings. *Management Science*, 60, 1945-1964.
- LO, C. K., YEUNG, A. C. & CHENG, T. 2009. ISO 9000 and supply chain efficiency: Empirical evidence on inventory and account receivable days. *International Journal of Production Economics*, 118, 367-374.
- LO, C. K. Y., PAGELL, M., FAN, D., WIENGARTEN, F. & YEUNG, A. C. L. 2014. OHSAS 18001 certification and operating performance: The role of complexity and coupling. *Journal of Operations Management*, 32, 268-280.
- LO, C. K. Y., TANG, C. S., ZHOU, Y., YEUNG, A. C. L. & FAN, D. 2018. Environmental Incidents and the Market Value of Firms: An Empirical Investigation in the Chinese Context. *Manufacturing & Service Operations Management*, 20, 422-439.

- LOH, L., THOMAS, T. & WANG, Y. 2017. Sustainability reporting and firm value: Evidence from Singapore-listed companies. *Sustainability*, 9, 2112.
- LONGONI, A., PAGELL, M., SHEVCHENKO, A. & KLASSEN, R. 2019. Human capital routines and sustainability trade-offs: The influence of conflicting schemas for operations and safety managers. *International Journal of Operations & Production Management*, 39, 690-713.
- LUO, X. & BHATTACHARYA, C. B. 2006. Corporate social responsibility, customer satisfaction, and market value. *Journal of Marketing*, 70, 1-18.
- MACKINLAY, A. C. 1997. Event Studies in Economics and Finance. *Journal of Economic Literature*, 35, 13-39.
- MONTGOMERY, C. A. & WERNERFELT, B. 1988. Diversification, Ricardian rents, and Tobin's q. *The Rand Journal of Economics*, 623-632.
- NETLAND, T. H., SCHLOETZER, J. D. & FERDOWS, K. 2021. Learning lean: rhythm of production and the pace of lean implementation. *International Journal of Operations & Production Management*, 41, 131-156.
- NISHANT, R., TEO, T. S. & GOH, M. 2017. Do shareholders value green information technology announcements? *Journal of the Association for Information Systems*, 18, 3.
- ORZES, G., MORETTO, A. M., MORO, M., ROSSI, M., SARTOR, M., CANIATO, F. & NASSIMBENI, G. 2020. The impact of the United Nations global compact on firm performance: A longitudinal analysis. *International Journal of Production Economics*, 227, 107664.
- PANWAR, R. & SUDDABY, R. 2021. Managing Transparency: Non-Financial Disclosure and the Responsible Corporation [Special Issue]. *California Management Review*.
- PAPOUTSI, A. & SODHI, M. S. 2020. Does disclosure in sustainability reports indicate actual sustainability performance? *Journal of Cleaner Production*, 121049.
- POLMAN, P. & BHATTACHARYA, C. 2016. Engaging employees to create a sustainable business. *Stanford Social Innovation Review*, 14, 34-39.
- QI, Y., WANG, X., ZHANG, M. & WANG, Q. 2023. Developing supply chain resilience through integration: An empirical study on an e-commerce platform. *Journal of Operations Management*, 69, 477-496.
- QIU, Y. & KAHN, M. E. 2018. Better sustainability assessment of green buildings with high-frequency data. *Nature Sustainability*, 1, 642-649.
- ROBINSON, M., KLEFFNER, A. & BERTELS, S. 2011. Signaling sustainability leadership: Empirical evidence of the value of DJSI membership. *Journal of Business Ethics*, 101, 493-505.
- RODRIGO, P., AQUEVEQUE, C. & DURAN, I. J. 2019. Do employees value strategic CSR? A tale of affective organizational commitment and its underlying mechanisms. *Business ethics: A European Review*, 28, 459-475.
- RODRIGUES, A. C., MARTINS, R. S., WANKE, P. F. & SIEGLER, J. 2018. Efficiency of specialized 3PL providers in an emerging economy. *International Journal of Production Economics*, 205, 163-178.
- SARKIS, J. 2001. Manufacturing's role in corporate environmental sustainability-Concerns for the new millennium. *International Journal of Operations & Production Management*, 21, 666-686.
- SCHADEWITZ, H. & NISKALA, M. 2010. Communication via responsibility reporting and its effect on firm value in Finland. *Corporate Social Responsibility and Environmental Management*, 17, 96-106.
- SEARCY, C. & BUSLOVICH, R. 2014. Corporate Perspectives on the Development and Use of Sustainability Reports. *Journal of Business Ethics*, 121, 149-169.

- SHAD, M. K., LAI, F.-W., FATT, C. L., KLEMEŠ, J. J. & BOKHARI, A. 2019. Integrating sustainability reporting into enterprise risk management and its relationship with business performance: A conceptual framework. *Journal of Cleaner Production*, 208, 415-425.
- SONG, S., LIAN, J., SKOWRONSKI, K. & YAN, T. 2023. Customer base environmental disclosure and supplier greenhouse gas emissions: a signaling theory perspective. *Journal of Operations Management*, 70(3), 355-380.
- SORESCU, A., WARREN, N. L. & ERTEKIN, L. 2017. Event study methodology in the marketing literature: an overview. *Journal of the Academy of Marketing Science*, 45, 186-207.
- SPENCE, M. 2002. Signaling in retrospect and the informational structure of markets. *American Economic Review*, 92, 434-459.
- SWIFT, C., GUIDE JR, V. D. R. & MUTHULINGAM, S. 2019. Does supply chain visibility affect operating performance? Evidence from conflict minerals disclosures. *Journal of Operations Management*, 65, 406-429.
- TOPPINEN, A. & KORHONEN-KURKI, K. 2013. Global Reporting Initiative and social impact in managing corporate responsibility: a case study of three multinationals in the forest industry. *Business Ethics: A European Review*, 22, 202-217.
- VERBEETEN, F. H., GAMERSCHLAG, R. & MÖLLER, K. 2016. Are CSR disclosures relevant for investors? Empirical evidence from Germany. *Management Decision*, 54, 1359-1382.
- WANG, J. X., CHOI, T.-M., WOOD, L. C., OLESEN, K. & REINERS, T. 2024. When suppliers engage in sustainable supply chain management: how does the stock market react? *International Journal of Operations & Production Management*, 44, 699-727.
- WANG, Y., JI, J., ZHANG, M. & WANG, X. 2025. Does workforce diversity, equity, and inclusion prevent patient safety incidents: a double machine learning approach. *Journal of the Association for Information Systems*, 26, 729-759.
- WARTICK, S. L. 1992. The relationship between intense media exposure and change in corporate reputation. *Business & Society*, 31, 33-49.
- WIENGARTEN, F., LO, C. K. & LAM, J. Y. 2017. How does sustainability leadership affect firm performance? The choices associated with appointing a chief officer of corporate social responsibility. *Journal of Business Ethics*, 140, 477-493.
- WILLIS, A. 2003. The role of the global reporting initiative's sustainability reporting guidelines in the social screening of investments. *Journal of Business Ethics*, 43, 233-237.
- WONG, C. W., WONG, C. Y., BOON-ITT, S. & TANG, A. K. 2021. Strategies for building environmental transparency and accountability. *Sustainability*, 13, 9116.
- XIA, Y., SINGHAL, V. R. & ZHANG, G. P. 2016. Product Design Awards and The Market Value of The Firm. *Production and Operations Management*, 25, 1038-1055.
- XU, M., LAI, I. K. W. & TANG, H. 2021. From corporate environmental responsibility to purchase intention of Chinese buyers: The mediation role of relationship quality. *Journal of Consumer Behaviour*, 20, 309-323.
- XU, M., TSE, Y. K., GENG, R., LIU, Z. & POTTER, A. 2025. Greenwashing and market value of firms: An empirical study. *International Journal of Production Economics*, 284, 109606.
- YANG, Y., ORZES, G., JIA, F. & CHEN, L. 2021. Does GRI sustainability reporting pay off? An empirical investigation of publicly listed firms in China. *Business & Society*, 60, 1738-1772.

- ZHAO, S., WANG, M., ZHU, Q., ZHOU, Q. & MAO, R. 2024. Effects of information asymmetry on green advertising for remanufacturing within a closed-loop supply chain. *Transportation Research Part E: Logistics and Transportation Review*, 188, 103618.
- ZHANG, G. P. & XIA, Y. 2013. Does quality still pay? A reexamination of the relationship between effective quality management and firm performance. *Production and operations management*, 22, 120-136

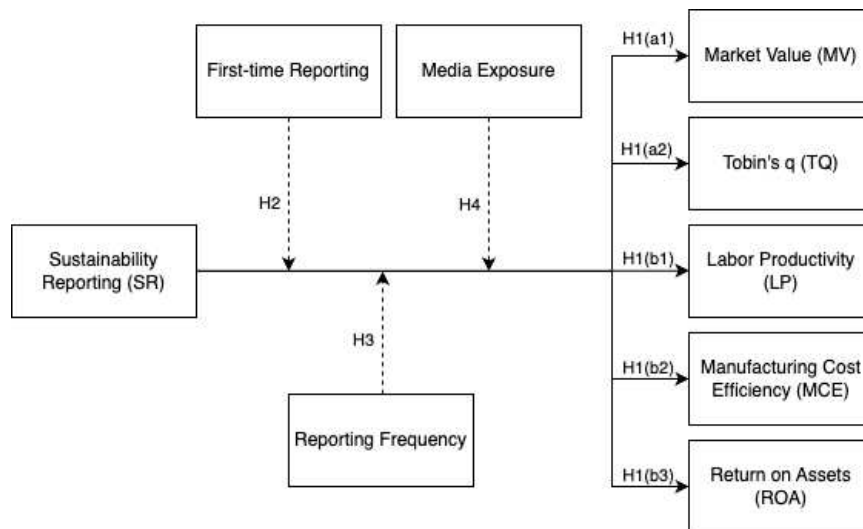


Figure 1. Conceptual framework

Table 1. Descriptive statistics**Panel A: Sector distribution of the observations**

Sector Description	SIC code	Number of observations
Food, textiles, furniture, paper and chemicals	2000-2999	613
Rubber, leather, stone, metals, machinery, and equipment	3000-3569, 3580-3659, and 3800-3999	345
Computers, electronics, communications, and defense	3570-3579, 3660-3699, and 3760-3789	129
Automobile, aircraft, and transportation	3700-3759, and 3790-3799	85
Other		82
Total		1254

Panel B: Matching Results across DVs and Datasets

Dataset	Analysis	Observations				
A restricted dataset is used to ensure that the event study hypotheses are tested using non-overlapping windows.	Even study	ROA	LP	C/S	MV	TQ
		278	275	276	266	274
Full observations	Regression	ROA	LP	C/S	MV	TQ
		1031	1041	1044	977	1068

Panel C: Matched sample characteristics by group

Variable	N	Sample group			Control group		
		Mean	Median	SD	Mean	Median	SD
Return on Assets (ROA)	1031	0.145	0.137	0.0692	0.144	0.136	0.0677
Labor Productivity (LP)	1041	114.482	69.649	177.193	113.612	69.034	175.262
COGS/Sales (C/S)	1044	0.570	0.586	0.205	0.570	0.589	0.201
Market Value (MV)	977	27529.830	10664.827	45025.121	27318.962	10562.156	44536.923
Tobin's q (TQ)	1068	2.033	1.781	0.961	2.018	1.760	0.951

Note: ROA is Return on Assets. LP is labor productivity. C/S is the Cost of Goods Sold / Sales. MV is market value. TQ is Tobin's q. Control groups were matched observations using portfolio matching by industry, combined with each dependent variable (Year $t-1$ to $t+1$). ROA, C/S and TQ are ratio variables. The units of LP and MV are million USD per thousand employees and million USD, respectively. The number of firm-year observations used in the event study is reduced to ensure that the hypothesis tests are not affected by overlapping event windows.

Table 2. Event study results

Period	Var.	N	Median	Z ^a	% positive	Z ^b	sk	Mean	t
Year -1 to Year 0	ROA	278	0.006	3.059 (0.002)**	59.35	3.275 (0.001)**		0.006	2.692 (0.008)**
	LP	275	2.346	2.192 (0.028)*	56.00	1.930 (0.054)+		2.025	1.621 (0.106)
	C/S	276	-0.003	-2.140 (0.032)*	46.01	-1.264 (0.206)	s	-0.017	-2.537 (0.012)*
	MV	266	4.469	0.783 (0.434)	50.00	0.000 (1.000)		458.171	1.621 (0.106)
	TQ	274	0.334	1.982 (0.047)*	56.57	2.114 (0.034)*		0.442	1.947 (0.053)+
Year -1 to Year 1	ROA	254	0.013	3.576 (0.000)***	61.42	4.019 (0.000)***		0.012	3.930 (0.000)***
	LP	252	5.146	3.011 (0.003)**	59.12	2.835 (0.005)**		6.782	2.297 (0.023)*
	C/S	255	-0.006	-3.367 (0.001)**	43.52	-2.004 (0.045)*		-0.031	-3.223 (0.001)**
	MV	254	329.969	2.396 (0.017)*	55.33	1.600 (0.109)	s	684.289	2.297 (0.023)*
	TQ	253	-0.103	0.763 (0.445)	47.83	-0.629 (0.530)		0.520	1.434 (0.153)
Year -1 to Year 2	ROA	236	0.142	2.018 (0.044)*	56.78	3.284 (0.001)**		0.008	3.801 (0.000)***
	LP	252	3.230	1.925 (0.054)+	57.76	2.298 (0.022)*		5.643	2.433 (0.016)*
	C/S	240	-0.003	-3.190 (0.001)**	46.25	-1.097 (0.272)		-0.047	-3.654 (0.000)***
	MV	221	363.326	2.046 (0.041)*	53.85	1.076 (0.282)		1116.701	2.433 (0.016)*
	TQ	236	0.001	-0.270 (0.787)	50.42	-0.065 (0.948)		0.279	0.633 (0.527)
Year 0 to Year 1	ROA	254	0.007	2.447 (0.014)*	57.87	2.738 (0.006)**		0.003	2.784 (0.06)*
	LP	232	3.181	1.819 (0.069)+	58.33	2.583 (0.010)*		6.457	2.160 (0.032)*
	C/S	255	-0.003	-3.127 (0.002)**	43.14	-2.129 (0.033)**		-0.015	-2.888 (0.004)**

Year 0 to Year 2	MV	244	142.752	1.854 (0.064) [†]	56.56	1.985 (0.047) [*]	s	201.070	2.160 (0.032) [*]
	TQ	253	0.207	0.797 (0.426)	55.73	1.760 (0.078) [†]		0.171	0.621 (0.535)
	ROA	236	0.009	1.627 (0.104)	55.51	2.287 (0.022) [*]		0.006	2.529 (0.012) [*]
	LP	232	2.463	1.819 (0.069) [†]	54.31	1.247 (0.212)		5.893	-2.096 (0.037) [*]
	C/S	240	-0.006	-2.812 (0.005) ^{**}	41.67	-2.517 (0.012) [*]		-0.031	-2.560 (0.011) [*]
	MV	221	64.304	1.441 (0.150)	52.94	0.807 (0.420)		739.807	2.096 (0.037) [*]
	TQ	236	-0.012	-0.200 (0.841)	50.00	0.000 (1.000)		-0.012	-0.303 (0.762) [*]
	ROA	236	0.001	0.976 (0.329)	53.39	0.692 (0.489)		0.001	0.471 (0.638)
	LP	232	-0.174	0.680 (0.490)	49.57	0.066 (0.948)		0.360	-1.511 (0.132)
	C/S	240	-0.001	-1.213 (0.225)	49.17	-0.194 (0.846)		-0.015	-1.433 (0.153)
Year 1 to Year 2	MV	221	11.054	0.163 (0.870)	50.23	0.000 (1.000)		723.476	1.511 (0.132)
	TQ	236	-0.028	-0.056 (0.955)	50.88	-0.195 (0.845)		-0.028	-0.874 (0.383)

Note:

† p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001 (2-tailed). p-value in parentheses.

ROA is Return on Assets; LP is labor productivity; C/S is COGS/Sales; MV is market value; and TQ is Tobin's q.

^aZ-statistics for medians using Wilcoxon signed-rank tests. ^bZ-statistics for % positive using binomial sign tests.

Event Year 0 is the year of the sustainability report release.

The column *sk* indicates the skewness. When the data are skewed (absolute skewness greater than 1), Sign results (*Z^b*) is more appropriate (Cowan, 1992; Swift et al., 2019).

Table 3. Regression results of operational efficacy

	Panel A					Panel B				
	Dependent variable: <i>Labor Productivity</i>					Dependent variable: <i>COGS/Sales</i>				
	Baseline Model (OLS)	Model 1 OLS	Model 2 RLM	Model 3 (OLS with IMR)	Model 4 (RLM with IMR)	Baseline Model (OLS)	Model 1 OLS	Model 2 RLM	Model 3 (OLS with IMR)	Model 4 (RLM with IMR)
Sample Firm's ROA	13.27 (0.45)	10.73 (0.37)	38.56** (2.58)	23.44 (0.81)	39.00** (2.59)	0.156** (2.92)	0.153** (2.93)	0.0140 (0.80)	0.153** (2.94)	0.0142 (0.81)
Industry's 3-year averaged ROA	-0.0924 (-0.76)	-0.0889 (-0.74)	-0.148+ (-1.75)	0.196 (1.33)	-0.132 (-1.44)	0.0939 (0.84)	0.0782 (0.70)	-0.00356 (-0.03)	0.101 (0.78)	-0.00616 (-0.05)
Firm size	0.613 (0.38)	0.338 (0.21)	2.557** (2.63)	-27.16*** (-3.42)	1.034 (0.28)	0.0172* (2.38)	0.0152* (2.09)	0.00417*** (3.32)	0.0436* (2.24)	0.00911* (1.98)
Media Exposure	-	-1.234 (-0.35)	1.309 (0.56)	1.030 (0.30)	1.415 (0.60)	-	-0.0109 (-0.94)	0.00331 (1.02)	-0.0129 (-1.07)	0.00276 (0.85)
First-time Reporting	-	24.60** (2.59)	18.28*** (3.40)	22.50* (2.38)	18.19*** (3.37)	-	-0.00928 (-0.46)	-0.0124 (-1.63)	-0.00678 (-0.33)	-0.0123 (-1.61)
Reporting Frequency	-	29.42** (2.86)	22.40*** (3.88)	26.79** (2.62)	22.32*** (3.85)	-	0.00497 (0.22)	-0.0131 (-1.61)	0.00776 (0.35)	-0.0129 (-1.58)
IMR	-	-	-	-140.8*** (-3.72)	-7.463 (-0.41)	-	-	-	0.148* (1.79)	0.0250 (1.09)
Constant	19.62 (0.84)	-4.203 (-0.15)	-15.06 (-0.64)	432.5*** (3.54)	8.491 (0.14)	-0.160* (-2.14)	-0.153* (-1.81)	-0.0186 (-0.55)	-0.610* (-2.03)	-0.0971 (-1.24)
Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1041	1041	1041	1041	1041	1044	1044	1044	1044	1044
R ²	0.119	0.126	-	0.144	-	0.285	0.287	-	0.290	-
adj. R ²	0.035	0.041	-	0.059	-	0.219	0.218	-	0.220	-
F	1.422***	1.475***	-	1.696***	-	4.278	4.160***	-	4.168***	-

Note: t statistics in parentheses. * $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (two-tailed). IMR is the inverse Mills ratio.

Table 4. Regression result for abnormal market value and Tobin's q

	Panel A Dependent Variable: <i>Market Value</i>					Panel B Dependent Variable: <i>Tobin's q</i>					Panel C Dependent variable: <i>ROA</i>				
	Baseline Model (OLS)	Model 1 OLS	Model 2 RLM	Model 3 (OLS with IMR)	Model 4 (RLM with IMR)	Baseline Model (OLS)	Model 1 OLS	Model 2 RLM	Model 3 (OLS with IMR)	Model 4 (RLM with IMR)	Baseline Model (OLS)	Model 1 OLS	Model 2 RLM	Model 3 (OLS with IMR)	Model 4 (RLM with IMR)
Sample's ROA	-8009.8 (-1.17)	-8108.4 (-1.17)	-6884.7 (-1.64)	-8459.5 (-1.22)	-7002.4 ⁺ (-1.68)	-0.449 ⁺ (-1.67)	-0.424 (-1.56)	-0.211 (-0.87)	-0.425 (-1.60)	-0.189 (-0.79)	0.0829*** (3.34)	0.0840*** (3.35)	0.116*** (5.27)	0.0736** (3.01)	0.102*** (4.65)
Industry's 3-year averaged ROA	- 33721.3* *	-33689.9**	-32732.7	-38558.7***	-36766.2	-1.528	-1.325	-1.051	-1.129	-0.614	8.08e-08	-1.92e-09	0.00000256	-0.000239 ⁺	-0.000227 ⁺
Firm size	(-2.99) -1107.8 ⁺ (-1.80)	(-2.89) -1155.4 ⁺ (-1.74)	(-1.26) 397.3 (1.33)	(-3.46) -7310.3*** (-3.32)	(-1.43) -3391.5** (-3.12)	(-1.02) 0.0341 ⁺ (1.77)	(-0.87) 0.0408* (2.06)	(-0.68) 0.0305 ⁺ (1.81)	(-0.66) 0.294*** (4.18)	(-0.40) 0.279*** (4.55)	(0.00) -0.00372** (-3.05)	(-0.00) -0.00295* (-2.37)	(0.02) -0.00318* (-2.31)	(-1.91) 0.0193*** (3.77)	(-1.76) 0.0195*** (3.79)
Media Exposure		-634.4 (-0.51)	414.8 (0.54)	-167.1 (-0.14)	579.1 (0.76)		0.0460 (0.96)	0.0596 (1.37)	0.0278 (0.58)	0.0415 (0.95)		0.00806** (2.67)	0.00919** (2.77)	0.00605* (2.00)	0.00678* (2.04)
First-time Reporting		972.2 (0.34)	2229.3 (1.23)	241.3 (0.08)	1702.8 (0.94)		0.226* (2.30)	0.314** (3.05)	0.247* (2.49)	0.333** (3.25)		0.0237** (3.08)	0.0283*** (3.63)	0.0252*** (3.31)	0.0289*** (3.75)
Reporting Frequency		1073.0 (0.33)	1815.7 (0.93)	89.71 (0.03)	1060.6 (0.55)		0.226* (2.14)	0.325** (2.96)	0.255* (2.40)	0.342** (3.13)		0.0237** (3.00)	0.0278*** (3.33)	0.0254** (3.24)	0.0291*** (3.53)
IMR				-31920.5** (-3.16)	-19013.5*** (-3.51)				1.316*** (3.88)	1.273*** (4.15)				0.114*** (4.47)	0.117*** (4.57)
Constant	6401.2 (0.27)	4293.4 (0.18)	-18404.5* (-2.34)	103455.9* (2.56)	41408.1* (2.23)	-0.477 (-1.06)	-0.682 (-1.42)	-0.646 (-1.40)	-4.751*** (-4.00)	-4.606*** (-4.38)	0.0243 (0.80)	0.0140 (0.43)	0.0137 (0.41)	-0.340*** (-4.00)	-0.345*** (-4.03)
Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	977	977	977	977	977	1068	1068	1068	1068	1068	1031	1031	1031	1031	1031
R ²	0.110	0.110	-	0.119	-	0.171	0.176	-	0.191	-	0.184	0.198	-	0.217	-
adj. R ²	0.020	0.017	-	0.026	-	0.096	0.098	-	0.113	-	0.106	0.118	-	0.138	-
F	1.226	1.185	-	1.281	-	2.268***	2.262***	-	2.468***	-	2.352***	2.486***	-	2.756***	-

Note: *t*-statistics in parentheses. * $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (two-tailed). IMR is the inverse Mills ratio.

Appendix I: Two concrete examples of SR

#	Reporting outlines and SR indices	Sustainability Goals and Actions (with SR indicators)
Nvidia SIC-36 (US Manufacturing) (FY 2024)⁴		
General disclosure indicators (GRI 2 series)	◇ <i>GRI 2-1</i>: Organizational details, ◇ <i>GRI 2-2</i>: Entities included in the organization’s sustainability reporting, ◇ <i>GRI 2-3</i>: Reporting period, frequency, and contact point, ◇ <i>GRI 2-5</i>: External assurance, ◇ <i>GRI 2-7</i>: Employees ◇ <i>GRI 2-9</i>: Governance structure and composition, ◇ <i>GRI 2-10</i>: Nomination and selection of the highest governance body ◇ <i>GRI 2-11</i>: Chair of the highest governance body, ◇ <i>GRI 2-12, 2-13, 2-14</i>: Sustainability governance, <i>GRI 2-15</i>: Conflicts of interest ◇ <i>GRI 2-16</i>: Communication of critical concerns, ◇ <i>GRI 2-17</i>: Collective knowledge of the highest governance body, ◇ <i>GRI 2-18</i>: Evaluation of the governance body's performance, ◇ <i>GRI 2-19, 2-20, 2-21</i>: Remuneration, <i>GRI 2-22</i>: Statement on sustainable development strategy ◇ <i>GRI 2-23, 2-24</i>: Policy commitments and embedding, <i>GRI 2-25, 2-26</i>: Raising concerns, <i>GRI 2-27</i>: Legal compliance ◇ <i>GRI 2-28</i>: Membership associations, <i>GRI 2-29</i>: Stakeholder engagement	<u>Achieve 100% renewable electricity at all controlled facilities by FY25.</u> • Achieved 76% renewable electricity use in FY24 via <i>GRI 302-1 and 302-4</i>. • Installed 846 kW of on-site solar and operated ISO 50001-certified energy management systems under <i>GRI 302-1 and GRI 302-4</i>. <u>Reduce lifecycle emissions and increase recyclability of products and packaging.</u> • Achieved >90% recyclable packaging by weight for NVIDIA GPU systems via <i>GRI 301-3</i>. • Conducted carbon foot printing on selected products and reused high-performance systems such as DGX via resale/refurbishment via <i>GRI 301-2, 301-3, and 306-2</i>. <u>Engage suppliers responsible for >60% of NVIDIA’s Scope 3, Category 1 emissions by FY2026.</u> • Included science-based targets in supplier expectations and integrated ESG terms into contracts (<i>GRI 305-3, 308-1, 308-2, 414-1, 414-2</i>). <u>Achieve and maintain pay equity and promote an inclusive, low-turnover workforce.</u> • Verified 100% gender and ethnic pay parity in the U.S (<i>GRI 405-2</i>) • Maintained a 2.7% employee turnover rate, significantly below industry average (<i>GRI 401-1</i>). • Offered mentorship and DEI learning to ~1,000 employees; expanded global wellness programs (<i>GRI 403-6 and 405-1</i>). <u>Ensure transparency and accountability in AI development.</u> • Launched “Model Card++” for disclosure of AI model intent, data, and performance characteristics (<i>GRI 416-1 and 417-1</i>). • Piloted an AI Ethics Committee and trained internal teams on responsible AI principles (<i>GRI 418-1</i>). <u>Strengthen ESG oversight and transparency across leadership and reporting.</u> • Formed a Corporate Sustainability Steering Committee and conducted quarterly sustainability calls with investors (<i>GRI 2-9 and GRI 2-29</i>).
Environmental indicators (GRI 3 series)	◇ <i>GRI 302-1, 302-3, 302-4, 302-5</i>: Energy consumption, intensity, and reduction ◇ <i>GRI 303-1, 303-3, 303-4, 303-5</i>: Water use and interactions ◇ <i>GRI 305-1, 305-2, 305-3, 305-4, 305-5</i>: GHG emissions and intensity ◇ <i>GRI 306-1, 306-2, 306-3, 306-4, 306-5</i>: Waste management ◇ <i>GRI 308-1, 308-2</i>: Supplier environmental assessment	

⁴ <https://images.nvidia.com/aem-dam/Solutions/documents/FY2024-NVIDIA-Corporate-Sustainability-Report.pdf>

Social indicators (GRI 4 series)	◇ <i>GRI 401-1, 401-2, 401-3: Employment and benefits</i> ◇ <i>GRI 403-1, 403-2, 403-4, 403-5, 403-6, 403-7, 403-8, 403-9: Occupational health and safety</i> ◇ <i>GRI 404-1, 404-2, 404-3: Training and performance reviews</i> ◇ <i>GRI 405-1, 405-2: Diversity and equal remuneration</i> ◇ <i>GRI 407-1, 408-1, 409-1: Freedom of association, child labor, forced labor</i> ◇ <i>GRI 414-1, 414-2: Supplier social assessment</i>	• Plan to implement a double materiality assessment by FY2025 (<i>GRI 3-1 and 3-2</i>).
Ford SIC-37 (US Manufacturing) (FY 2023)⁵		
General disclosure indicators (GRI 2 series)	◇ <i>GRI 2-1: Organizational details</i> ◇ <i>to 2-30 (General Disclosures),</i> ◇ <i>GRI 201–207 (Economic),</i> ◇ <i>GRI 301–308 (Environmental),</i> ◇ <i>GRI 401–418 (Social).</i>	<u>Carbon neutrality by 2050.</u> • 100% carbon-free electricity in manufacturing by 2035. Transparency in Scope 1–3 emissions via <i>GRI 305</i>. Electric vehicle initiatives reported under <i>GRI 302 and 305</i>. <u>Use only recycled or renewable content in vehicle plastics.</u> • Interim targets: 20% recycled/renewable plastics in NA/EU by 2025 (<i>GRI 301-2</i>). • Component remanufacturing and recycled materials use in vehicle parts. <u>Zero water withdrawals for manufacturing processes.</u> • Water stewardship practices reported under <i>GRI 303</i>. • Use of CDP Water data to report withdrawals, discharges, and risk areas. <u>Diverse culture and ethical sourcing.</u> • Worker well-being and health & safety (<i>GRI 403</i>). • Supplier assessments using SAQs aligned with <i>GRI 308 and 414</i>. • Human rights audits and remediation plans disclosed. <u>Zero waste to landfill and eliminate single-use plastics by 2030.</u> • Waste streams reported under <i>GRI 306</i>. • Environmental auditing and supplier compliance built into contracts. <u>Products designed with leading safety and ethical digital practices.</u> • Product safety recalls (<i>GRI 416</i>), customer privacy and cybersecurity policies (<i>GRI 418</i>). • Responsible marketing practices (<i>GRI 417</i>).
Environmental indicators (GRI 3 series)	◇ Scope 1, 2, and 3 emissions (<i>GRI 305-1 to 305-3</i>) ◇ Waste generated/diverted (<i>GRI 306-1 to 306-5</i>) ◇ Water withdrawal/discharge (<i>GRI 303-3 to 303-5</i>)	
Social indicators (GRI 4 series)	◇ Employment metrics (<i>GRI 401-1 to 401-3</i>) ◇ Diversity (<i>GRI 405</i>) ◇ Child labor (<i>GRI 408</i>)	

⁵ <https://corporate.ford.com/content/dam/corporate/us/en-us/documents/reports/ford-gri-report.pdf>

Appendix II. Correlation matrix and descriptive analysis

Table A1: Descriptive Statistics and Correlation Matrix for ROA

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Abnormal ROA	1.00						
(2) Sustainability related media exposure	0.028	1.00					
(3) First-time Reporting	0.020	0.015	1.00				
(4) Reporting frequency	0.005	-0.003	-0.864*	1.00			
(5) Sample's ROA	0.037	-0.083*	-0.071*	0.056	1.00		
(6) Industry's 3-year averaged ROA	-0.078*	0.387*	0.046	-0.051	-0.104*	1.00	
(7) Firm size	-0.119*	-0.177*	-0.230*	0.217*	0.080*	-0.032	1.00
Mean	0.011	-2.251	0.206	0.655	0.069	-0.179	9.416
SD	0.043	0.629	0.405	0.386	0.078	0.229	1.396

Note: *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)

Table A2: Descriptive Statistics and Correlation Matrix for LP

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Abnormal LP	1.00						
(2) Sustainability related media exposure	-0.069*	1.00					
(3) First-time Reporting	-0.029	0.008	1.00				
(4) Reporting frequency	0.059	0.008	-0.864*	1.00			
(5) Sample's ROA	-0.024	-0.124*	-0.059*	0.040	1.00		
(6) Industry's 3-year averaged ROA	-0.061*	0.391*	0.040	-0.048	-0.122*	1.00	
(7) Firm size	0.056	-0.184*	-0.218*	0.199*	0.141*	-0.040	1.00
Mean	8.349	-2.25	0.205	0.656	0.067	-0.179	9.373
SD	54.334	0.634	0.404	0.386	0.084	0.23	1.426

Note: *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)

Table A3: Descriptive Statistics and Correlations Matrix of COGS/Sales model

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Abnormal COGS/sales	1.00						
(2) Sustainability related media exposure	-0.167*	1.00					
(3) First-time Reporting	-0.05	0.00	1.00				
(4) Reporting frequency	0.03	0.01	-0.864*	1.00			
(5) Sample's ROA	0.093*	-0.116*	-0.05	0.04	1.00		
(6) Industry's 3-year averaged ROA	-0.01	0.392*	0.04	-0.05	-0.116*	1.00	
(7) Firm size	0.168*	-0.192*	-0.217*	0.198*	0.151*	-0.05	1.00
Mean	-0.03	0.20	0.07	9.40	0.067	-0.178	9.40
SD	0.15	0.40	0.08	1.42	0.084	0.23	1.415

Note: *** p<0.01, ** p<0.05, * p<0.1 (two-tailed).

Table A4: Descriptive Statistics and Correlations Matrix of Market Value Model

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Abnormal Tobin's q	1.00						
(2) Sustainability related media exposure	-0.088*	1.00					
(3) First-time Reporting	0.023	0.008	1.00				
(4) Reporting frequency	-0.024	0.008	-0.864*	1.00			
(5) Sample's ROA	0.01	-0.124*	-0.059*	0.04	1.00		
(6) Industry's 3-year averaged ROA	-0.105*	0.391*	0.04	-0.048	-0.122*	1.00	
(7) Firm size	-0.063*	-0.184*	-0.218*	0.199*	0.141*	-0.04	1.00
Mean	425.169	-2.25	0.205	0.656	0.067	-0.179	9.373
SD	19113.681	0.634	0.404	0.386	0.084	0.23	1.426

Note: *** p<0.01, ** p<0.05, * p<0.1 (two-tailed).

Table A5: Descriptive Statistics and Correlation Matrix of Tobin's q model

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Abnormal market value	1.00						
(2) Sustainability related media exposure	0.011	1.00					
(3) First-time Reporting	-0.044	0.008	1.00				
(4) Reporting frequency	0.047	0.008	-0.864*	1.00			
(5) Sample's ROA	-0.021	-0.124*	-0.059*	0.040	1.00		
(6) Industry's 3-year averaged ROA	0.021	0.391*	0.040	-0.048	-0.122*	1.00	
(7) Firm size	0.030	-0.184*	-0.218*	0.199*	0.141*	-0.040	1.00
Mean	0.035	-2.25	0.205	0.656	0.067	-0.179	9.373
SD	0.62	0.634	0.404	0.386	0.084	0.23	1.426

Note: *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)