A Supply Chain Advantage in Disruptive Times: New Perspectives on ESG Strategy

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This study investigates the causal relationship between enhanced environmental, social, and governance (ESG) practices and firm resilience during disruptions, using the COVID-19 pandemic as a natural experiment. We define a firm's resilience as its relatively superior financial performance during the pandemic. Our instrumental variable approach leverages exogenous variations in firm-level ESG controversies publicized by informal institutions (e.g., the global media) and country-level regulatory pressures on ESG adoption by formal institutions (e.g., the rule of law) to isolate the ESG effect. We find that increased ESG practices strengthen a firm's resilience during disruptions: a 1% increase in ESG practice scores leads to a 0.124% increase in firms' return on assets. Exploiting the heterogeneity of stakeholder resources, our mechanism analyses reveal robust evidence that ESG practices strengthen relational ties with suppliers and buyers, fostering procurement and sales advantages during severe external constraints. These benefits extend to firms at both upstream and downstream supply chain tiers, demonstrating the importance of ESG adoption for enhancing resilience across the supply chain. By quantifying the economic rationale for ESG practices, our findings provide empirical evidence supporting the strategic imperative of prioritizing specific stakeholder alignments instead of broad, vague ESG practices that may harm firm performance.

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Key words: ESG strategy, firm resilience, responsible operations, supply chain risk

1. Introduction

There is an increasing trend of corporations adopting environmental, social, and governance (ESG) frameworks towards sustainability and social responsibility. With about 90% of public and 67% of private companies adopting ESG strategies, its asset value by 2030 is predicted to hit $40 trillion (Ground 2022, Bloomberg 2024). In theory, ESG practices can mitigate environmental risks, enhance social capital, and build a more adaptable workforce, all contributing to a firm's ability to withstand disruptions. However, the effectiveness of ESG strategies remains controversial, as executives see the need but lack a convincing business case (Alves et al. 2022, Bothello et al. 2023, McGowan 2023).[1] A key reason is that "ESG is complicated" and that CEOs need precision to "move from intentions to actions" (Cutter and Glazer 2024). Unilever, for example, one of the first companies to embrace ESG more than a decade ago, is weakening or abandoning a number of environmental and social objectives (Afanasieva 2024). Under the provocative headline: 'Defining a new era for sustainability leadership', its CEO Hein says: "The reality is that Unilever's sustainability agenda covers a wide range of issues, but we have learned from experience that we need to be more focused in our allocation of resources to make tangible progress on the big, complex

[1] Reflecting the diverse terminology in the industry and academic literature, throughout this study, terms such as "ESG practices," "initiatives," "strategies," "investment," and "adoption" are used interchangeably.

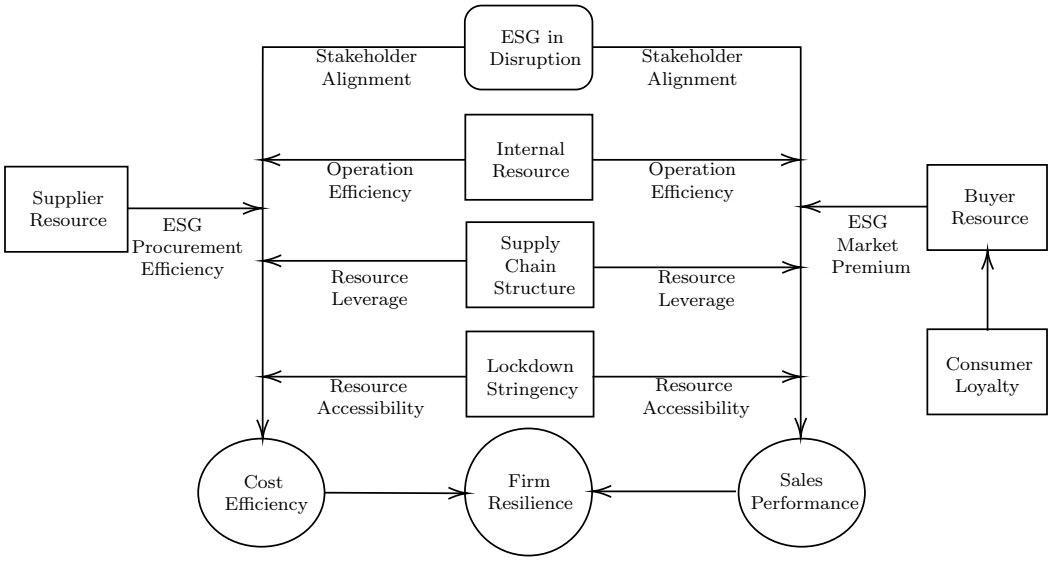
challenges we face." (Afanasieva 2024) The shift comes amid growing pressure from shareholders in global corporations to cut costs and focus more on market performance than ESG. The backlash on ESG adoption is also driven by Unilever's previous broad, vague goals and commitments that cannot be easily mapped to operational outcomes (Downes 2024). As Unilever's policy change is being closely watched by other companies as a potential precedent, clarifying and quantifying the effect of ESG practices becomes imperative (Howard-Grenville 2021).

This study provides the first worldwide causal quantification of the ESG strategy's effect on resilience in a supply chain context. Our estimation reveals that, while slightly hurting firm performance under normal conditions, ESG significantly improves resilience during disruptions. In particular, a 1% increase in the ESG practice score leads to a 0.124% increase in firms' return on assets (ROA) during the disruption. Yet, while quantifying the resilience benefits of ESG practices is crucial, a significant knowledge gap persists regarding the empirical investigation of the underlying mechanisms driving this effect. This issue is significant because understanding the pathways from ESG to resilience is critical for CEOs to take action. Our main contribution is filling this critical gap in the literature.

A key challenge in identifying the source of the ESG resilience effect is that the pathway from ESG to resilience is *latent*, so one cannot directly observe the exact interactions of ESG practices and stakeholder actions (Ortiz-de Mandojana and Bansal 2016). Our novel solution exploits the fact that stakeholder contributions are influenced by their resource richness, the examination of which reveals whether a particular type of stakeholder resource is activated by ESG practices in contributing to firm resilience. Specifically, our investigation starts with a simple yet fundamental observation that, regardless of how ESG activities confer resilience, they must eventually manifest through cost efficiency, sales improvement, or a combination of both. The cost efficiency and sales performance pathways must then be influenced by latent interactions between ESG activities and stakeholder resources. Since not directly observable, we leverage the key insights from the stakeholder theory and the extended resource-based view (ERBV) theory, which predict that a firm's ability to appropriate stakeholder resources is critically influenced by (a) the resource availability of stakeholders and (b) the relational ties between a firm and its stakeholders. Because (a) can be observed from the data and (b) can be approximated by the firm's ESG practices, we can empirically investigate what types of stakeholder resources are activated by the firm's ESG practices through resource heterogeneity analyses. Figure 1 illustrates our investigation framework.

Our framework analysis suggests that ESG practices enhance resilience primarily by fostering greater stakeholder alignment. This is manifested through supply priority conferred by upstream suppliers and an ESG price premium driven by customer loyalty of downstream buyers. However, broad ESG engagements hurt firms' performance during normal times, suggesting that broad,

Figure 1 A Supply Chain Theory of ESG-driven Resilience



Note. The figure highlights cost efficiency and sales performance as the key pathways from ESG adoption to firm resilience. It also illustrates all potential stakeholders' resources that moderate these effects: the firm's internal resources contribute to operational efficiency, supplier resources enhance procurement efficiency, and buyer resources increase market premiums. Additionally, the supply chain structure impacts a firm's ability to leverage supply chain resources effectively, while lockdown stringency influences the accessibility of external resources.

vague ESG activities not only divert critical resources from firms' core operations but also risk reputational damage through accusations of greenwashing from customers and wasteful spending from investors (Cutter and Glazer 2024). Yet, despite such concerns, broad ESG engagements strengthen firms' resilience during disruptive times, implying that at least a subset of ESG practices significantly improves firms' performance under severe resource constraints. Our results indicate that this subset of practices is concentrated in stakeholder alignments with upstream suppliers as well as downstream customers, affording a greater procurement and sales advantage under severe resource constraints. Such a finding is surprising because it implies that a small set of ESG activities can offset the burden of broad ESG engagements during disruptive times. Hence, if firms narrow their ESG practices to concrete activities that foster stakeholder alignments, they are likely to generate positive financial performance during both normal and disruptive times, offering a compelling case for firms to strengthen their sustainable practices without financial backlashes. Our results lend support to Unilever's policy shift to focus on more concrete, limited pledges to drive greater operational efficiency in reducing waste and improving financial performance.

This research advances the understanding of supply chain resilience and sustainability on multiple fronts. First, this study is among the first to rigorously quantify the impact of ESG practices on a firm's resilience within the global supply chain context. By substantiating ESG's role in resource flow coordination, our findings respond directly to industry calls for empirical evidence supporting ESG initiatives (Alves et al. 2022, McGowan 2023). This contribution is particularly timely in light

of the growing recognition of sustainability and resilience in supply chain management. Second, we develop and validate a novel theoretical framework that quantitatively delineates the pathways from ESG practices to enhanced firm resilience, addressing a crucial gap in existing research. We concurrently address the challenge of establishing causal relationships with extensive data collection to precisely trace the sources of enhanced supply chain resilience in order to isolate the effects of specific ESG practices. Our methodological innovation clarifies previously obscured causal pathways and contributes to setting enhanced benchmarks for empirical research on corporate sustainability. Third, this study adds to the literature on responsible sourcing and customer loyalty in supply chain network (Guo et al. 2016, Atasu et al. 2020, Buell and Kalkanci 2021) and supply risk management (Tomlin 2006, Sodhi et al. 2012), and, more importantly, pioneers a novel, empirically-testable framework on sustainability and resilience.

Our study also enriches stakeholder and ERBV theories by demonstrating how specific stakeholder interactions and operational capabilities underpin ESG's resilience effects. We introduce the concept of an ESG-driven stakeholder alignment, which our analysis shows to become critical during disruptions, thereby enhancing resilience. This conceptualization finds strong empirical support through the recent COVID-19 pandemic and earlier global disruptions (see Appendix Figure A3), suggesting its robustness and applicability in fostering supply chain resilience during global disruptions. Besides enriching the academic understanding of supply chain resilience, we offer actionable managerial insights by delineating specific aspects of ESG practices that bolster firm resilience through procurement and sales efficiencies. Our research thus contributes to the literature on vertical ties and supply chain resilience by providing empirical evidence for how robust ESG practices contribute to firm resilience (Ang et al. 2017, Orsdemir et al. 2019, Davis and Hyndman 2019, Bakshi et al. 2023, Ha et al. 2023).

2. Related Literature

Our research contributes to two streams of literature: responsible operations and supply chain risk management. We further integrate perspectives from two theoretical frameworks that elucidate firm performance within the supply chain setting, the stakeholder theory, and the ERBV theory. Below we discuss the related literature and theories in turn.

2.1. Responsible Operations

An important branch of research on responsible operations focuses on how ESG practices influence corporate behavior, financial market performance, and consumer responses. The primary focus of this body of literature is to explore the effect of ESG practices on firm performance and shareholder value. The findings are mixed. Several studies highlight a positive influence on investor-corporate relationships and overall firm performance (Albuquerque et al. 2019, Awaysheh et al. 2020). In

contrast, others indicate that ESG-aligned investments may either detrimentally affect portfolio performance (Bothello et al. 2023) or have no significant impact (Kim and Yoon 2023). Consumer-focused literature on transparency of corporate social responsibility (CSR) also presents mixed results: clear communication can increase brand loyalty (Buell and Kalkanci 2021), but CSR might also inadvertently lower employee commitment (List and Momeni 2020). While the literature above explores ESG's impact on corporate disclosure, financial performance, and consumer behavior, it overlooks the role of ESG practices in enhancing firm resilience. This oversight represents a critical gap in understanding the impact of ESG practices on firm performance, given that a primary goal of ESG practices is to strengthen stakeholder ties that are likely to influence firm resilience during global supply chain disruptions (Merchant 2023). By addressing this gap, our research enriches the ESG discourse and offers vital insights into ESG's pivotal role in firm resilience.

More generally, the literature on socially responsible operations highlights that firms dedicated to ethical procurement and sustainable supply chain practices experience enhanced investor sentiment (Flammer 2015), elevated long-term performance (Eccles et al. 2014), and superior financial results (Cousins et al. 2020). Key mechanisms facilitating these outcomes include the optimization of organizational processes (Flammer 2015), the cultivation of stronger customer loyalty and trust (Buell and Kalkanci 2021), the enhancement of employee morale and motivation (Tan and Netessine 2014), increased regulatory compliance (Dang et al. 2023), and reduced litigation risks (Koh et al. 2014). Building upon these insights, our study introduces an ESG-driven stakeholder alignment theory, proposing that ESG practices contribute to firm resilience by fostering robust and congruent stakeholder relationships, thus offering a strategic advantage during supply chain disruptions.

2.2. Supply Chain Resilience and Risk Management

Supply chain resilience has gained significant attention due to increased disruption risks that impede physical, financial, and information flow throughout the supply chain (Tomlin 2006, Lamorgese et al. 2024, Kundu et al. 2024). To achieve supply chain resilience, studies have proposed strategies such as dual sourcing, inventory buffering, contingent sourcing, flexibility, and reliability to mitigate disruption risks (Jain et al. 2014, Liu et al. 2016, Dong et al. 2022, Wang and Webster 2022). This literature does not consider the role of ESG practices in firm resilience.

From a stakeholder perspective, ESG investment engages diverse stakeholders and fosters strong ties and better visibility for companies to maintain operations and navigate disruptions effectively (Ivanov 2021, Lee et al. 2021). Along this line of work, Chung et al. (2023) show that ESG initiatives improve operational efficiency in the hotel sector during the COVID-19 pandemic, illustrating the tangible benefits of sustainable practices in crisis management. In a parallel vein, Lamorgese et al. (2024) report that managerial practices significantly improve firms' sales performance amidst

disruptions in Italy. Complementing the above studies and going beyond a specific industry sector or country, we aim to empirically investigate why ESG practices lead to firms' resilience. This broader scope, encompassing a global viewpoint and a multi-dimensional analysis of ESG from a supply chain perspective, helps to clarify pathways through which sustainable practices mitigate risks and enhance operational continuity during disruptions.

2.3. Stakeholder Theory and Extended Resource Based View

Stakeholder theory posits that managers should focus on generating value for a wide array of stakeholders—employees, customers, suppliers, communities, and the environment—rather than exclusively aiming to maximize shareholder wealth (Freeman et al. 2004). This theory has garnered substantial recognition in academic and business circles for its integral role in fostering organizational success and introducing a moral dimension to corporate practices. A stakeholder-centric approach is instrumental in cultivating robust relationships and mitigating risks within intricate supply chains (Donaldson and Preston 1995). In this context, ESG practices emerge as pivotal avenues for companies to recognize the varied interests of stakeholders. Clarkson (1995) offers a stakeholder framework for assessing corporate social performance, underscoring the necessity of integrating social and environmental considerations with financial outcomes. Echoing this framework, Deng et al. (2013) argue that CSR efforts, encompassing environmental sustainability, employee welfare, and community engagement, foster stakeholder synergies, bolster their readiness to back company operations, and enhance long-term value generation.

The ERBV theory elucidates how a firm's unique resources, both tangible and intangible, underpin its competitive advantage, resilience, and supply chain performance (Wernerfelt 1984). These resources (internal, supplier, and customer) contribute to above-normal performance and are central to a firm's ESG strategy. Key to the theory is the integration of ESG dimensions, environmental, social, and governance, into a firm's strategic resource management. Tangible assets, as do inventories, enhance physical resilience (Liu et al. 2016), while intangible assets improve governance, stakeholder engagement, and efficient resource utilization (Erhun et al. 2021, Kesavan et al. 2022, Kraft et al. 2022, Kundu et al. 2024). Notably, achieving high ESG performance requires collaboration beyond a firm's internal resources to include suppliers, customers, and the entire operational environment, as effective governance involves coordinating with these external stakeholders (Lavie 2006). High ESG performance signifies strong coordination capabilities, which makes firms more resilient to disruptions (Müller et al. 2023). Thus, leveraging ESG practices for better supply chain coordination and resource sharing is a strategic approach to enhancing resilience and navigating through disruptions. The combined stakeholder theory and ERBV theory spotlight the significance of stakeholder support and provide a compelling justification for our mechanism investigation: the

heterogeneity of resource richness of stakeholders identifies pathways from ESG practices (stakeholder ties) to firm resilience (resource appropriation from stakeholders).

The rest of this paper is organized as follows: Section 3 describes our empirical strategy and data collection. Section 4 presents empirical findings. Section 5 analyzes the mechanisms underlying the resilience effect of ESGs, and Section 6 is dedicated to robustness checks. Finally, Section 7 discusses the managerial insights of our key findings and suggests directions for future research.

3. Empirical Strategy

We develop an instrumental variable (IV) to identify the causal relationship between the firms' ESG adoption and operational performance during disruption. Given the multitude of factors influencing firms' ESG adoption, we focus on drivers rooted in both formal and informal institutions. These two types of institution drivers are complementary and mutually reinforcing (Krueger et al. 2021).

3.1. Instrument Development: Theoretical Foundation

Firms' ESG adoption is critically influenced by national institutions, among which the political system, the labor and education system, and the cultural system are the most important aspects of institutions that impact firms' ESG decisions (Ioannou and Serafeim 2012). The confluence of these factors is tightly reflected in the rule of law, which is "the bedrock of just, inclusive and peaceful societies" (UNESCO 2019, p.3). "It compels institutions to be accountable, to safeguard human rights, to be fair and transparent, and to empower citizens to participate and engage constructively in society," and education is critical in "promoting the rule of law" (UNESCO 2019, p.3).[2] These national institutions, embodied through the rule of law, exert significant regulatory pressure on firms' ESG adoption decisions, serving as the formal institution driver.

The impact of the rule of law on a firm's ESG decisions is not uniform, with some firms being more exposed to the rule of law pressures and others less exposed. To capture this firm-level variation, we leverage the exogenous variation in firms' ESG controversies exposed by informal institutions (e.g., media, ranking agencies, and non-government organizations). ESG controversies are random negative events related to a firm's ESG performance that are publicized in global media and other informal institutions, damaging the firm's reputation. Such negative exposures are beyond a firm's direct control and constitute exogenous reputation shocks unforeseen by the firm (Dai et al. 2021). In response to negative ESG controversies, firms seek to restore their reputation and improve stakeholder relations by enhancing their ESG practices (Donaldson and Preston 1995,

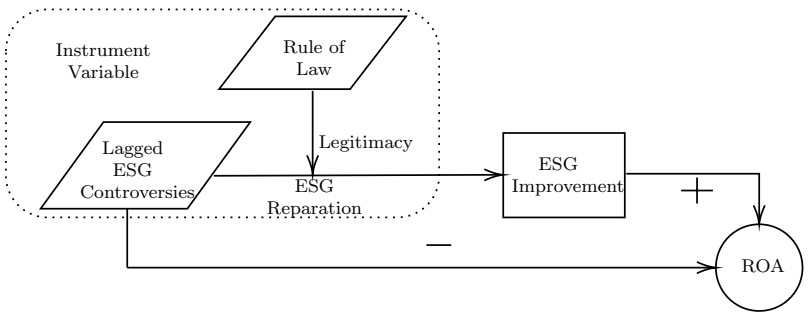
[2] The influence of political and labor factors on the rule of law is evident. For example, USAID proclaims that the rule of law is fundamental to its mission and "serves as a foundation for democracy, guardrail of good governance, and facilitator of inclusive economic growth" (USAID 2024). Culture is also tightly intertwined with the rule of law, see for example (Frankel and Braun 2021).

Li et al. 2019). According to stakeholder theory, a poor reputation harms a firm's performance by impairing its relationships with stakeholders (Donaldson and Preston 1995). The literature establishes that firms respond to such controversies by enhancing their ESG practices to repair their reputation, leading to positive improvements in ESG performance in the following year (Li et al. 2019, DasGupta 2022, Agnese et al. 2023). ESG practices also benefit firms by enhancing their perceived organizational legitimacy (Zahller et al. 2015), a motivation attributed to informal institutions' pressures on ESG adoption.

The firms' drive for legitimacy is reinforced by the effectiveness of legal authorities in enforcing regulations (Tyler 2003), as robust legal frameworks increase corporate accountability and lead to more effective ESG outcomes (Ioannou and Serafeim 2012). In societies with a strong rule of law, firms are more motivated to promote their organizational legitimacy, whereas ESG initiatives act as a critical channel to demonstrate such legitimacy (see Appendix Figure A1). Reputation legitimacy and stakeholder concerns are two critical factors that represent 47% and 32% weights respectively in driving firms' ESG practices (Boffo and Patalano 2020). Thus, the interaction between a firm's ESG controversies and the rule of law in its home country is a significant driver of ESG improvements in the following year.

We leverage these two external drivers, the rule of law as the formal institution driver and ESG controversies as the informal institution driver, to develop our instrumental variable (IV). The IV is constructed by interacting a firm's ESG controversies with the regulatory pressure it faces, defined as *lagged ESG controversies* $\times$ *rule of law* (see Figure 2). Both factors are largely exogenous to the firm, making this interaction a strong and effective instrument for ESG adoption. We recognize, however, that multiple factors could potentially influence ESG controversies and affect firm performance. As such, we address instrument validity in the next section.

Figure 2 Instrument Variable Justification



Note. Instrument variable: lagged ESG controversies $\times$ rule of law. Lagged ESG controversies push firms to repair their ESG, during which the rule of law as the external pressure enhances the reparation behavior based on legitimacy theory. The instrument variable therefore predicts the variation in ESG performance. ESG improvement is positive to ROA, while lagged ESG controversies are negative to ROA, leading to downside bias.

3.2. Instrument Validity

Our identification strategy assumes that the interaction term, lagged ESG controversies × rule of law, is exogenous, conditional on the baseline controls. Specifically, we compare ESG remediation in firms operating under higher rule-of-law pressure to those under lower pressure, specifically in years following significant ESG controversies versus years with lesser controversies. This mirrors the logic of difference-in-differences estimation, where operational performance in firms following high ESG controversies is compared to that in firms following low ESG controversies, focusing on firms that exhibit a higher motivation (due to the rule of law) to remediate their ESG practices relative to those with lower motivation. The interaction with the rule of law is thus crucial to strengthen the validity of our instrument, as the effectiveness of ESG remediation is likely more pronounced when the rule of law is stringently enforced.

Causal inference in our model requires that the interaction between lagged ESG controversies and a country's rule of law impacts firm performance in the following year solely through ESG remediation. This requirement is violated when there exist other potential nonlinear changes over time that might be correlated with ESG controversies, thereby confounding the 2SLS estimates. We mitigate this concern by including time-fixed effects, which account for common shocks or trends that affect all entities similarly within a given time, thus isolating unobserved temporal factors.

The validity of our instrument also requires that the instrument—the one-year lagged ESG controversies—is not correlated with the regression errors. For this to hold, the lagged ESG controversies must influence firm performance solely through ESG improvements in the following year. According to the efficient market hypothesis, stakeholders' overreactions to bad news tend to impact market performance only in the short term. Over time, as more information becomes available and is absorbed by the market, stock prices (and stakeholders' beliefs) realign with the firm's fundamental value, minimizing the long-term impact of the initial shock (Fama 1998). In the context of negative ESG news, Karpoff et al. (2005) find that while environmental violations lead to significant reputational penalties and stock price declines in the short term, the financial impact diminishes over time as firms address these issues and restore stakeholder confidence. Given this, using a firm's one-year lagged negative ESG news as an instrument is appropriate, as the effects on firm performance are likely to weaken and dissipate by the end of the following year.

Nevertheless, caution is warranted regarding any potential remaining effects. The extant literature on the relationship between ESG controversies and firm performance suggests that these controversies negatively affect firm performance (Kang and Kim 2014, Xue et al. 2023). If this negative effect were to persist for more than one year, it could continue to harm firm performance in the subsequent year, as illustrated by the negative trajectory shown in Figure 2. A prolonged negative impact could exert a downward bias in the IV estimation of the resilience effects, only

underestimating the true impact of ESG remediation on firm performance. Still, to mitigate potential downward bias in our estimates, we next address possible violations of the exclusion restriction where one-year lagged ESG controversies might directly correlate with firms' financial performance.

3.2.1. Exclusion Restriction Extant literature indicates three key categories of factors—internal firm characteristics, industry-specific conditions, and broader economic and regulatory environments—could correlate with both ESG controversies and the error terms in our model.

Internal firm characteristics play a significant role in shaping both ESG controversies and firm performance. Larger firms, for instance, are generally more visible and thus subject to greater scrutiny, which can increase the likelihood of ESG controversies. However, larger firms also possess more resources to manage ESG risks, potentially reducing the frequency and severity of ESG incidents. To control for firm size, we include variables such as the logarithm of total assets (*ln(at)*) and the ratio of property, plant, and equipment to total assets (*ppent/at*). These controls normalize differences in scale across firms, ensuring that the estimated impact of ESG remediation on performance is not simply a reflection of firm size variations. Moreover, financially robust firms are better equipped to proactively address ESG issues, which can reduce the incidence and severity of ESG controversies. To account for financial strength, we incorporate controls on market capitalization scaled by total assets (*caps/at*) and the leverage ratio (*lr*), capturing a firm's capacity to invest in ESG initiatives. We also include a firm's reputation, proxied by goodwill scaled by total assets (*gdwl/at*), as a control for reputational influence on ESG practices (Fombrun and Shanley 1990). We further account for operational efficiency, another crucial factor influencing both ESG and performance outcomes, by including controls such as inventory turnover (*invturn*), retained earnings to total assets (*re/at*), and the SG&A to sales ratio (*xsga/sale*) (Porter 2008). These controls collectively ensure that the impact of ESG controversies on performance is not confounded by firm-level variations in size, financial health, reputation, or operational efficiency.

Industry-specific conditions could influence the relationship between ESG controversies and firm performance. Different industries face unique regulatory pressures and environmental challenges that can increase the likelihood of ESG controversies, especially in carbon-intensive, labor-intensive, and agriculture sectors (Margolis and Walsh 2003). To control for these variations, we use industry-year fixed effects to account for industry-level time-varying shocks such as regulatory changes, technological advancements, and market demand shifts. This approach ensures that the impact of ESG remediation on firm performance is not confounded by industry-wide changes. Additionally, a firm's market position can significantly influence its strategic priorities, including its approach to ESG issues (Porter 2008). We control for market power and competitive dynamics by including variables such as market share (*mktshr*), revenue growth (*revtg*), and Tobin's Q (*tq*). These

controls help ensure that the relationship between ESG controversies and firm performance is not confounded by differences in market standing across different industries.

Broader economic and regulatory environments can influence the relationship between ESG controversies and firm performance. Economic conditions and regulatory changes exert external pressures that can affect all firms within an industry. To control for these effects, we rely primarily on industry-year fixed effects, which help reduce the risk of confounding the impact of ESG remediation with broader economic trends or regulatory shifts (Aguilera et al. 2007). These fixed effects are particularly effective in accounting for macroeconomic fluctuations, such as recessions or expansions, and changes in the regulatory landscape that might simultaneously influence ESG controversies and firm performance. Note that the impact of country-specific factors is absorbed by the firm-fixed effects in our model.

3.2.2. Omitted Variable To address potential omitted variable bias, we recognize that firms' responses to disruptions, such as the COVID-19 pandemic, involve various capabilities—internal, external, and strategic—that influence financial performance (Müller et al. 2023). These capabilities are typically unobservable and could vary over time. We therefore use firm and industry-year fixed effects to control for differences among firms' capabilities that could vary by industry characteristics to isolate the impact of ESG strategy adoption on performance during disruptions. In addition, firms may experience uniform external shocks at different times across different industries, which could distort our estimates. To counter this, we allow control variables to vary over time to safeguard against biases from cross-sectional shocks. This is achieved by incorporating time-fixed effects with year interactions in our model, essentially creating time-varying controls to account for characteristics that change within firms over time (Nunn and Qian 2011).

As with all IV estimations, our 2SLS results reflect the local average treatment effect (LATE), which captures the impact of ESG improvements specifically for those firms that respond to negative ESG reports in global media (Angrist and Imbens 1995). Our estimates are thus driven by firms that adjust their ESG practices in response to these negative reports, rather than reflecting the average effect across all firms. This means that the results may not generalize to firms whose ESG practices remain unaffected by such media exposure. To address this concern and ensure the rigor of our findings, we perform a series of robustness checks in Section 6.

3.3. Model Specification

To assess the effect of ESG strategies on firm resilience, we define resilience as a firm's ability to outperform during disruptions (Ivanov 2021). The dependent variable is the return on assets (ROA), which measures operational efficiency under challenging conditions.

The key independent variable is the ESG score (*E1*), representing the firm's ESG strategy implementation. We interact the ESG score with a binary indicator I for the onset of the COVID-19 pandemic, where $I = 0$ for years before 2020 and $I = 1$ for 2020 and beyond (WHO 2021). This interaction term identifies the resilience effects of ESG strategies, and the pandemic is verified as a structural break in Section 6. To control for potential confounding factors discussed earlier, we include them as control variables. We also incorporate traditional resilience buffers, such as inventory levels scaled by sales (*inv/sale*) and net working capital scaled by total assets (*wcap/at*).

In the first stage of our IV estimation (see Equation 2), we predict the firm's ESG score ($\widehat{ESG}_{it}$) using the lagged ESG controversies score × rule of law, $Lagged(controv_rle)_{it}$, as an instrumental variable, reflecting the firm's motivation for ESG engagements. In the second stage (see Equation 1), we use the instrumented firm ESG score ($\widehat{ESG}_{it}$) to predict firm performance, specifically focusing on return on assets ROA. The index i denotes firms, and t denotes years.

The dependent variable, ROA_{it}, is the indicator variable of firm i performance in year t. $\widehat{ESG}_{it}$ is the endogenous variable of interest, the ESG improvement by firm i in year t. $\mathbf{X}_{it}$ is vector of time-varying controls ($\mathbf{X}_{it} \times I_t$), firm fixed effects F_i, and industry-year fixed effects (Ind_I_{it}). The disruption effect I is absorbed by the time-fixed effect. The resilience effect is quantified by the coefficients (α_1) of the interaction term ($\widehat{ESG}_{it} \times I$), indicating how ESG practices during disruptions influence firm performance. Our primary focus is on the resilience effect, specifically the coefficient of the interaction term, rather than merely the impact of ESG. Note, however, that the estimation of the interaction term between ESG and the disruption event I can be potentially biased because ESG is endogenous while disruptions (I) are exogenous. We address this potential bias by generating an instrumental variable for the interaction term ($\widehat{ESG}_{it} \times I$) to ensure robustness and validity (Nunn and Qian 2014).

$$ROA_{it} = \alpha_1 \widehat{ESG}_{it} \times I + \alpha_2 \widehat{ESG}_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \tag{1}$$

$$\begin{aligned} \widehat{ESG}_{it} &= \beta_1 Lagged(controv_rle)_{it} \times I + \beta_2 Lagged(controv_rle)_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \\ \widehat{ESG}_{it} \times I &= \gamma_1 Lagged(controv_rle)_{it} \times I + \gamma_2 Lagged(controv_rle)_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \end{aligned} \tag{2}$$

3.4. Data Collection

ESG and ESG Controversies. We obtain the worldwide firm-level ESG data from 2003 to 2023 from the London Stock Exchange Group (LSEG)' Refinitiv ESG database (LSEG 2023), which has been widely used in prior ESG research (Eccles et al. 2014). The study employs the comprehensive ESG overall score (supplemented by its constituent subpillars and categories; see Appendix Table A16) to capture the firm's ESG performance. Additionally, we obtain the ESG Controversies score, which is calculated based on 23 specific ESG controversy topics for the given year.[3] This score

[3] The 23 ESG controversy topics cover all environment, social, and governance dimensions (LSEG 2023).

reflects the firm's negative events as reported by global media sources (LSEG 2023). The Refinitiv ESG database yields 105,371 firm-year observations encompassing 15,806 unique firms.

Financial Data. The operations and financial data come from Wharton Research Data Services (WRDS) Compustat - Capital IQ North America and Global Fundamentals Annual (2002-2023). The North America dataset includes 265,029 firm-year observations from 27,003 unique firms, while the Global dataset contains 736,072 firm-year observations from 54,246 unique firms. These datasets are combined by matching fiscal year (fyear) and global company key (gvkey), removing any observations with missing fyear or gvkey, and resolving duplicates by prioritizing North America data. Tobin's Q and equity market data are obtained from Compustat Security Daily by using stock prices and common shares at year-end. All financial data are converted to USD using yearly exchange rates from UNCTADstat (2003-2022), IMF statistics, and OANDA for 2023 (UNCTADstat 2024, IMF 2024, OANDA 2023). Variables are standardized using z-scores for regression analysis. The datasets are merged using fiscal year and international securities identification number (isin). Firms in the financial, utilities, and real estate sectors are excluded, resulting in 55,403 firm-year observations (2003-2023) from 8,250 unique firms, with eight observations missing sector data. Descriptive statistics in Appendix Table A3 show the industrial sector leading with 13,041 observations (23.54%), followed by consumer discretionary (16.73%) and materials (15.38%), with communication services having the fewest observations (6.09%).

Supply Chain Network Data. Supply chain relationship data are sourced from the FactSet Revere database, covering 2003 to 2023 (FactSet 2024). The dataset includes 748,494 pair-year observations from 170,743 unique supplier-buyer pairs, with over 20,000 global supply chain pairs reported annually, verified by multiple sources, 10-K filings, public information, and business news. The FactSet data is merged with Compustat financial data by fiscal year (fyear) and international securities identification number (isin) to extract financial and operational details about the focal firm's suppliers and buyers. We focus on factors likely to moderate the ESG investment effect on financial performance, including employee size, total assets, ESG investment, inventory metrics, working capital, cash, and accounts receivable/payable for both upstream suppliers and downstream buyers. For further analysis, we calculate several supply chain network metrics. Network size is measured by the total number of distinct supplier and buyer locations. To capture vertical structure, we calculate an upstreamness score based on the shortest distance from the consumption goods sector (GICS codes 25 and 30) (Gofman and Wu 2022), with an alternative score derived from the Bureau of Economic Analysis (BEA) input-output table (Antràs et al. 2012).[4] Additionally, centrality metrics—authority, betweenness, in-degree, and out-degree—are calculated from the

[4] The U.S. 2017 input-output use table is used for calculating upstreamness by industry sector, available at https://www.bea.gov/industry/input-output-accounts-data (accessed March 13, 2024).

FactSet data, reflecting the firm's role and load within the supply chain (Carvalho 2014). Authority index indicates operational criticality, in-degree represents supplier load, out-degree reflects demand load, and the betweenness index captures the firm's bridging role. Detailed formulations are provided in Appendix A8.

Regulatory Environment. We collect the containment index, which measures the lockdown stringency in specific countries during the COVID-19 pandemic, from the Oxford Coronavirus Government Response Tracker (OxCGRT) project (Hale et al. 2021).[5] We also obtain the population vaccinated index from OxCGRT, which measures the percentage of the fully vaccinated population in the corresponding country. In addition, we collect the ESG policy data from the United Nations Principles for Responsible Investment regulation database (PRI 2024). PRI's regulation database encompasses 868 policy tools across 116 countries globally, spanning from 1960 to 2022.

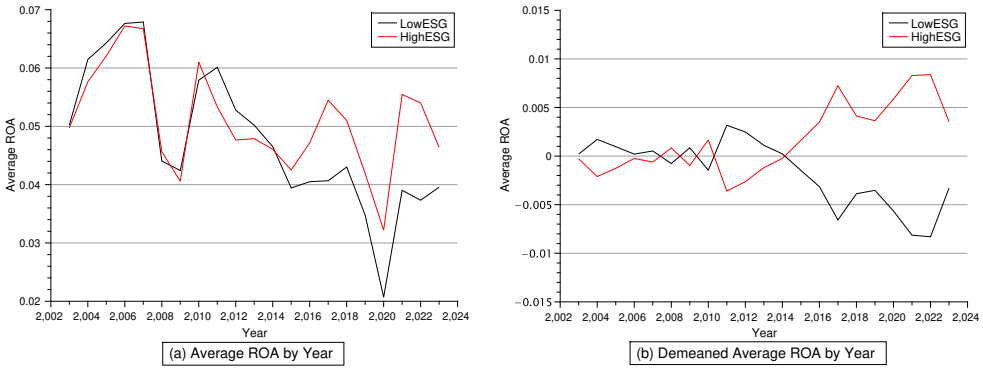
Table A1 in the appendix describes all variables, including supply chain resources, network indicators, and ESG sub-pillars, with pairwise correlations summarized in Table A2.

4. Main Results

4.1. Model Free Evidence

To preliminarily explore the relationship between ESG adoption and firms' financial performance, we begin by examining the average Return on Assets (ROA) by year, as depicted in Figure 3.

Figure 3 **Average ROA by Year and ESG**



Note. Firms are categorized into high and low ESG groups based on their ESG performance relative to the national mean.

We categorize the firms into two groups based on their overall ESG scores, comparing those above (High ESG) and below (Low ESG) the national mean. Figure 3 illustrates that, in line with the impact of COVID-19, there is a sharp decline in ROA for both groups in 2020, followed by a

[5] The thirteen metrics used to calculate the Stringency Index are: thirteen policy response indicators including school closures, workplace closures, travel bans, testing policy, contact tracing, face coverings, and vaccine policy rescaled to a value from 0 to 100 (100 = strictest).

recovery. Prior to 2014, no significant difference is observed between the groups and the trends are similar. Post-2014, the High ESG group begins to outperform the Low ESG group, with a notable increase from 2014 to 2017, reaching a peak before converging slightly until 2019. The divergence then becomes significant again from 2019 to 2022, reaching another peak during the COVID-19 disruptions, before narrowing post-2022. This pattern highlights two critical periods: 2014 to 2017 and the COVID-19 era from 2019 to 2022, suggesting distinctive impacts of ESG adoption on financial performance during these times.

4.2. ESG Resilience Effects

The 2SLS estimation results are detailed in Table 1. In Model I, inventory ($inv/sale$) and working capital ($wcap/at$) are not included in the controls. Columns 1-2 display the instrument variables generation in the first stage, indicating the firms' ESG adoption $\widehat{ESG}_{it}$ and the interaction term $\widehat{ESG}_{it} \times I$ are significantly predicted by the lagged instrument, $Lagged(controv_rle)_{it}$ and the interaction term, $Lagged(controv_rle)_{it} \times I$. In the second stage (Column 3), the *Instrumented E1* $\times I$ entry highlights the resilience effect. Specifically, a unit increase in the ESG score during disruptions is correlated with a 0.287 unit uplift in the subsequent year's ROA ($p < 0.05$).[6]

Table 1 The Effect of ESG Adoption on Firm Resilience

	Model I			Model II (add inv/sale, wcap/at)		
	E1	*E1*×*I*	*ROA*	*E1*	*E1*×*I*	*ROA*
	(1)	(2)	(3)	(4)	(5)	(6)
controv_rle.L1	0.056***	-0.021***		0.056***	-0.023***	
	(0.007)	(0.004)		(0.007)	(0.004)	
controv_rle.L1 × *I*	-0.020**	0.083***		-0.021***	0.089***	
	(0.006)	(0.008)		(0.006)	(0.008)	
Instrumented E1			-0.453*			-0.430*
			(0.196)			(0.193)
Instrumented E1 × *I*			0.287*			0.344**
			(0.119)			(0.112)
Num.Obs.	47411	47411	47411	47411	47411	47411
R^2	0.864	0.710	0.704	0.864	0.712	0.713
Std.Errors	HC1	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X
Industry-Year FE	X	X	X	X	X	X

Note. Model I, excluding $inv/sale$ and $wcap/at$, analyzes ESG's impact on ROA. Columns (1-2) are for the first stage and column (3) is for the second stage. Model II adds $inv/sale$ and $wcap/at$ to isolate ESG's effects from operational redundancy, with columns (4-5) for the first stage and column (6) for the second stage. The coefficients of all controls including $inv/sale$ and $wcap/at$ are omitted. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

In Model II, to distinguish the impact of ESG from a firm's operational redundancy, we include inventory and working capital as part of the time-varying controls. Similar to Model I, columns 4-5

[6] The entry *Instrumented E1* in Columns 3 and 6 shows the ESG adoption hurts ROA during normal times: a unit increment in the ESG score leads to a 0.453 and 0.430 unit decrease in ROA in Model I and II. Both effects are statistically significant with $p < 0.05$.

show the first stage for instrument generation and indicate the endogenous variables are significantly predicted. Column 6 presents the outcomes of the second-stage regression analysis, revealing that the *Instrumented E1* $\times I$ entry accentuates the resilience effect. Specifically, a unit increase in the ESG score amidst disruptive periods is associated with a 0.344 unit (0.124 percentage points) of enhancement in the disruption period's ROA ($p < 0.01$).[7] The average resilience benefit attributed to ESG factors amounts to $217 million per firm and $1.25 trillion global impact per year during COVID-19.[8] The results from Models I and II demonstrate that the ESG resilience effect during the pandemic remains robust and consistent even after controlling for inventory and working capital (key physical and financial buffers for resilience). This confirms that ESG's impact on resilience is independent of these major operational buffers. Overall, the 2SLS estimates strongly support an ESG-induced resilience effect.

4.3. Relevance and Validity

A valid instrumental variable satisfies two conditions: (1) relevance - strongly correlated with the endogenous variable; (2) exogeneity - uncorrelated with the error term. We verify instrument validity using the weak instrument test and Wu-Hausman test. The weak instrument test for both $\widehat{ESG}_{it}$ and the interaction term $\widehat{ESG}_{it} * I$ is statistically significant ($p < 0.001$), confirming a strong correlation between the instruments and endogenous variables. The Wu-Hausman test is also significant ($p < 0.001$), further supporting the validity of the instruments. We address the exogeneity condition by following established literature to minimize any potential correlation between the instruments and the error term, as discussed in Section 3. Heteroskedasticity-robust standard errors (HC1 correction) are employed to correct for potential bias in 2SLS estimation. Additionally, the minimal diagonal value of the Cholesky decomposition for the full regression model is $48.4 \gg 0.1$, indicating that multicollinearity is not a concern for estimation reliability.

5. Mechanisms

A key objective of this research is to investigate why ESG activities confer firm resilience effect. Toward this goal, we conduct a comprehensive mechanism analysis to uncover pathways through which ESG practices lead to improved firm resilience based on the framework in Figure 1. We lead the investigation by first analyzing the effect of ESG initiatives on key operational performance metrics that include *sale*, *cogs*/*sale*, and *salemargin* to pinpoint the augmented operation capabilities facilitated by ESG adoption during disruptions. We then trace the augmented operation

[7] Unstandardized coefficient $= \alpha \times \sigma_{ROA}/\sigma_{E1}$, where the coefficient $\alpha = 0.344$ as shown in Table 1.

[8] The annual global average assets is $1.01 quadrillion over the COVID-19 years of 2020-2022. Dividing by the number of firms (5,797), the average asset value per firm is $175 billion. Applying the unstandardized coefficient of 0.124, the estimated average annual economic impact of ESG adoption is $217 million per firm and $1.25 trillion globally.

capabilities within the supply chain by leveraging resource heterogeneity among stakeholders (suppliers and buyers) and supply chain structures that impact resource availability. To assess ESG's function in stakeholder alignment that generates strong relational ties, we subsequently explore the variability in firms' ESG-driven resilience effects in response to different levels of lockdown stringency during the COVID-19 pandemic.

5.1. Operation Performance Metrics

We adopt the same 2SLS IV estimation approach as in our main analysis. Given that both ROA and individual operational metrics measure aspects of firm performance, the instruments in the main analysis remain effective and valid. The specification for the first stage is maintained as outlined in (2). In the second stage, we replace the dependent variable ROA with Y_{it}^{j}, which encompasses key operational performance metrics. This alteration is reflected in the second-stage regression shown in (3). We maintain the same set of controls and fixed effects for operational performance metrics as used for ROA in the main analysis.

$$Y_{it}^{j} = \alpha_1 \widehat{ESG}_{it} \times I + \alpha_2 \widehat{ESG}_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \tag{3}$$

In (3), $j = 1, 2, 3$ corresponds to different metrics: $j = 1$ for the cost of goods sold (scaled by sales), $j = 2$ for sales, and $j = 3$ for sales margin. The results are shown in Table 2.

Table 2 The Effect of ESG on Operation Performance Metrics

	First Stage		Second Stage		
	E1	*E1*× *I*	*cogs/sale*	*sale*	*salemargin*
	(1)	(2)	(3)	(4)	(5)
controv_rle.L1	0.056***	-0.023***			
	(0.007)	(0.004)			
controv_rle.L1 × *I*	-0.021***	0.089***			
	(0.006)	(0.008)			
Instrumented E1			-1.074	-0.079+	-0.019
			(0.676)	(0.045)	(0.108)
Instrumented E1 × *I*			-1.814*	-0.164***	0.174**
			(0.759)	(0.042)	(0.065)
Num.Obs.	47411	47411	47411	47411	47411
R^2	0.864	0.712	0.582	0.980	0.910
Std.Errors	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X
Firm FE	X	X	X	X	X
Industry-Year FE	X	X	X	X	X

Note. Columns 1-2 display first stage IV results for *Instrumented E1* and *Instrumented E1*×I. Columns 3-5 present second stage IV results of ESG's impact on *cogs/sale*, *sale*, and *salemargin* correspondingly. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Columns 1-2 present first-stage instrument generation for *Instrumented E1* and *Instrumented E1* × *I*, both achieving significant prediction. Columns 3-5 delineate the impact of ESG adoption on firms' purchase costs (*cogs/sale*), sales (*sale*), and sales margins (*salemargin*). Notably, a unit increase in the ESG score correlates with a 1.814 unit reduction in purchase costs

amidst disruptions, significant at $p < 0.05$. Similarly, this ESG score increase is associated with a 0.164 unit decrease in sales during disruptions ($p < 0.001$). The same increase in the ESG score is linked to a 0.174 unit improvement in sales margins during disruptions, significant at $p < 0.01$. The ESG's effects are most pronounced on the *cogs/sale* compared to *sale* and *salemargin*.

The results indicate that during disruptions, a unit increase in ESG score significantly reduces *cogs/sale*. This reduction is primarily driven by enhanced cost efficiency in procurement (Swift et al. 2019), improved sales (Tangpong 2011), or a combination of both. However, the observed decrease in sales suggests that the cost reduction outweighs the sales decline, resulting in a lower *cogs/sale* ratio. Given that operational efficiency is already accounted for using *xsga/sales* and *invturn*, the lower ratio is mainly attributable to procurement cost reductions. A detailed analysis is provided in Appendix A3. This finding aligns with industry reports highlighting ESG's positive impact on procurement, driven by improved resource efficiency, better supplier engagement, and reduced delays (Jamaluddin 2022). Consequently, firms with suppliers offering relatively lower inventory costs stand to gain more resilience from ESG practices during disruptions. We explore the varied resilience benefits linked to supplier resources in Section 5.2. Notably, the cost reduction is insignificant during normal times but becomes significant only during disruptions. This suggests that the resilience effect stems not from squeezing suppliers but from firms' enhanced ability to secure scarce resources more effectively when supply constraints are high.

On the other hand, the decrease in sales suggests that the margin advantage may also be partially due to a price premium linked to customer loyalty (Buell and Kalkanci 2021). It is noteworthy that firms with higher ESG engagement experience a drop in sales during disruptions. This counterintuitive result is likely due to the higher demand elasticity of products from ESG-focused firms, which may be more price-sensitive during challenging times. In other words, products from high-ESG firms suffer steeper declines in sales compared to those from non-ESG counterparts when resources are limited. This suggests that any ESG price premium is insufficient to fully offset the drop in sales volume during disruptions.

The combined evidence suggests that ESG's resilience advantage likely comes from enhanced procurement efficiency and to a lesser degree from improved price premiums. To verify the validity of these two potential pathways to resilience, we leverage stakeholder and the ERBV theories, which predict that resilience from ESG practices (via stakeholder ties) is shaped by resource abundance among stakeholders - the suppliers and buyers. Through heterogeneity analysis that assesses the richness of their operational and financial resources, we expose evidence of how ESG practices contribute to resilience from key stakeholders and their resources.

To facilitate our subsequent analysis, we represent firms' key stakeholders' resources as Shr^r_{it}. To account for endogeneity and establish causality, we develop a new instrument comprised of a

triple interaction term $\widehat{ESG}_{it} * I * Shr^r_{it}$, which is predicted using $Lagged(controv_rle)_{it} \times I \times Shr^r_{it}$ in the first stage regression, as shown in (5). This new instrument is appended to the other two endogenous variables in the first stage regression for $\widehat{ESG}_{it} * I$ and $\widehat{ESG}_{it} * Shr^r_{it}$, as illustrated in (5). Since the direct effect of the firms' stakeholders' resources Shr^r_{it} is absorbed by the firm fixed effects, the difference between (4) and (1) is the double interaction terms: $Lagged(controv_rle)_{it} \times I$, $\widehat{ESG}_{it} \times Shr^r_{it}$ and triple interaction term: $\widehat{ESG}_{it} \times I \times Shr^r_{it}$ in (4). The coefficient α_1 triple interaction term captures the differential effect of ESG-driven resilience between firms with high corresponding stakeholder resources and those with low levels.

$$\begin{aligned} ROA_{it} = {} & \alpha_1 \widehat{ESG}_{it} \times I \times Shr^r_{it} + \alpha_2 \widehat{ESG}_{it} \times I + \alpha_3 \widehat{ESG}_{it} \times Shr^r_{it} \\ & + \alpha_4 \widehat{ESG}_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \end{aligned} \tag{4}$$

$$\begin{aligned} \widehat{ESG}_{it} = {} & \beta_1 Lagged(controv_rle)_{it} \times I \times Shr^r_{it} + \beta_2 Lagged(controv_rle)_{it} \times I \\ & + \beta_3 Lagged(controv_rle)_{it} \times Shr^r_{it} + \beta_4 Lagged(controv_rle)_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \\ \widehat{ESG}_{it} * I = {} & \gamma_1 Lagged(controv_rle)_{it} \times I \times Shr^r_{it} + \gamma_2 Lagged(controv_rle)_{it} \times I \\ & + \gamma_3 Lagged(controv_rle)_{it} \times Shr^r_{it} + \gamma_4 Lagged(controv_rle)_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \\ \widehat{ESG}_{it} * I * Shr^r_{it} = {} & \lambda_1 Lagged(controv_rle)_{it} \times I \times Shr^r_{it} + \lambda_2 Lagged(controv_rle)_{it} \times I \\ & + \lambda_3 Lagged(controv_rle)_{it} \times Shr^r_{it} + \lambda_4 Lagged(controv_rle)_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \end{aligned} \tag{5}$$

The various stakeholder resources may be endogenous to firms' characteristics (e.g., larger firms may possess higher stakeholder resources). While the direct effects of stakeholder resources are absorbed by firms' fixed effects, they may still bias estimation results due to reduced variances. We therefore check whether firms with high ESG practices differ in their stakeholder resources relative to those with low ESG practices; see Appendix Table A4. The profiles of most stakeholder resources are similar between high and low ESG firms, except for the centrality measure, where high ESG firms typically have high in-degree (number of suppliers) and out-degree (number of buyers). This correlation exerts an upward estimation bias concerning centrality heterogeneity, and therefore, the true effects are likely smaller than reported estimates.[9]

5.2. Supplier and Buyer Resources

The earlier mechanism analysis reveals that ESG primarily helps firms build resilience through reduced purchase costs on the supply side and potentially through price premiums on the buying side. To confirm this finding, we conduct heterogeneity analysis across supplier and buyer resources, with the rationale that firms with high ESG engagement should garner more benefits from more resourceful stakeholders than less resourceful ones. Table 3 outlines the moderation effects of supplier and buyer resources. We test the average level of cash level (*ch/at*), account receivables (*rect/sale*), working capital (*wcap/at*) and numbers of location (*loc_n*).

[9] Our subsequent examination of centrality reveals a positive (triple interaction) coefficient, indicating that part of the positive impact of ESG on resilience is due to firms' higher centrality position. This reflects the unique advantages of firms occupying central positions in supply chains.

Table 3 Moderation Effects of Supplier and Buyer Resource on Firm ESG Resilience

	Supplier Resources				Buyer Resources			
	ch/at (1)	*rect/sale* (2)	*wcap/at* (3)	*loc_n* (4)	*ch/at* (5)	*rect/sale* (6)	*wcap/at* (7)	*loc_n* (8)
	IV Second Stage: *ROA*							
Instrumented E1	-0.660+	-0.616+	-0.540+	-0.655+	-0.666+	-0.695+	-0.658	-0.615
	(0.349)	(0.324)	(0.322)	(0.348)	(0.402)	(0.413)	(0.414)	(0.401)
Instrumented E1 × *I*	0.313*	0.469**	0.373**	0.922***	0.277*	0.305*	0.284*	0.414*
	(0.123)	(0.176)	(0.136)	(0.259)	(0.127)	(0.138)	(0.131)	(0.165)
Instrumented E1 × *r.*	0.056	-0.010	0.039	-0.048	-0.176**	-0.054	-0.045	-0.047
	(0.075)	(0.037)	(0.062)	(0.047)	(0.062)	(0.035)	(0.050)	(0.050)
Instrumented E1 × *I* × *r.*	0.189	-0.153*	0.242*	-0.001	0.109	-0.043	0.200**	0.054*
	(0.179)	(0.076)	(0.103)	(0.035)	(0.076)	(0.063)	(0.075)	(0.027)
Num. Obs.	33873	33982	33996	35041	29786	29820	29862	31344
R^2	0.691	0.697	0.708	0.653	0.703	0.706	0.709	0.715
Std. Errors	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X	X	X
Industry-Year FE	X	X	X	X	X	X	X	X

Note. All instruments used in the first-stage regressions are statistically significant; details are omitted for conciseness. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Columns 1-4 test the impact of supplier resources on firm resilience whereas columns 5-8 test that of buyer resources. The overarching results are similar: suppliers' and buyers' financial resources matter for the focal firm's resilience. Specifically, both suppliers' and buyers' cash levels (ch/at) are positively associated with firm resilience, though the effect is statistically insignificant. In contrast, high accounts receivables ($rect/sale$) are negatively associated with firm resilience, with the effect being more significant for suppliers than buyers. This indicates that liquidity shortages among suppliers hinder procurement efficiency, as suppliers are more likely to pass on trade credit costs through pricing. On the buyer side, the liquidity shortage effect is less pronounced and statistically insignificant, implying either the absence of an ESG price premium or a weak impact.

The working capital ratio ($wcap/at$) shows a strong positive association with firm resilience and is statistically significant for both suppliers and buyers. This indicates that the resilience benefits of ESG primarily stem from financially resourceful suppliers and buyers, enhancing procurement efficiency (from suppliers) and supporting price premiums (from buyers). However, the effect is stronger for suppliers, suggesting procurement efficiency is likely the more critical resilience driver, with price premiums serving as a complementary factor.

Geographic diversity (loc_n) has contrasting effects: it is negative on the supplier side (though statistically insignificant) but positive on the buyer side. This implies that diverse buyer locations increase the likelihood that some buyers can afford ESG price premiums during disruptions. For suppliers, however, greater location diversity may signal a more complex supply structure or weaker stakeholder relationships, reducing procurement efficiency.

The above analysis highlights two key ESG resilience pathways: procurement cost efficiency from suppliers and price premiums from buyers during disruptions, with procurement efficiency playing a more substantial role.

5.3. Supply Chain Structure

We focus on the upstreamness and centrality of the supply chain structure, which shape a firm's strategic position and resource leverage with suppliers and buyers. Although our earlier analysis suggests a potential ESG price premium, it remains unclear whether this is driven by business-to-business interactions or end consumers through increased loyalty (Guo et al. 2016, Li and Wu 2020, Kraft et al. 2022). To explore this, we assess whether firms closer to consumers benefit more from ESG price premiums. In supply chains, consumer-driven effects typically impact downstream firms first but weaken further upstream (Carvalho 2014). Thus, firms near the consumer end may experience stronger ESG resilience due to consumer loyalty and willingness to pay premiums during disruptions. Additionally, a firm's centrality within the supply chain, reflecting its influence and connectivity, is another factor contributing to ESG resilience.

Table 4 The Moderation Effects of Supply Chain Networks on the Firm ESG Resilience Effect

	Upstreamness		Centrality			
	Upstream	*Upstream I/O*	*Authority*	*Between*	*In Degree*	*Out Degree*
	(1)	(2)	(3)	(4)	(5)	(6)
IV Second Stage: *ROA*						
Instrumented E1	-0.702+	-0.428*	-0.921*	-0.998**	-0.743*	-0.934*
	(0.393)	(0.190)	(0.376)	(0.378)	(0.344)	(0.385)
Instrumented E1 × *I*	0.372*	0.348**	0.518***	0.502**	0.581***	0.432**
	(0.174)	(0.115)	(0.157)	(0.162)	(0.171)	(0.158)
Instrumented E1 × *SC*	-0.048	-0.038	0.007	-0.005	0.074*	-0.080
	(0.100)	(0.111)	(0.023)	(0.032)	(0.034)	(0.066)
Instrumented E1 × *I* × *SC*	0.252	0.120	0.161*	0.324+	0.043	0.147*
	(0.266)	(0.105)	(0.063)	(0.179)	(0.034)	(0.061)
Num. Obs.	30850	47410	36443	36443	36443	36443
R^2	0.699	0.711	0.654	0.638	0.678	0.654
Std. Errors	HC1	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X
Industry_Year FE	X	X	X	X	X	X

Note. All instruments used in the first-stage regressions are statistically significant; details are omitted for conciseness. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Table 4 shows the moderating effects of upstreamness and centrality on ESG resilience. Columns 1 and 2 examine *upstreamness*, measured by real network data and BEA's input-output tables. Both show non-significant results, indicating that the ESG resilience effect is not significantly influenced by a firm's supply chain position. Hence, the ESG price premium is not limited to end consumers, and firms can benefit from ESG engagement regardless of their proximity to consumers.

Columns 3-5 test supply chain network centrality. All four centrality measures positively moderate ESG resilience, with *Authority*, *Out Degree*, and *Betweenness* being more significant than *In Degree*. *Authority* and *Betweenness* reflect a firm's centrality based on connections, while *Out Degree* and *In Degree* represent downstream and upstream connections. This suggests that firms with extensive network connections gain more resilience benefits from ESG, likely due to stronger stakeholder ties and better market opportunities. However, these estimates may be biased upwards, as high ESG firms tend to occupy authoritative positions, suggesting the actual ESG-driven resilience can be less significantly affected by network centrality.

Our analysis highlights that ESG activities foster resilience through relational ties with suppliers and buyers. The concept of the relational tie, while intuitively appealing, remains a latent measurement in our study context. Part of the challenge is that one cannot directly measure the relational tie using secondary data. In the next section, we approximate their value by examining whether they emerge during times of resource scarcity.

5.4. Regulation Environment

To corroborate the concept of ESG-driven relational ties, we employ the stringency of COVID-19 lockdown measures as a gauge to examine how external constraints on resource mobility during crises affect the utility of ESG practices in bolstering resilience. Our approach posits that variations in regulatory standards across countries dictate resource availability, which, in turn, underscores the significance of relational ties in enabling firms to achieve resilience amid external pressures. Table 5 presents results in the interplay between regulatory environments and the impact of ESG on a firm's resilience.

Table 5 The Moderation Effects of Regulatory Environment on Firm ESG Resilience Effect

	Containment (1)	*Population Vac.* (2)	*ESG Policy Num.* (3)
	IV Second Stage: *ROA*		
Instrumented E1	-0.152	-0.705***	-0.570**
	(0.295)	(0.166)	(0.218)
Instrumented E1 × *I*	0.029	0.728**	0.266+
	(0.304)	(0.247)	(0.153)
Instrumented E1 × *Reg*	-0.556**	0.780**	0.207
	(0.210)	(0.269)	(0.155)
Instrumented E1 × *I* × *Reg*	0.428+	-0.980*	0.164+
	(0.245)	(0.190)	(0.092)
Num. Obs.	47351	47351	47392
R^2	0.710	0.706	0.703
Std. Errors	HC1	HC1	HC1
X × Year	X	X	X
Firm FE	X	X	X
Industry-Year FE	X	X	X

Note. All instruments used in the first-stage regressions are statistically significant; details are omitted for conciseness. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Column 1 shows that countries with stringent pandemic measures, such as school and workplace closures, public transport restrictions, and movement limitations, exhibit a positive influence on ESG's role in enhancing resilience. This positive effect likely stems from the fact that (a) stringent measures lead to scarcity of resources during the pandemic (primarily due to movement restrictions), and (b) if relational ties are the credible pathway for firms with high ESG activities to gain resilience, then this resilience benefit should be more prominent when resources are scarce, i.e., when countries impose stringent measures. Conversely, column 2 shows a negative effect of population vaccine rates on ESG's resilience benefits. Higher vaccination rates enable more economic activities, significantly loosening resource limitations. Combined with the positive effect of stringency measures, we conclude that ESG adoption is more crucial to firm resilience when external resources are scarce due to limited economic activities. Collectively, these results affirm that relational ties play a crucial role in enabling firms to gain resilience through ESG activities.

Further, column 3 indicates that a higher number of ESG investment policies positively impact ESG initiatives on firm resilience. More policies indicate a societal emphasis on ESG but have no bearing on the resource availability of firms. Therefore, the positive effect is unlikely to be driven by resource scarcity, but rather due to the relational tie strength driven by societal perception of ESG engagements. According to legitimacy theory, firms benefit from ESG adoption in societies that value ESG highly. As such, the relational ties attributed to firms' ESG activities in these countries are enhanced, increasing their ability to source resilience from suppliers and buyers during the pandemic. To sum up, our analysis of regulatory stringencies across countries supports the notion that relational ties are the critical pathway for firms to gain resilience through ESG activities.

5.5. ESG Pillars and Components

To provide practical managerial insights, we explore which ESG pillars and subcomponents foster strong relational ties and improve firm resilience. Our analysis highlights that the key ESG components promoting resilience are *community*, *human rights*, and *workforce* from the social dimension, and *management structure* from the governance dimension (see Appendix A4).

First, *community* engagement builds trust and goodwill, ensuring stakeholder support during disruptions, while strong ties enhance customer loyalty and market differentiation. Suppliers are more likely to prioritize the firm during resource scarcity, and customers tend to remain loyal to firms contributing positively to their communities, ensuring sustained demand. Second, respect for *human rights* fosters ethical supplier and customer relations, ensuring continuity in crises. Suppliers and buyers are inclined to maintain relationships with firms upholding high ethical standards, knowing that these firms prioritize fair and respectful practices. This loyalty is critical during disruptions, securing supply chain reliability. Third, a motivated and well-trained *workforce* boosts

internal and external efficiency, streamlining procurement processes and reducing operational bottlenecks. Employees engaged in diverse and inclusive environments are more efficient, and this contributes to better communication and collaboration with suppliers, reinforcing customer loyalty and trust. Finally, *management structure* supports these social elements by ensuring clear, transparent communication between the firm, its suppliers, and its customers. An independent and diverse board, adhering to best practices, reduces misunderstandings and enhances collaboration, deepening supply chain relationships essential for resilience during disruptions.

Collectively, these components strengthen relational ties, leading to prioritized and reliable supplies from suppliers and sustained demand and loyalty from buyers. These relationships are crucial for maintaining resilience during disruptions, as firms focused on these ESG components are better positioned to handle challenges and maintain operational stability. While ESG is an effective framework for stakeholder engagement, managers need not be confined strictly to it; fostering responsibility toward stakeholders is the broader objective (Cutter and Glazer 2024). From this perspective, Unilever's strategic focus on the four key ESG dimensions, rather than broad goals, can make its supply chain more efficient and resilient.

6. Robustness Check

First, we adopt an alternative estimation method, the difference in differences (DiD) with continuous treatment to show the reliability of our findings. Second, we employ alternative measurements, specifically, return on investment (ROI) and return on equity (ROE), as dependent variables to test the impact of ESG strategy on resilience. The results show our findings are robust with alternative estimation methods and alternative measurements. Detailed results are in Appendix A5.

6.1. DiD with Continuous Treatment

COVID-19 as an exogenous disruption simultaneously raises the requirements of resilience in companies worldwide. All firms are forced to be treated unexpectedly. Therefore, the interaction of disruption and ESG performance provides an opportunity to identify the causal effect of the ESG strategy on firms' resilience. In particular, incorporating the interaction term between ESG performance and the disruption event into the DiD strategy overcomes the potential concerns of reverse causality and joint determination. Following Nunn and Qian (2011) and Lins et al. (2017), we employ a generalized DiD analysis with a continuous treatment framework.

With a continuous DiD regression, we compare the relative change in firms' financial performance in the pre-pandemic period relative to the post-pandemic period between firms that adopt ESG well and the firms that do not. The causal effects of the intensity of ESG adoption on firm resilience can then be estimated through the comparison of financial performance between firms with higher

ESG scores and firms with lower ESG scores.[10] Similar to the IV estimation strategy, we use the year 2020 as the cutoff period and define the periods before the year 2020 as the pre-disruption periods and the periods after and including 2020 as the post-disruption periods. We also control for both firm and year-fixed effects to isolate the ESG adoption effect on firm resilience. Fixed effects control for any firm-level, time-invariant differences in financial performance that persist before and after disruptions. For instance, firms with superior ESG strategy implementation may excel in operational aspects, such as internal management, which can translate into enhanced financial performance. Our strategy relies on no other global shocks occurring around the same time as COVID-19 that are correlated with firms' ESG adoption. We address this concern regarding identification by explicitly controlling for time-varying firm characteristics that could bias our estimates. The DiD estimation model is presented in (6).

$$ROA_{it} = \alpha_1 ESG_{it} \times I + \alpha_2 ESG_{it} + \mathbf{X}_{it} \times I_t + F_i + Industry_I_{it} + \epsilon_{it}. \tag{6}$$

The DiD estimation results, shown in Appendix Table A8, indicate that the interaction of $ESG \times I$ has a significantly positive effect on firm performance, suggesting that higher ESG practices enhance firm resilience during disruptions. This effect remains consistent, regardless of whether inventory and working capital are included as control variables, indicating that ESG's impact on resilience extends beyond these factors.

To verify the DiD identification strategy, we perform a flexible estimation and placebo test, confirming that the observed effects are attributable to ESG adoption during the disruption. We also examine the entire dataset (2003-2023) to test for potential structural changes using sequential estimates to handle multiple break dates (Hansen 2001). Instead of the simultaneous method in the flexible estimation, we conduct a sequential (one-by-one) estimate to deal with potential multiple break dates sequentially. These results align with the IV estimations.

6.2. Alternative Dependent Variable: ROI and ROE

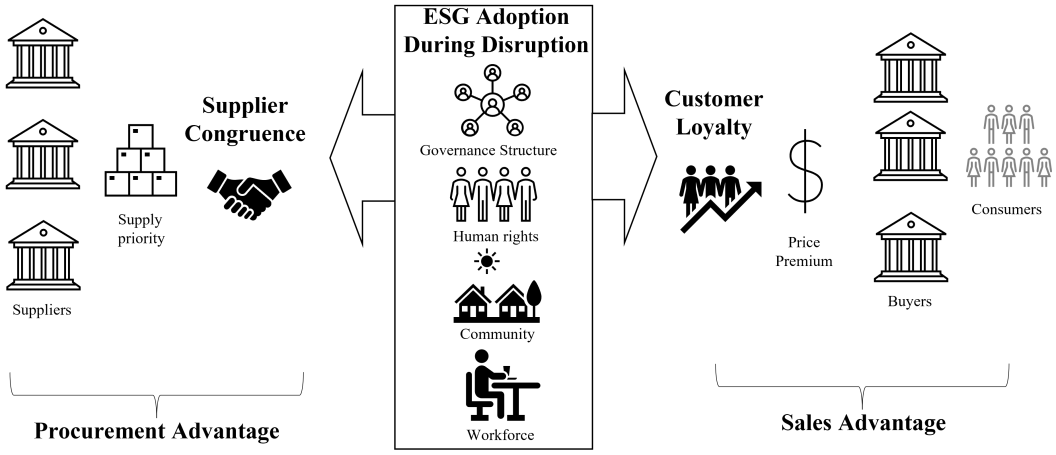
To assess the robustness of our findings, we use alternative metrics to examine the impact of ESG adoption on Return on Investment (ROI) and Return on Equity (ROE) during disruptions. Employing both 2SLS and DiD estimation methods, the results consistently align with our results on ROA, indicating a significant and positive influence of ESG adoption on firm resilience. Detailed results are in Appendix Table A15.

[10] Given the unexpected nature of the disruption, firms did not tailor their ESG strategies in anticipation of COVID-19. Moreover, ESG adoption levels displayed consistent trends, either negative or neutral, prior to the disruption, confirming the observed resilience effects stem directly from ESG adoption during disruptions.

7. Discussion and Conclusion

Our study empirically explores whether and why ESG practices underpin firm resilience. Leveraging the interaction of ESG controversies and the rule of law as an instrument within a 2SLS framework (and further supported by DiD estimation), our analysis reveals that ESG practices significantly enhance firms' resilience. Figure 4 summarizes our empirical investigation on the pathways from ESG practices to firm resilience.

Figure 4 Summary of Findings



Note. ESG adoption strengthens relational ties, helping firms align operational processes with suppliers that enhance procurement and obtain sales advantages during disruptions. This alignment is driven by governance structure, human rights, community, and workforce within the ESG framework (detailed in Appendix A4 and A7). ESG efforts in these four components help firms strengthen supplier ties and cultivate customer loyalty regardless of supply chain network positions or the proximity to end consumers.

A critical pathway we highlight is the pivotal role of the relational ties that ESG practices provide in mitigating various global economic shocks. ESG-driven resilience emerges primarily from strengthened ties with suppliers and to a lesser extent with buyers, delivering procurement and price advantages during disruptions. Heterogeneity tests involving suppliers' and buyers' resources, supply chain structures, and lockdown stringency show that stronger supplier and buyer relationships, facilitated by ESG-driven relational ties, enhance resilience during disruptions. Such relational ties operate analogously to how total quality management (TQM) and just-in-time (JIT) systems facilitate stakeholder engagement in the supply chain, thereby reducing operational costs and improving operational efficiency (Hendricks and Singhal 1997).

One key managerial implication is that firms can garner resilience benefits without explicitly focusing their strategic initiatives on resilience. While a firm's strategic initiatives (e.g., TQM, JIT, lean systems, or ESG) have drastically different objectives, they can create a common foundation for stronger stakeholder engagement through several pathways. The first pathway is a shared process improvement component that requires a deeper understanding of stakeholders' capabilities

and objectives, necessitating open communication and fostering a sense of partnership (Ang et al. 2017, Kundu et al. 2024). Such a pathway builds trust and strengthens supplier relationships and buyer loyalty, which becomes effective during disruptive times. The second pathway is stronger employee participation in resolving process gaps among stakeholders (Kesavan et al. 2022). This helps to foster a sense of ownership in joint successes, where engaged employees are more likely to solve process inefficiencies and respond to crises rapidly. The third pathway is more frequent communications to align stakeholders' actions in response to external changes in customer demands or regulatory pressures (Davis and Hyndman 2019, Bakshi et al. 2023, Ha et al. 2023). More frequent communication allows increased transparency and visibility in aligning stakeholders' production and logistic processes (Lee et al. 2021). This enables firms to understand their upstream production flows with more clarity and to more effectively coordinate resource flows during the disruption. Finally, the fourth pathway is a long-term perspective, as firms' strategic initiatives take time to come to fruition and all stakeholders must focus on building sustainable business processes to achieve long-term strategic goals, even if this means that firms must sacrifice for short-term losses. Such a long-term orientation creates a more reliable and deeper supply network with trust, allowing firms to coordinate their resource flow more effectively in rapid response to disruptions. These pathways collectively contribute to swift resource coordination, enabling the supply chain to adapt and mitigate disruptions effectively.

While both ESG practices and operations-focused initiatives such as TQM and JIT, share a common foundation in building stakeholder trust as relational ties, ESG practices extend beyond a purely profit-maximization focus by embedding broader societal and environmental goals alongside economic objectives. As such, the financial returns on ESG practices may not be immediately apparent to executives, and there might even be short-term negative impacts. It is therefore even more critical than TQM or JIT practices for executives and company board members to take a long-term perspective to foster socially responsible business practices. The current intense debate on ESG practices can therefore be traced back to the conflict between short-term and long-term views on socially responsible practices (Cutter and Glazer 2024). Our study highlights that taking a long-term view helps to create a more resilient supply network, potentially offsetting the possible negative short-term impact on firm profits.

Aligning with the analytical perspective of Orsdemir et al. (2019), which underscores ESG's role in fostering vertical ties and strengthening supplier relationships, our findings offer a complementary empirical perspective. The primary driver of ESG's positive impact on resilience is enhanced supplier and buyer engagement, echoing responsible sourcing and the crucial role of close supplier and buyer collaboration (Davis and Hyndman 2019, Erhun et al. 2021, Ha et al. 2023). This synergy between our findings and existing literature, including the relational resilience insights

from Kundu et al. (2024), underscores the criticality of relational trust in navigating supply chain shocks. This confluence of insights positions ESG not merely as a component of ethical compliance but as a cornerstone of strategic resilience by enabling stakeholder engagement in supply chain management.

This study opens interesting avenues for further investigation in corporate social responsibility, governance, and firm resilience. Our study focuses on the focal firm's ESG effects on resilience, but ESG strategies could be more effective if they are integrated and collaborated across the supply network rather than being implemented in isolation by individual firms. This observation underscores the importance of exploring dyadic or triadic relationships within the network to more precisely understand how coordinated ESG efforts can enhance resilience. Investigating these relationships can help to provide specific empirical insights on the effective ESG integration, through shared resource management and strategic collaboration among all stakeholders, which could contribute more significantly to the overall resilience of the supply network.

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Appendix

A1. Additional Descriptive Statistics

Table A1 Variable Description

Variable	Definition	N	Mean	Median	SD
ROA	Annual return on assets measures: *ib/at*	55,403	0.05	0.05	0.06
E1	Overall ESG score	55,403	0.44	0.43	0.21
controv	ESG controversies score	55,372	0.92	1.00	0.21
rle	Rule of law	55,004	0.73	0.84	0.25
ln(at)	Total assets (logarithm)	55,403	9.38	8.94	2.55
inv/sale	Total inventories scaled by sales	55,403	0.13	0.11	0.09
wcap/at	Net working capital scaled by assets	55,403	0.16	0.14	0.16
caps/at	Capital surplus scaled by assets	55,369	0.15	0.07	0.21
gdwl/at	Goodwill scaled by total assets	55,250	0.10	0.04	0.12
ppent/at	Property, plant, and equipment scaled by total assets	55,403	0.30	0.26	0.20
mktshr	Market share	55,403	0.47	0.15	0.74
lr	Leverage ratio	55,403	0.74	0.50	0.78
tq	Tobin's q	55,403	1.31	1.01	0.91
re/at	Assets financed by retained earnings: *re/at*	55,403	0.21	0.22	0.28
revgrw	Revenue growth: *(revt - l1.revt)/l1.revt*	48,265	0.08	0.05	0.19
xsga/sale	General & administrative expenses to sales: *xsga/sale*	54,512	4.52	0.31	9.88
invturn	Inventory turnover: *cogs/((invt + l1.invt)/2)*	55,403	14.32	5.39	22.41
ROE	Profit per shareholder investment unit	55,403	0.10	0.10	0.15
ROI	Net profit per investment cost	55,403	0.07	0.07	0.10
E4	Environment Pillar Score	55,372	0.37	0.36	0.28
E5	Governance Pillar Score	55,403	0.50	0.51	0.22
E6	Social Pillar Score	55,372	0.44	0.42	0.24
E7	Resource Use Score (E pillar)	55,372	0.41	0.40	0.33
E8	Emissions Score (E pillar)	55,372	0.41	0.40	0.33
E9	Innovation Score (E pillar)	55,296	0.24	0.00	0.30
E10	Workforce Score (S pillar)	55,372	0.53	0.54	0.28
E11	Human Rights Score (S pillar)	55,372	0.29	0.15	0.33
E12	Community Score (S pillar)	55,372	0.50	0.50	0.29
E13	Product Responsibility Score (S pillar)	55,372	0.44	0.42	0.32
E14	Management Score (G pillar)	55,403	0.52	0.53	0.28
E15	Shareholders Score (G pillar)	55,403	0.52	0.52	0.28
E16	CSR Strategy Score (G pillar)	55,403	0.37	0.34	0.33
upstream	Firm's proximity to raw material production	34,670	1.14	1.00	1.00
up_stream_IO	Firm's industry input-output based upstream	55,401	1.93	1.97	0.36
between	Firm's centrality in information/resource flow	41,269	0.00	0.00	0.00
hub	Firm's centrality measures connection to authority	41,269	0.00	0.00	0.00
authority	Firm's centrality measures connection to hub links	41,269	0.00	0.00	0.00
in-degree	Inbound links indicating firm's importance	41,269	12.78	4.00	30.83
out-degree	Outbound links indicating firm's outreach	41,269	8.62	3.00	20.01
b_loc_n	Count of buyers unique locations	35,213	4.97	3.00	5.33
b_ap/cogs	Cost relative to sales for purchased goods (average)*	33,451	0.21	0.18	0.11
b_ch/at	Liquidity measured by cash/total assets (average)*	33,373	0.11	0.10	0.06
b_ELI	Buyers' empirical leanness indicator (average)*	32,983	-0.82	-0.97	0.87
b_invturn	Buyers' inventory turnover (average)*	33,003	15.28	7.78	18.50
b_inv/sale	Inventory amount relative to sales (average)*	33,458	0.13	0.12	0.07
b_rect/sale	Sales proportion yet to be collected (average)*	33,416	0.19	0.18	0.10
b_wcap/at	Working capital portion of assets (average)*	33,462	0.14	0.13	0.12
s_loc_n	Count of suppliers unique locations	39,287	5.02	3.00	5.50
s_ap/cogs	Suppliers' cost for goods sold relative to sales (average)*	38,007	0.23	0.19	0.14
s_ch/at	Suppliers' liquidity via cash/total assets (average)*	37,900	0.14	0.13	0.07
s_ELI	Suppliers' empirical leanness indicator (average)*	36,946	-0.34	-0.48	0.95
s_invturn	Suppliers' inventory turnover (average)*	36,957	34.48	9.76	58.15
s_inv/sale	Suppliers' inventory relative to sales (average)*	38,044	0.12	0.12	0.08
s_rect/sale	Suppliers' sales pending collection (average)*	38,034	0.24	0.21	0.10
s_wcap/at	Working capital's share in suppliers' assets (average)*	38,056	0.19	0.18	0.12
si_idx	Degree of stringency during COVID-19	17,336	47.31	50.11	18.04
human_rights	Degree of human rights respect	33,340	2.23	2.27	0.24
p_n_cum	Cumulative ESG policy number issued	55,167	13.60	12.00	12.22

Note. All values winsorized at 5% quantile. Unique number of firms: 7928. Year range: 2003 - 2023. * The operational and financial variable values are the average value of the supplier/buyer base.

Table A2 Pairwise Correlations

Variable	*ROA*	*E1*	*tq*	*lr*	*xsga/sale*	*mktshr*	*invturn*	*revgrw*	*ln(at)*	*caps/at*	*gdwl/at*	*ppent/at*	*invsale*	*wcap/at*
ROA	1.000													
E1	0.053***	1.000												
tq	0.194***	-0.002	1.000											
lr	-0.256***	0.114***	0.041***	1.000										
xsga/sale	-0.031***	0.009**	-0.354***	-0.079***	1.000									
mktshr	0.070***	0.312***	0.039***	0.122***	0.051***	1.000								
invturn	-0.039***	-0.024***	0.035***	0.091***	-0.072***	0.061***	1.000							
revgrw	0.213***	-0.075***	0.154***	-0.048***	-0.079***	-0.016***	0.028***	1.000						
ln(at)	0.056***	0.257***	-0.507***	0.069***	0.640***	0.371***	-0.064***	-0.081***	1.000					
caps/at	-0.229***	-0.127***	0.231***	-0.066***	-0.089***	-0.077***	0.008*	0.095***	-0.253***	1.000				
gdwl/at	0.000	0.122***	0.247***	0.103***	-0.217***	0.098***	0.105***	0.003	-0.219***	0.120***	1.000			
ppent/at	-0.058***	0.006	-0.172***	0.135***	-0.001	-0.024***	0.076***	-0.021***	0.087***	-0.160***	-0.379***	1.000		
invsale	-0.087***	-0.040***	-0.075***	-0.106***	0.033***	-0.179***	-0.555***	-0.079***	-0.028***	-0.001	-0.155***	-0.144***	1.000	
wcap/at	0.124***	-0.167***	0.110***	-0.417***	0.064***	-0.198***	-0.236***	0.036***	-0.179***	0.219***	-0.231***	-0.399***	0.362***	1.000

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3 GICS sector codes and names with frequency and percentage

GICS Sector Code	GICS Sector Name	Freq.	Percent (%)
10	Energy	3,642	6.57
15	Materials	8,517	15.38
20	Industrials	13,041	23.54
25	Consumer Discretionary	9,270	16.73
30	Consumer Staples	5,574	10.06
35	Health Care	5,653	10.20
45	Information Technology	6,327	11.42
50	Communication Services	3,371	6.09
Total		55,395	100.00

Note. Classification based on all observations. Observations for analysis depend on the number of complete cases.

A2. Stakeholder Resources Comparison by ESG adoption

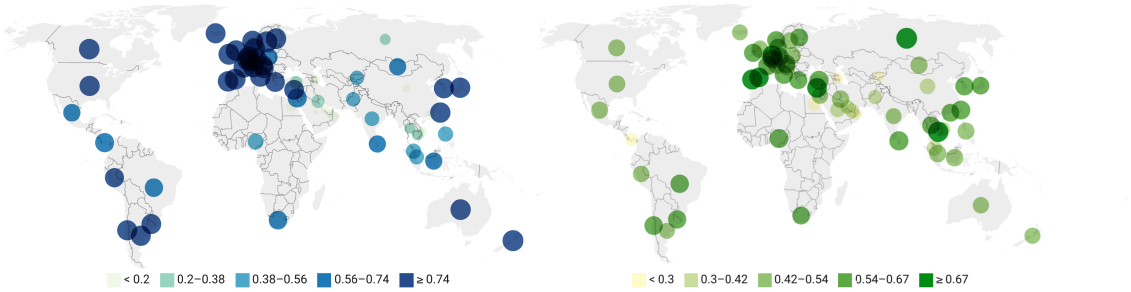
We separate the firms based on their annual ESG score into High and Low categories compared to their national mean in the corresponding years. We then calculate the mean and standard deviation of each stakeholder resource of the firms in these two groups for comparison.

Table A4 Stakeholder Resources Comparison by HighESG and LowESG

	High ESG			Low ESG		
Variable	N	Mean	SD	N	Mean	SD
wcap/at	26986	0.136	0.148	28417	0.189	0.174
inv/sale	26986	0.122	0.088	28417	0.130	0.101
s_ch/at	21439	0.140	0.067	16461	0.136	0.076
s_ap/cogs	21465	0.237	0.140	16542	0.225	0.139
s_rect/sale	21489	0.242	0.100	16545	0.231	0.109
s_wcap/at	21494	0.187	0.113	16562	0.190	0.125
s_inv/sale	21489	0.123	0.072	16555	0.126	0.082
s_ELI	21007	0.249	0.914	15939	0.461	0.993
s_loc_n	21904	6.537	6.556	17383	3.102	2.780
b_ch/at	18972	0.111	0.058	14401	0.106	0.061
b_ap/cogs	18993	0.208	0.110	14458	0.211	0.118
b_rect/sale	18968	0.190	0.097	14448	0.191	0.101
b_wcap/at	18997	0.142	0.118	14465	0.134	0.122
b_inv/sale	18996	0.130	0.072	14462	0.128	0.075
b_ELI	18746	-0.779	0.851	14237	-0.884	0.892
b_loc_n	19659	6.017	6.264	15554	3.638	3.397
upstream	19308	1.099	0.954	15362	1.197	1.045
up_stream_IO	26985	1.932	0.362	28416	1.928	0.366
in-degree	22054	19.386	40.194	19215	5.207	8.909
out-degree	22054	11.514	25.712	19215	5.296	8.973
human_rights	14935	2.247	0.234	18405	2.213	0.248
si_idx	8705	45.145	17.340	8631	49.492	18.462
p_n_cum	26881	13.126	11.270	28286	14.057	13.051

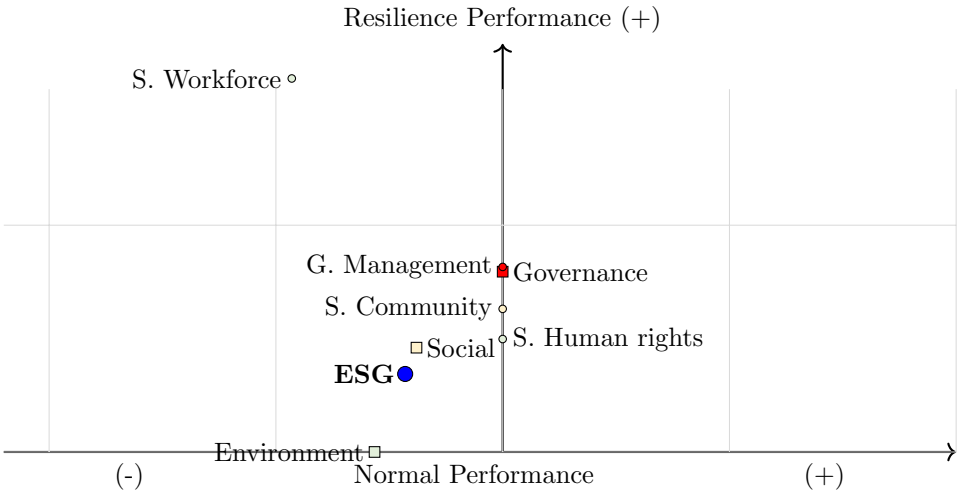
Note. The table compares the profiles of firms' internal resources (inventory and working capital) and their key stakeholders resource (supplier base, buyer base, supply chain structure, regulation environment) in HighESG group and LowESG group in our dataset. Most stakeholder resources have similar profiles between high and low ESG firms, except for the centrality measure, where high ESG firms typically have high in-degree (number of suppliers) and out-degree (number of buyers).

Figure A1 Rule of Law and Average ESG Initiatives (2020)



Note. The figure illustrates the relationship between country-level rule of law and firm-level ESG initiatives. In the left map, blue circles represent the country-level role of law indices, with larger and darker circles indicating higher values. In the right map, green circles depict average ESG scores, whereas larger and darker circles signify higher scores.

Figure A2 Selected ESG Subpillars and Components Effect Mapping



Note. Based on Tables A5 - A7, this chart illustrates the ESG adoption effect on ROA for ESG's three main sub-pillars—governance(G.), environment(E.), and social(S.)—and corresponding effective key components during normal conditions and disruptions. Key findings include governance and social pillars significantly enhancing resilience, while the environmental pillar, particularly resource use and emission reduction, shows a nuanced effect on normal performance. Detailed markers represent different aspects: circles for overall ESG impact, rectangles for sub-pillar effects, and smaller markers for specific components, demonstrating the varied influence on procurement competitiveness and resilience, as evidenced by their positioning on the resilience and performance axes.

A3. Cost Efficiency vs. Price Premium

Given that $cogs/sale = w \times units/p \times units = w/p$ where w and p represent unit purchasing cost and unit selling price respectively, this suggests that either the unit procurement cost w is significantly lower (relative to low ESG firm) or the unit selling prices p is significantly higher (relative to low ESG firm). Thus, the estimation suggests that firms engaging in ESG activities may derive resilience either from a more efficient procurement process (e.g., due to stronger ties with suppliers to obtain priority supply during disruption) or from a higher price premium (e.g., due to customers supporting firms' ESG activities).

Assuming that the units purchased are similar to units sold, then a more precise prediction can be derived on whether firms with high ESG activities primarily benefit from a more efficient procurement process (relatively lower purchasing price) or better customer engagement (relatively higher selling price) during the disruption. Let $cogs'$ and $sale'$ denote the impact of ESG on the cost of goods sold and sales during the disruption. Then it follows

$$\frac{cogs'}{sale'} - \frac{cogs}{sale} \approx -1.814\sigma_{cogs/sale} = -1.814, \tag{A1}$$

where $\sigma_{cogs/sale}$ is the standard deviation of $cogs/sale$ which is standardized to 1. Notice that $sale' = sale - 0.164\sigma_{sale} = sale - 0.164$ (where the standard deviation of sales σ_{sale} is also standardized to 1). Substituting this into (A1) and denote $cogs' = cogs - x$, then

$$\frac{cogs - x}{sale - 0.164} - \frac{cogs}{sale} \approx -1.814. \tag{A2}$$

For (A2) to hold, it must be true that $x > 0.164$. The impact of ESG on $cogs/sale$ can therefore be expressed as

$$\Delta := \frac{cogs - x}{sale - 0.164} = \frac{w \times units - x}{p \times units - 0.164} = \frac{w \times units - \Delta_w \times units'}{p \times units - \Delta_p \times units'}. \tag{A3}$$

Assuming $units' > 0$ (i.e., the disruption has a negative shock on units sold), then it follows from (A3) that $\Delta_w > \Delta_p$ (because $x > 0.164$). That is, the cost reduction from the procurement process is more salient than the potential price premium from the buyer side. Hence, firms with higher ESG engagements garner resilience mainly from a more efficient procurement process, allowing them to obtain inputs at a relatively lower cost than firms with lower ESG activities.

A4. Analysis of ESG Pillars and Subcomponents

The exploitation of regulatory variations across countries strongly supports that relational ties are crucial for firms to gain resilience from suppliers through ESG activities. To provide actionable managerial insights, we delve into ESG's pillars and subcomponents, exploring their impact on firm resilience through their capacity to strengthen relational ties. These ESG pillars include environment (*E4*), social (*E5*), and governance (*E6*). Relevant components within each pillar are also explored for a more granular analysis. For the environmental pillar, we include resource use (*E7*), emissions (*E8*), and environmental innovation (*E9*). In the social pillar, we analyze the workforce (*E10*), human rights (*E11*), community engagement (*E12*), and product responsibility (*E13*). Lastly, under the governance pillar, we evaluate management practices (*E14*), shareholder relations (*E15*), and CSR strategy (*E16*). These individual components are included because of their close ties with the stakeholder theory and are likely to influence firms' ability to appropriate performance boosts from supply chain partners. Definitions of these components are provided in Table A16, sourced from the Refinitiv ESG Scores Methodology (LSEG 2023). Examining these pillars and respective sub-components helps pinpoint specific sets of factors that are responsible for desirable resilience effects.

We investigate the specific contributions of ESG sub-dimensions to firm resilience. This exploration involves a detailed examination of the three primary pillars of ESG: environmental, social, and governance as well as core components of each.

$$ROA_{it} = \alpha_1 \widehat{ESGsub}^s_{it} \times I + \alpha_2 \widehat{ESGsub}^s_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \tag{A4}$$

$$\begin{aligned} \widehat{ESGsub}^s_{it} &= \beta_1 LaggedDem_{it} \times I + \beta_2 LaggedDem_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \\ \widehat{ESGsub}^s_{it} * I &= \gamma_1 LaggedDem_{it} \times I + \gamma_2 LaggedDem_{it} + \mathbf{X}_{it} \times I_t + F_i + Ind_I_{it} + \epsilon_{it} \end{aligned} \tag{A5}$$

We use the same 2SLS instrumental variable estimation for the ESG resilience effect in the primary analysis. We substitute the independent variable with specific ESG sub-dimensions, denoted as $ESGsub^s_i$, encompassing three dimensions $E4 - E6$ and core components $E7 - E16$, and keep

the instruments and controls the same.[11] The regression models for these analyses are articulated in (A5) for the first stage and in (A4) for the second stage.

Table A5 The Effect of Environment Dimension on Firm Resilience

	EnvironmentPillar			ResourceUse			Emissions			Innovation		
	E4 (1)	*E4*× *I* (2)	*ROA* (3)	*E7* (4)	*E7*× *I* (5)	*ROA* (6)	*E8* (7)	*E8*× *I* (8)	*ROA* (9)	*E9* (10)	*E9*× *I* (11)	*ROA* (12)
Dem.L1	0.054***	-0.011*		0.051***	-0.007+		0.053***	-0.009*		0.020*	-0.029***	
	(0.007)	(0.004)		(0.008)	(0.004)		(0.008)	(0.004)		(0.010)	(0.006)	
Dem.L1 × *I*	-0.049***	0.080***		-0.051***	0.052***		-0.040***	0.073***		-0.029***	0.121***	
	(0.006)	(0.008)		(0.007)	(0.008)		(0.007)	(0.008)		(0.008)	(0.010)	
Instrumented Esub			-0.565**			-0.597*			-0.569**			-1.795
			(0.214)			(0.236)			(0.212)			(1.551)
Instrumented Esub × *I*			0.149			0.180			0.235			-0.110
			(0.171)			(0.290)			(0.166)			(0.416)
Num.Obs.	47411	47411	47411	47411	47411	47411	47411	47411	47411	47345	47345	47345
R^2	0.855	0.716	0.697	0.822	0.693	0.683	0.829	0.705	0.689	0.781	0.613	-0.043
R^2 Adj.	0.828	0.663	0.640	0.788	0.635	0.623	0.797	0.649	0.630	0.740	0.540	-0.239
Std.Errors	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X	X	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X	X	X	X	X	X	X
Industry-Year	X	X	X	X	X	X	X	X	X	X	X	X

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Table A5 delineates the impact of the environmental dimension and its core components on firm resilience. Columns 1-3 elucidate the overarching effect of the environmental dimension, with Columns 1 and 2 representing the first-stage predictions. Column 3, detailing the second stage, reveals the resilience effect via the interaction term $Instrumented\ Esub \times I$, indicating that a unit increase in the environmental dimension results in a 0.511 unit rise in ROA amidst disruptions ($p < 0.001$). Columns 4-6 examine the influence of resource use on firm resilience, characterizing firms' efficiency in utilizing materials, energy, or water and their eco-solutions in the supply chain. Particularly, the interaction term in Column 6 suggests that a unit increase in resource use is associated with a 0.872 unit increase in firm ROA during disruptions ($p < 0.01$). Columns 7-9 explore the effects of emissions on firm resilience, assessing firms' commitment to and effectiveness in reducing emissions during production. The second-stage results in Column 9, through the interaction term, demonstrate the resilience effect; a unit increase in emission leads to a 0.872 unit increase in firm *ROA* during disruptions ($p < 0.001$). Columns 10-12 scrutinize the innovation effect, reporting negative impacts in disruptive times, albeit statistically non-significant and likely biased due to negative R^2 values.

Table A6 presents the impact of the governance dimension and its core components on firm resilience. The results reveal a significant resilience effect of the overall governance dimension: a unit increase in the governance dimension leads to a 1.289 unit increase in ROA during disruptions

[11] We assume that ideological orientation influences both overall ESG engagement and its specific components in a similar way; additionally, we verify the relevance of the instruments across our econometric evaluations to ensure effective IV.

Table A6 The Effect of Governance Dimension on Firm Resilience

	GovernancePillar			Management			Shareholders			CSR Strategy		
	E5 (1)	*E5× I* (2)	*ROA* (3)	*E14* (4)	*E14× I* (5)	*ROA* (6)	*E15* (7)	*E15× I* (8)	*ROA* (9)	*E16* (10)	*E16× I* (11)	*ROA* (12)
Dem.L1	0.023*	-0.024***		0.027*	-0.021***		-0.028*	-0.027***		0.039***	0.004	
	(0.011)	(0.005)		(0.012)	(0.006)		(0.012)	(0.006)		(0.009)	(0.005)	
Dem.L1 × I	0.021*	0.065***		0.017+	0.060***		0.034***	0.048***		-0.007	0.013	
	(0.008)	(0.010)		(0.009)	(0.010)		(0.009)	(0.010)		(0.008)	(0.008)	
Instrumented Gsub			-0.564			-0.549			1.135			-1.098*
			(0.372)			(0.356)			(1.980)			(0.459)
Instrumented Gsub × I			0.795***			0.816***			0.028			2.581
			(0.179)			(0.185)			(1.482)			(1.584)
Num.Obs.	47411	47411	47411	47411	47411	47411	47411	47411	47411	47411	47411	47411
R^2	0.702	0.587	0.622	0.657	0.556	0.611	0.634	0.528	0.252	0.783	0.656	0.039
R^2 Adj.	0.646	0.509	0.551	0.593	0.472	0.538	0.566	0.439	0.112	0.743	0.591	-0.142
Std.Errors	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X	X	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X	X	X	X	X	X	X
Industry-Year	X	X	X	X	X	X	X	X	X	X	X	X

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

($p < 0.001$). Columns 4-6 elucidate the role of management in enhancing firm resilience, highlighting firms' dedication and efficacy in corporate governance practices. Notably, the interaction term in Column 6 indicates that a unit rise in the management score is linked to a 1.289 unit increase in firm ROA amidst disruptions ($p < 0.001$). The analysis extends to Columns 7-9 and assesses the influence of the shareholder score on firm resilience, focusing on firms' commitment to equitable shareholder treatment. The results in Column 9 show a positive effect on resilience during disruptions, although this finding is not statistically significant. Finally, Columns 10-12 reflect the impact of CSR Strategy on firm resilience, indicating a negative effect in disruptive environments. However, the negative indication is statistically non-significant and likely biased due to negative R^2 values.

Table A7 The Effect of Social Dimension on Firm Resilience

	SocialPillar			HumanRights			Community			ProductResponsibility		
	E6 (1)	*E6× I* (2)	*ROA* (3)	*E11* (4)	*E11× I* (5)	*ROA* (6)	*E12* (7)	*E12× I* (8)	*ROA* (9)	*E13* (10)	*E13× I* (11)	*ROA* (12)
Dem.L1	0.057***	-0.023***		0.016	-0.036***		0.056***	-0.036***		0.062***	0.004	
	(0.007)	(0.005)		(0.010)	(0.005)		(0.009)	(0.005)		(0.010)	(0.005)	
Dem.L1 × I	-0.016*	0.073***		0.010	0.097***		-0.019*	0.058***		-0.062***	0.014	
	(0.007)	(0.009)		(0.008)	(0.009)		(0.008)	(0.009)		(0.008)	(0.009)	
Instrumented Ssub			-0.380*			-0.894			-0.165			-0.543***
			(0.191)			(0.662)			(0.254)			(0.142)
Instrumented Ssub × I			0.460***			0.498***			0.631**			0.422
			(0.135)			(0.114)			(0.218)			(0.760)
Num.Obs.	47411	47411	47411	47411	47411	47411	47411	47411	47411	47411	47411	47411
R^2	0.846	0.693	0.708	0.774	0.655	0.575	0.785	0.634	0.702	0.749	0.623	0.664
R^2 Adj.	0.817	0.636	0.654	0.731	0.590	0.495	0.745	0.565	0.646	0.701	0.553	0.601
Std.Errors	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1	HC1
X × Year	X	X	X	X	X	X	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X	X	X	X	X	X	X
Industry-Year	X	X	X	X	X	X	X	X	X	X	X	X

Note. Workforce component is omitted due to the ineffectiveness of IV estimation (negative R^2); Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Table A7 elucidates the social dimension's contribution to firm resilience, segmented into core components. Columns 1-3 illustrate the comprehensive impact of the social dimension, manifesting a pronounced resilience effect: a unit increase in the social dimension corresponds to a 1.117 unit

augmentation in ROA amidst disruptions ($p < 0.001$). The assessment extends to Columns 4-6, focusing on the human rights score, which gauges firms' adherence to human rights standards. The analysis reveals statistically non-significant positive resilience effects. Columns 7-9 investigate the community score's impact, reflecting on firms' contributions to public goods and ethical practices. The results suggest positive implications in disruptive settings yet lack statistical significance and are likely biased due to negative R^2 values. Lastly, Columns 10-12 scrutinize product responsibility, evaluating firms' commitment to quality goods and services and privacy safeguards. The results show the increase in product responsibility by one unit leads to a 1.263 unit augmentation to the firm resilience, with marginal significance ($p < 0.1$). Notably, the non-significant of $Dem.L1 \times I$ in the first stage shows a weak instrument for this component, which may bias the IV estimates and lead to a downward biased standard error.

These results collectively show that governance and social dimensions exhibit relatively stronger resilience effects than the environmental dimension. Given that the governance and social dimensions focus on stakeholder ties, they are more likely to foster relational ties with supply chain partners than the environmental dimension. The results support our argument that ESG activities foster relational ties as a pathway to gain resilience during disruption.

A5. DiD regression for the robustness check

A5.1. Main Results Table A8 shows the main results of the DiD estimation.

Table A8 DiD: The Effect of ESG Adoption on Firm Resilience

	ROA			
	(1)	(2)	(3)	(4)
E1	-0.003	-0.006	-0.003	-0.006
	(0.007)	(0.007)	(0.007)	(0.007)
$E1 \times I$	0.033***	0.035***	0.032***	0.034***
	(0.009)	(0.009)	(0.009)	(0.009)
inv/sale		-0.286***		-0.280***
		(0.016)		(0.016)
wcap/at			-0.058**	-0.039*
			(0.019)	(0.019)
Num.Obs.	48092	48092	48092	48092
R^2	0.731	0.739	0.732	0.739
R^2 Adj.	0.682	0.691	0.682	0.691
Std.Errors	HC1	HC1	HC1	HC1
$\mathbf{X} \times Year$	X	X	X	X
Firm FE X	X	X	X	X
Industry-Year FE X	X	X	X	X

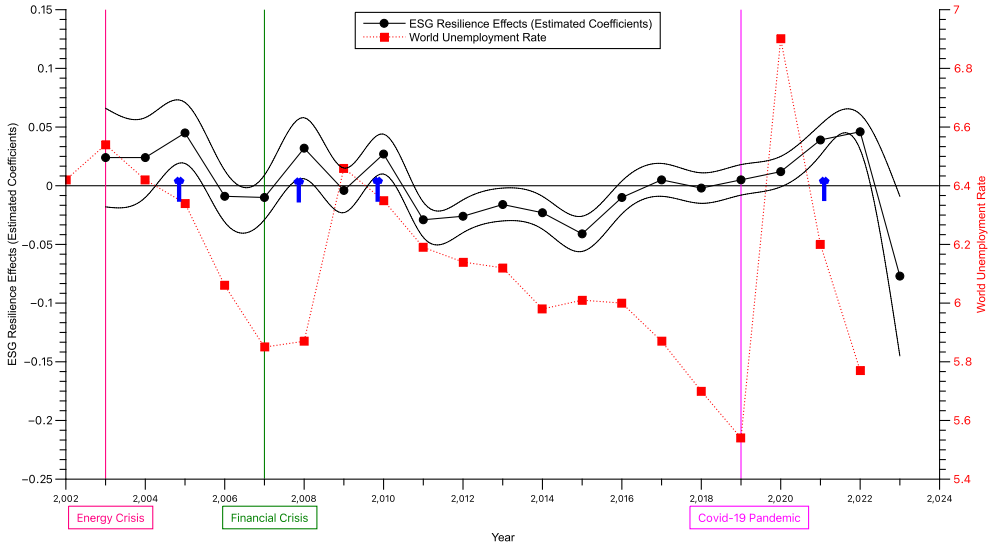
Note. Column 1, excluding *inv/sale* and *wcap/at*, analyzes ESG's impact on ROA during disruptions. Columns 2-4 add *inv/sale* and *wcap/at* as time-varying controls separately and both, differentiating ESG's effects from operational redundancy. Coefficients of *inv/sale* and *wcap/at* show the value in the year 2020. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

A5.2. Flexible Estimation by Year The estimation requires choosing a date when the disruption happened. The WHO publishes the outbreak of the pandemic in 2020 as a global public health risk (WHO 2021). Given the evidence, a reasonable cutoff date should be the year 2020 as the first post-disruption period. To verify this assumption and the parallel trends, a fully flexible estimation is employed that allows the ESG score to interact with fixed effects for each period within the entire dataset spanning from 2003 to 2023, as detailed in (A6).

$$ROA_{it} = \alpha_j ESG_{it} \times \mathbf{I}_t^j + \beta ESG_{it} + \mathbf{X}_{it} \times I_t + F_i + Industry_I_{it} + \epsilon_{it}. \tag{A6}$$

The results of the estimation are illustrated in Table A9. A clear pattern emerges from the table. The relationship between the ESG score and ROA is constant over time and small, even negative, from 2011 to 2019, and then steadily increases in magnitude from 2020 to 2022. The patterns in the data can be seen most clearly by plotting the coefficients of the interaction terms over time. Figure A3 is based on the point estimates from columns (1) and the 95 percent confidence intervals. We do not detect discernible trends in the estimated interaction effects in the periods immediately prior to COVID-19, which suggests that any subsequent changes are likely due to the ESG practices during the disruption. To confirm the disruption, we add the global unemployment rate from the World Bank (World Bank 2024). We find that the unemployment rate increased by about 25% from 2019 to 2020 and reached the peak in 2020, while decreasing before the disruption (2010-2019). This supports our identification strategy using 2020 as the disruption indicator, and excludes other global shocks that seriously affect the global economy and firms' operations.

Figure A3 Flexible Estimation: Effect of ESG (Standardized ESG Score) on ROA by Time Period



Note. The figure plots the dynamic effects estimation of the ESG adoption on firms' ROA by year (see Table A9). The dynamic analysis shows that ESG's impact on ROA becomes prominent following major global crises. The resilience benefits correlate with the severity of disruptions, as indicated by unemployment rates, emphasizing the critical role of ESG in navigating severe disruptions.

Interestingly, we find positive, large effects during 2005, 2008, and 2010. According to our findings of the ESG resilience effect, there should be severe global disruptions during those years with a negative impact on firms' operations and economies, which could also be verified by the global unemployment rates. The energy crisis during the 2003 Iraq War and the 2007-2009 financial crisis, known as "The Great Recession," precipitated significant global economic upheavals and increased unemployment rates. The immediate positive impact of ESG on firms' ROA following these disruptions underscores the crucial role of ESG resilience in navigating such profound global shocks. Furthermore, Figure A3 illustrates that resilience effect size is positively correlated with the magnitude of the disruption, as indicated by the levels of unemployment, which helps confirm our findings regarding the significance of ESG adoption on a firm's resilience during disruptions. Collectively, these findings suggest that the ESG resilience effect may not be restricted to the COVID-19 disruption, but rather can be broadly applicable in any period of serious disruption events. This supports our argument that relational ties are more critical during trying times.

For the robustness of the resilience effect identification, we performed a set of placebo tests by sequential rolling estimates with alternative cutoffs and time windows (Nunn and Qian 2011). We examine four years segments from 2015 to 2023. For each four-year window, we treat the later two years as the post-disruption period by using the same specification from (6). The results are illustrated in Table A10, and they show that the resilience effect is non-significant or marginally significant when we set the cutoff in 2017, 2018, 2019, but the positive effect becomes significant in 2020 and is much stronger in 2021. The results suggest that selecting the year 2020 as the starting point of the disruption is valid and prudent.

Table A9 displays yearly flexible estimation results.

Table A9 Flexible Estimates: ESG Score and Firms' Performance by Year

	2003-2007	*2008-2012*	*2013-2017*	*2018-2023*
E1 × Year	(2003) 0.024 (0.042) (2004) 0.024 (0.034) (2005) 0.045+ (0.026) (2006) -0.009 (0.022) (2007) -0.010 (0.019)	(2008) 0.032 (0.026) (2009) -0.004 (0.019) (2010) 0.027+ (0.017) (2011) -0.029+ (0.015) (2012) -0.026+ (0.014)	(2013) -0.016 (0.014) (2014) -0.023+ (0.014) (2015) -0.041** (0.015) (2016) -0.010 (0.014) (2017) 0.005 (0.014)	(2018) -0.002 (0.013) (2019) 0.005 (0.013) (2020) 0.012 (0.013) (2021) 0.039** (0.013) (2022) 0.046** (0.015) (2023) -0.077 (0.068)
Num.Obs.	48092			
R^2	0.740			
Std.Errors	HC1			
$\mathbf{X}\times Year$	X			
Firm FE	X			
Industry-Year FE	X			

Note. The table illustrates the dynamic effects of ESG adoption on firms' ROA by year. Significance levels: + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

A5.3. Placebo Test Table A10 shows the DiD estimation with alternative cut-offs for the placebo test. Figure A4 plots the residual variance, identifying structural breaks throughout the dataset spanning from 2003 to 2023.

Table A10 The Impact of ESG Adoption with Alternative Cut-Offs

	Placebo Treatment Periods					
	2015-2018 Post=2017, 2018	2016-2019 Post=2018, 2019	2017-2020 Post=2019, 2020	2018-2021 Post=2020, 2021	2019-2022 Post=2021, 2022	2022-2023 Post=2022, 2023
	(1)	(2)	(3)	(4)	(5)	(6)
	ROA					
E1	-0.014	-0.005	-0.007	-0.032+	-0.032+	-0.015
	(-0.02)	(-0.019)	(-0.02)	(-0.018)	(-0.018)	(-0.022)
E1 x Post	0.021+	0.004	0.003	0.020+	0.027**	0.01
	(-0.012)	(-0.011)	(-0.011)	(-0.011)	(-0.01)	(-0.012)
Num.Obs.	11701	13244	14948	17153	19041	15337
R^2	0.838	0.832	0.834	0.839	0.847	0.877
R^2 Adj.	0.757	0.749	0.751	0.756	0.77	0.792
Std.Errors	HC1	HC1	HC1	HC1	HC1	HC1
$\mathbf{X}\times$ *Year*	X	X	X	X	X	X
Firm FE	X	X	X	X	X	X
Industry-Year	X	X	X	X	X	X

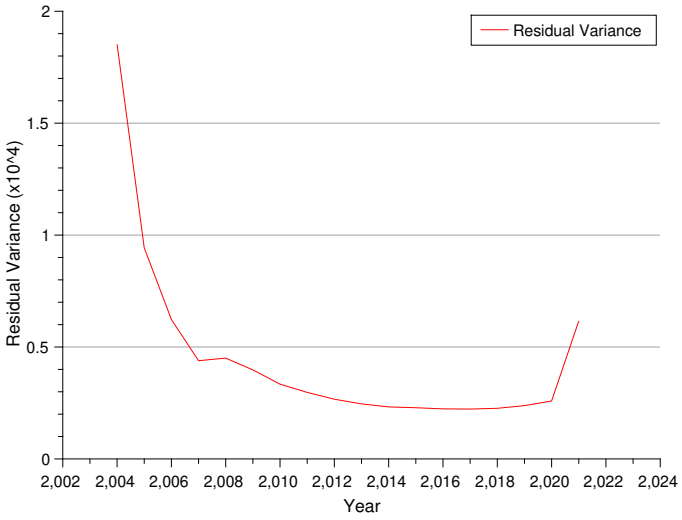
Note. The table presents placebo tests using a series of four-year time windows, designating the final two years within each window as the post-period to assess the impact of ESG adoption on firms' ROA. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

By fitting separately the same models to the data before and after each break date, we compute the sum of squared errors for the combined pre- and post-break models across the entire dataset and divide by the sample size, thereby obtaining a residual variance for each break date. The results are plotted in Figure A4. The bottom is essentially flat, meaning that there is not much structural shift between 2014 - 2019. This implies that ESG's main effect is fairly stable during these years. In contrast, in 2020 there is a significant structural shift, suggesting that the underlying process generating the data has changed. The ESG's effect shift in 2020 signifies the start of the disruption. This is consistent with our rolling estimations and flexible estimations.

We also verify mechanisms in the operational performance metrics with DiD estimation. The results, as detailed in Table A14, corroborate our IV estimation results, revealing that ESG adoption enhances firm resilience by lowering procurement costs and boosting profitability. These results align with our conclusion that ESG initiatives strengthen relationships with stakeholders (e.g., suppliers and buyers), enhancing firm resilience. For managerial implications, we verify the unpacking of ESG sub-dimensions and the core components, with detailed results presented in Table A11 for environment dimension, Table A12 for governance dimension, and Table A13 for social dimension.

A5.4. DiD: Impact of ESG subpillars Table A11, A12, and A13 show the DiD estimation with ESG subpillars.

Figure A4 Least Squares Breakdate Estimation: Residual Variance as a Function of Breakdate



Note. The figure plots the residual variance (sum of squared errors divided by sample size) of estimation for the effect of ESG adoption on firms' ROA across the entire dataset period (2003-2023).

Table A11 DiD: The Effect of the Environment Dimension on Firm Resilience

	EnvironmentPillar *E4* (1)	ResourceUse *E7* (2)	Emissions *E8* (3)	Innovation *E9* (4)
		ROA		
Esub	-0.009	-0.015*	-0.002	-0.006
	-0.007	-0.006	-0.007	-0.006
Esub × *I*	0.018*	0.022*	0.016+	0.010
	-0.009	-0.009	-0.009	-0.008
Num.Obs.	48072	48072	48072	48006
R^2	0.725	0.725	0.725	0.725
R^2 Adj.	0.674	0.674	0.674	0.674
Std.Errors	HC1	HC1	HC1	HC1
X× *Year*	X	X	X	X
Firm FE	X	X	X	X
Industry-Year	X	X	X	X

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Table A12 DiD: The Effect of the Governance Dimension on Firm Resilience

	GovernancePillar	Management	Shareholders	CSR Strategy
	E5	*E14*	*E15*	*E16*
	(1)	(2)	(3)	(4)
	ROA			
Esub	-0.005	-0.004	-0.007	0.001
	-0.005	-0.005	-0.005	-0.006
E5× *I*	0.021**	0.020*	0.016*	-0.004
	-0.008	-0.008	-0.008	-0.008
Num.Obs.	48092	48092	48092	48092
R^2	0.725	0.725	0.725	0.725
R^2 Adj.	0.674	0.674	0.674	0.674
Std.Errors	HC1	HC1	HC1	HC1
X× *Year*	X	X	X	X
Firm FE	X	X	X	X
Industry-Year	X	X	X	X

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

Table A13 DiD: The Effect of Social Dimension on Firm Resilience

	SocialPillar	Workforce	HumanRights	Community	ProductResponsibility
	E6	*E10*	*E11*	*E12*	*E13*
	(1)	(2)	(3)	(4)	(5)
	ROA				
Esub	0.000	0.016**	-0.010+	-0.010+	0.003
	-0.007	-0.006	-0.006	-0.006	-0.005
E6× *I*	0.017+	0.009	0.010	0.031***	-0.015+
	-0.009	-0.009	-0.008	-0.008	-0.008
Num.Obs.	48072	48072	48072	48072	48072
R^2	0.725	0.725	0.725	0.725	0.725
R^2 Adj.	0.674	0.674	0.674	0.674	0.674
Std.Errors	HC1	HC1	HC1	HC1	HC1
X × *Year*	X	X	X	X	X
Firm FE	X	X	X	X	X
Industry-Year	X	X	X	X	X

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

A5.5. DiD: Impact of ESG on Operation Performance Metrics Table A14 shows the results of the impact of ESG on Operation Performance Metrics.

Table A14 DiD: Regression - Operation Performance Metrics

	cogssale	*sale*	*salemrgn*
	(1)	(2)	(3)
E1	-0.006	-0.010***	0.002
	(0.029)	(0.002)	(0.005)
E1× *I*	-0.153+	0.001	0.020***
	(0.087)	(0.003)	(0.006)
Num.Obs.	48092	48092	48092
R^2	0.591	0.983	0.910
R^2 Adj.	0.515	0.980	0.893
Std.Errors	HC1	HC1	HC1
X× *Year*	X	X	X
Firm FE	X	X	X
Industry-Year	X	X	X

Note. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

A6. Alternative Measurements: ROI and ROE

Table A15 shows the resilience effects with alternative performance measures with both 2SLS and DiD estimation.

Table A15 The Effect of ESG on Firm Resilience with Alternative Measures: ROI and ROE

Panel A: 2SLS	*E1*	*E1*× *I*	*ROI*	*ROE*
	(1)	(2)	(3)	(4)
Dem.L1	0.241***	-0.093***		
	(0.022)	(0.020)		
Dem.L1 × *I*	-0.001	0.064***		
	(0.006)	(0.009)		
Instrumented E1			-0.274+	-0.121
			(0.148)	(0.152)
Instrumented E1 × *I*			0.700***	0.589***
			(0.155)	(0.158)
Num.Obs.	47600	47600	47600	47600
R^2	0.864	0.709	0.682	0.655
R^2 Adj.	0.838	0.655	0.622	0.590
Panel B: DiD			*ROI*	*ROE*
E1			-0.006	-0.010
			(0.007)	(0.008)
E1× *I*			0.025**	0.024*
			(0.009)	(0.010)
Num.Obs.			48092	48092
R^2			0.725	0.683
R^2 Adj.			0.674	0.624
Std.Errors	HC1	HC1	HC1	HC1
X× *Year*	X	X	X	X
Firm FE	X	X	X	X
Industry-Year FE	X	X	X	X

Note. Panel A presents the 2SLS estimation results for alternative dependent variables, with Columns 1-2 displaying the first-stage results, and Columns 3-4 showcasing the second stage. Panel B reveals the DiD estimation results for alternative dependent variables. Significance levels are indicated as + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Heteroskedasticity-robust standard errors (HC1) are employed.

A7. ESG subpillars Definitions

Table A16 ESG Subpillars and Key Components Definitions

Pillars	Categories	Components	Categories Definition
Environmental	Emission	Emissions	The emission reduction score measures a company's commitment and effectiveness towards reducing environmental emissions in its production and operational processes.
		Waste	
		Biodiversity	
		Environmental management systems	
	Innovation	Product innovation	The innovation score reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed products.
		Green revenues, research and development (R&D) and capital expenditures (CapEx)	
	Resource use	Water	The resource use score reflects a company's performance and capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management.
		Energy	
		Sustainable packaging	
		Environmental supply chain	
Social	Community	Equally important to all industry	The community score measures the company's commitment to being a good citizen, protecting public health and respecting business ethics.
		groups, hence a median weight of five is assigned to all	
	Human rights	Human rights	The human rights score measures a company's effectiveness in terms of respecting fundamental human rights conventions.
	Product responsibility	Responsible marketing	The product responsibility score reflects a company's capacity to produce quality goods and services, integrating the customer's health and safety, integrity and data privacy. respecting fundamental human rights conventions.
		Product quality	
		Data privacy	
	Workforce	Diversity and inclusion	The workforce score measures a company's effectiveness in terms of providing job satisfaction, a healthy and safe workplace, maintaining diversity and equal opportunities, and development opportunities for its workforce.
		Career development and training	
		Working conditions	
		Health and safety	
Governance	CSR strategy	CSR strategy ESG reporting and transparency	The CSR strategy score reflects a company's practices to communicate that it integrates economic (financial), social and environmental dimensions into its day-to-day decision-making processes.
	Management	Structure (independence, diversity, committees) Compensation	The management score measures a company's commitment and effectiveness towards following best practice corporate governance principles.
	Shareholders	Shareholder rights Takeover defenses	The shareholders score measures a company's effectiveness towards equal treatment of shareholders and the use of anti-takeover devices.

Note. The table compiles its sources from the Refinitive data descriptive manual (LSEG 2023).

A8. Upstreamness and Centrality

A8.1. Upstreamness Let $G = (V, E)$ represent a directed supply chain network where V consists of nodes (firms) and E represents directed edges (supply relationships). A firm $v_f \in V$ is classified as a final goods producer based on GICS codes, and the set of final goods producers is denoted $F \subseteq V$.

The upstreamness $U(v)$ of a firm v is defined as the minimum number of steps to reach any final goods producer:

$$U(v) = \min_{v_f \in F} d(v, v_f)$$

where $d(v, v_f)$ represents the shortest path distance. If no path exists, upstreamness is considered infinite, indicating no direct or indirect supply chain connection to final goods producers.

A8.2. Betweenness Centrality Betweenness centrality $C_B(v)$ of a firm v measures its importance in facilitating connections between other firms in the network:

$$C_B(v) = \sum_{\substack{s,t \in V \\ s \neq v \neq t}} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

where:

- σ_{st} is the total number of shortest paths from node s to node t.
- $\sigma_{st}(v)$ is the number of those paths that pass through node v.

Firms with high betweenness centrality frequently lie on critical paths between other firms, indicating greater influence within the supply chain.

A8.3. Authority Scores Authority and hub are scores capture a firm's role in pointing to and being pointed to by others:

- A good hub links to many good authorities.
- A good authority is linked to many good hubs.

These scores are updated iteratively:

$$A(i) = \sum_{p \in M(i)} H(p), \quad H(i) = \sum_{q \in L(i)} A(q)$$

where:

- $A(i)$ and $H(i)$ are the authority and hub scores of firm i.
- $M(i)$ is the set of nodes that link to node i (in-links).
- $L(i)$ is the set of nodes that node i links to (out-links).

The process continues until the scores converge.

A8.4. In-Degree and Out-Degree The in-degree and out-degree of a firm v are defined as:

$$\text{In-Degree}(v) = |\{(u, v) \in E\}|, \quad \text{Out-Degree}(v) = |\{(v, w) \in E\}|$$

In-degree counts how many firms supply to v, while out-degree counts how many firms v supplies to.