

# Supply Chain ESG Risk Contagion and Governance: A Case Study of Apple Inc.

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## Abstract

In the field of ESG research, the contagion mechanisms of supply-chain ESG risks and their corresponding governance strategies have generally been overlooked. Taking the 2010 Foxconn suicide incidents and the resulting brand reputation crisis at Apple as its research object, this study employs the event study methodology to document the phenomenon of ESG risk contagion from an upstream supplier to a downstream end-brand enterprise. It further delineates the contagion pathway, encompassing stages such as media exposure and stock price volatility. Finally, the paper synthesizes the response strategies adopted by various parties following risk contagion, including internal supply-chain governance and external oversight. From the perspective of risk contagion, this study constructs a comprehensive supply-chain ESG risk management framework consisting of “ESG risk identification → contagion pathway analysis → governance strategy response”. The framework not only enriches the theoretical literature on ESG but also offers practical guidance for firms seeking to mitigate externality risks and enhance supply-chain resilience. Additionally, it provides a theoretical foundation for national authorities to refine ESG disclosure requirements and regulatory policies.

## Keywords

supply chain, ESG risk, supply chain ESG risk contagion, event study method

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## 1. Introduction

Against the backdrop of ongoing digital transformation, the contagion of ESG risks through supply chains has emerged as a central challenge for corporate operations and brand reputation management. This issue has grown particularly acute as ESG regulatory scrutiny worldwide extends from individual firms to entire supply chain networks, making the development of robust risk prevention systems an urgent priority (Liu et al., 2025). Governments are actively advancing supply chain ESG disclosure and oversight. In China, although mandatory legislation has yet to be introduced, the Shanghai Stock Exchange's 2024 Self-Regulatory Guidelines for Listed Companies No. 14 — Sustainable Development Report (Trial) explicitly encourages listed companies to disclose key aspects of supply chain responsibility. On the international front, the EU's Corporate Sustainability Due Diligence Directive, which entered into force in 2024, requires large enterprises to progressively establish due diligence and disclosure mechanisms for human rights and environmental risks across their supply chains. These developments highlight that any negative incident in the supply chain, such as environmental damage or labor disputes, can rapidly damage the reputation and operations of core firms and therefore impose far greater demands on companies to establish truly sustainable supply chain systems.

The literature on supply chain ESG issues has expanded considerably in recent years, yet most studies concentrate on the positive spillover effects of strong ESG performance onto other supply chain partners,

largely overlooking the contagion pathways of ESG risks and the governance responses they provoke. The 2010 Foxconn employee suicide incidents, which plunged Apple into a major brand-reputation crisis, provide a vivid and instructive case for examining these dynamics. Accordingly, this paper takes the impact of the Foxconn suicide incidents on Apple, together with the subsequent responses of both Apple and Foxconn, as its primary focus to investigate the mechanisms by which ESG risks propagate along supply chains and the governance approaches that can be deployed in response.

Through the case analysis, this study finds that ESG risks originating from upstream suppliers propagate to downstream clients via the mechanism of “incident trigger → media amplification → short-term valuation loss → capital market reaction.” Following the incident, the upstream supplier implemented internal rectification measures; the downstream client, in turn, responded by introducing third-party audits, strengthening supplier disclosure requirements, and optimizing supply chain structure to mitigate and govern such risks.

This study makes contributions in three respects. First, in terms of research perspective, whereas existing studies on the economic consequences of ESG predominantly examine the impact of positive ESG performance on focal firms themselves or the positive spillover effects along supply chains, this paper shifts the focus to a risk-based perspective, exploring the contagion of negative ESG incidents across the supply chain, thereby enriching the ESG literature.

Second, in terms of research findings, the case analysis elucidates the specific contagion pathway of ESG risk from upstream to downstream—namely, the complete chain of “incident trigger → media amplification → short-term valuation loss → capital market reaction”—deepening theoretical understanding of how non-financial risks diffuse within supply chains. At the same time, the paper investigates the responsive strategies adopted by various parties along the supply chain after risk contagion, thereby contributing to the theoretical framework of supply chain risk management.

Third, in terms of research methodology, the existing literature on the economic consequences of ESG predominantly employs large-sample empirical analysis, which is unable to elucidate the specific mechanisms or pathways through which ESG operates. In contrast, this study adopts a case study approach to conduct an in-depth examination of the contagion mechanisms and pathways of ESG-related risks, thereby further enriching the theoretical research on the economic consequences of ESG.

## 2. Literature Review

In recent years, ESG has become a prominent topic in academia. As ties between upstream and downstream firms in supply chains have grown increasingly close, a substantial body of literature has shifted attention toward the spillover effects of corporate ESG performance across the supply chain, subjecting these effects to rigorous empirical testing. These studies consistently find that strong ESG performance by a focal firm exerts positive influences on both its upstream suppliers and downstream customers: on the one hand, it helps improve suppliers' own ESG outcomes and green innovation capabilities; on the other, it enhances the stability of downstream clients, reduces their default risk, and ultimately strengthens overall supply chain resilience.

Specifically, Gârleanu et al. (2015) demonstrate that strong ESG performance by a firm can be transmitted along the supply chain, thereby enhancing suppliers' innovation levels. Xiao et al. (2024) and Yan et al. (2024) find that superior ESG performance by downstream customers improves upstream suppliers' ESG performance and green innovation through structural empowerment, resource empowerment, and green technology spillovers, forming a positive feedback loop. Li et al. (2023) and Xin et al. (2024) show that strong ESG performance strengthens a firm's bargaining power within the supply chain by enhancing corporate reputation and alleviating financing constraints, which in turn increases the stability of downstream customers. Su and Zhou (2024) further reveal that the better a firm's ESG performance, the lower the default risk of its downstream customers. Moreover, from the perspective of the overall supply chain, Wang and Hu (2024) and Yuan et al. (2025) indicate that strong ESG performance can be transmitted throughout the supply chain, ultimately improving the resilience of the entire supply chain. Lin and Wei (2023) further document that ESG performance enhances supply chain resilience by increasing information transparency and easing financing constraints, thereby optimizing customer structure.

## 3. Overview of the ESG Risk Contagion Event

### 3.1 Background on Apple Inc.

Apple Inc. is a U.S.-based multinational technology company founded in 1976 and listed on the NASDAQ Stock Market on December 12, 1980. For fiscal year 2024, the company reported annual revenue of US\$391.035 billion and net profit of US\$93.736 billion. Since 2018, its revenue has consistently stayed above US\$260 billion, with net profit remaining above US\$55 billion, reflecting strong profitability and financial stability. The bulk of its income comes from iPhone, Mac, iPad, wearables, and services, with the iPhone line continuing to serve as the core product family, accounting for roughly 51% of total revenue in fiscal 2024.

In terms of operating model, Apple concentrates on the parts of the value chain where it holds the greatest strengths while outsourcing non-core activities. This approach allows the company to rely on an extensive supply chain for rapid global market expansion (Surdu, 2011), thereby optimizing resource allocation and maximizing capital efficiency. Structurally, Apple works with around 800 suppliers worldwide. Upstream component suppliers are geographically dispersed, whereas final assembly is heavily concentrated in the hands of a small number of contract manufacturers, most notably Foxconn. Downstream, Apple reaches consumers globally through a combination of its own retail channels and third-party distributors.

### 3.2 Background on Foxconn Technology Group

Foxconn Technology Group, officially Hon Hai Precision Industry Co., Ltd., was founded in Taiwan, China in 1974 and was formally listed on the Taiwan Stock Exchange in 1991. Its core business is to provide downstream customers with comprehensive “design, manufacturing, assembly, and after-sales services” for electronic products.

Foxconn serves as Apple's primary supplier and accounts for as much as 65% of the company's total production capacity, well ahead of other contract manufacturers such as Luxshare Precision or Pegatron. According to data of 2025, Foxconn handles 70% of the production for both the iPhone Pro and Pro Max series.

### 3.3 The ESG Risk Incident

Between January 23 and May 27, 2010, thirteen employees at Foxconn's Shenzhen plants took their own lives in a series of tragedies that shocked the world and drew intense global media coverage. The relentless reporting not only put Foxconn itself under a harsh spotlight but also turned public and media criticism toward Apple. As the dominant player in the supply chain, Apple was accused of failing to uphold its social responsibilities, particularly with regard to oversight of working conditions at its contract manufacturers and the mental well-being of the workers who assembled its products.

## 4. Analysis of the Impact, Contagion Pathways, and Governance of the ESG Risk Event

The Foxconn suicide incidents rapidly escalated across online platforms, triggering an ESG risk that propagated through the supply chain and delivered a clear negative shock to Apple's share price. Through a combination of internal remedial actions by the firms involved and sustained external oversight, the crisis was eventually brought under control.

### 4.1 Impact of Foxconn's ESG Incident on Downstream Apple

To examine the negative impact of the Foxconn suicide incidents on Apple Inc.'s stock price, this study employs the event study methodology and calculates the cumulative abnormal returns for both Foxconn and Apple within their respective event windows. Since the incident erupted online on May 25, the event date is defined as May 25, 2010. The estimation window is set from 120 trading days to 1 trading day prior to the event day, i.e., [-120, -1]. Given that multiple employee suicides occurred within the same year in this case, to avoid contamination from other events in a longer window, the event window for Foxconn is selected as the four trading days following the event day, i.e., [0, 4], while the event window for Apple is set as the two trading days following the event day, i.e., [0, 2]. Accordingly, daily stock returns and corresponding market returns for both companies are retrieved from the Wind Database, covering the period from December 1, 2009 to May 31, 2010, with the S&P 500 Index used as the market benchmark for Apple Inc. and the Taiwan Weighted Index used for Foxconn.

This study employs the market model to compute abnormal returns. Specifically, a regression model for expected returns is first estimated using the firm's daily stock returns and the corresponding market index returns over the estimation window. The resulting regression parameters are then applied, together with the actual market returns observed during the event window, to generate the expected (normal) returns for each firm in the event period. Abnormal returns are subsequently calculated as the difference between the actual realized returns and the expected returns derived from the model. The computational formula for abnormal returns is provided in Equation (1).

$$AR_{it} = R_{it} - E(R_{it}) \quad (1)$$

where  $R_{it}$  denotes the actual return of the firm on day  $t$ , and  $E(R_{it})$  is the expected return on day  $t$  predicted by the market model.

The cumulative abnormal return (CAR) is obtained by summing the daily abnormal returns over the chosen event window  $[0, 4]$ . The calculation is shown in Equation (2).

$$CAR = \sum_{t=0}^4 AR_{it} \quad (2)$$

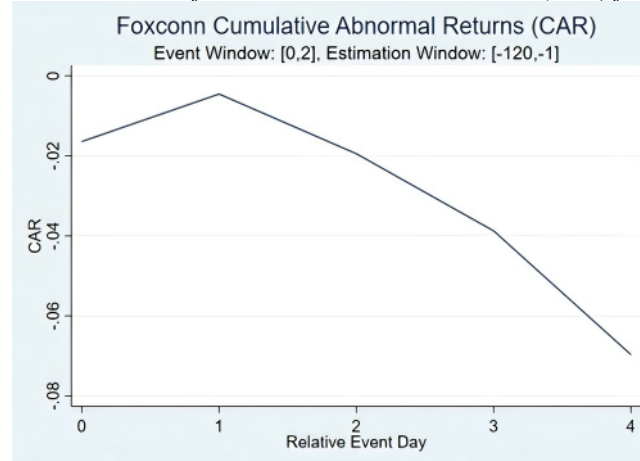
The calculated cumulative abnormal returns for Foxconn over the event window are reported in Table 1.

*Table 1: Cumulative Abnormal Returns for Foxconn over the Event Window*

Event Window	Abnormal Return (AR)	Cumulative Abnormal Return (CAR)
0	-0.0176017	-0.0176017
1	0.0119327	-0.005669
2	-0.0149096	-0.0205786
3	-0.0193598	-0.0399384
4	-0.0309221	-0.0708605

The trend of Foxconn's cumulative abnormal returns is illustrated in Figure 1.

*Figure 1: The Trend of Cumulative Abnormal Returns (CAR) for Foxconn*



It can be observed that after the Foxconn suicide cluster erupted online on May 25, 2010, Foxconn's cumulative abnormal return (CAR) was negative and exhibited a downward trend throughout the event window, indicating that the incident exerted a short-term negative impact on Foxconn's own stock price.

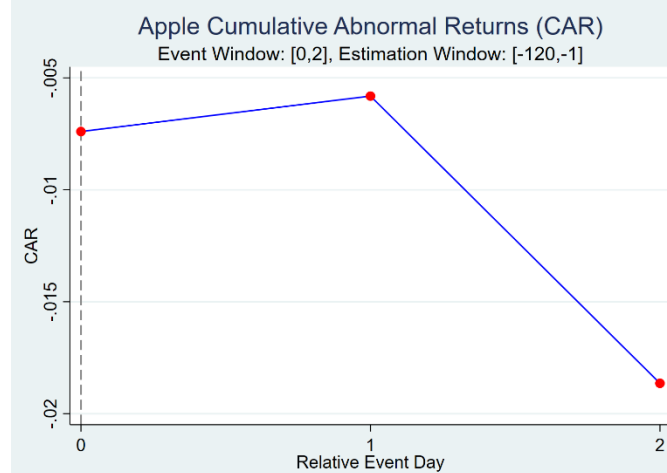
By summing the abnormal returns from May 25, 2010, through the two trading days following the event day, the cumulative abnormal return (CAR) for Apple over the event window is obtained. The results are presented in Table 2.

*Table 2: Cumulative Abnormal Returns for Apple over the Event Window*

Event Window	Abnormal Return (AR)	Cumulative Abnormal Return (CAR)
0	-0.0073978	-0.0073978
1	0.0015836	-0.0058142
2	-0.0128274	-0.0186415

Based on the results in Table 2, the trend of Apple Inc.'s cumulative abnormal returns (CAR) is plotted, as shown in Figure 2.

Figure 2: The Trend of Cumulative Abnormal Returns (CAR) of Apple Inc.



As shown in the figure above, Apple's cumulative abnormal returns remained negative and exhibited a downward trend throughout the event window. This indicates that the outbreak of the 2010 Foxconn suicide incidents on the internet exerted a short-term negative impact on Apple's stock price.

## 4.2 Contagion Mechanism of ESG Risks in the Supply Chain

The CAR analysis reveals that both Foxconn and Apple recorded negative cumulative abnormal returns during the event window. Integrating the contextual background outlined earlier, this study identifies that ESG risk was transmitted to Apple through the pathway of “event trigger → public opinion amplification → short-term valuation loss → capital market response”.

Firstly, the direct harm inflicted by Foxconn on its employees constitutes the originating point of the ESG risk. Stakeholder theory posits that a firm's survival and development depend on the engagement and contributions of its stakeholders (Benson, 1978). These stakeholders encompass not only core groups such as shareholders and employees but also latent stakeholders (e.g., consumers and suppliers) and marginal stakeholders (e.g., special interest groups and local communities) (Chen & Jia, 2004). Different stakeholders possess varying degrees of power and distinct demands, thereby providing the firm with diverse resources (Tan et al., 2022). Strong ESG performance reflects a company's fulfillment of social responsibilities, enabling it to meet stakeholders' expectations, secure their support, and ultimately transform such support into valuable core resources. Conversely, poor ESG performance damages stakeholders' interests and claims. Foxconn's longstanding practices of excessive overtime and inadequate pay and benefits severely undermined the rights of employees, who represent a core stakeholder group. These conditions ultimately led to more than a dozen suicide incidents, which acted as the triggering event in the ESG risk contagion process and produced negative cumulative abnormal returns for Foxconn.

Secondly, the combined effect of the structural features of Apple's supply chain, media amplification, and shifting investor sentiment ultimately caused Foxconn's own ESG risk to spill over to Apple. On one hand, Apple employs a light-asset operating model that enables efficient resource allocation and rapid expansion. At the same time, however, this model creates substantial dependence on upstream suppliers, allowing ESG risks originating at the supplier level to propagate downstream to Apple itself. On the other hand, the media, functioning as an influential special stakeholder, markedly reduced information asymmetry through extensive and in-depth reporting. This process elevated the ESG incident from an internal supplier problem to a full-fledged public crisis during the “public opinion amplification” stage. What began as a single supplier's managerial failure thereby evolved into broad public questioning of Apple's overall ESG commitments (Zhai et al., 2022) and inflicted reputational damage on the company. Corporate reputation represents an intangible yet accumulable asset (Tadelis, 1999). A strong reputation fosters greater consumer loyalty and serves as a protective buffer when firms face crises (Chen, 2009). The sustained negative coverage eroded the reputational capital that Apple had built over many years, undermined its established positive ESG image, and diminished

trust and confidence among both investors and consumers (Bi & Geng, 2012). Consequently, the risk was further magnified.

Finally, research in behavioral finance indicates that online sentiment is an important factor influencing stock prices (Chen et al., 2019). The rapid dissemination of negative media reports and consumer boycotts quickly reached the capital markets, shifting investor sentiment from optimism to pessimism. Investors began reassessing Apple's supply-chain management capabilities and ESG performance, which triggered short-term stock price volatility for the company.

Thus, the ESG risk completed its full contagion from an upstream supplier to the end-enterprise in the supply chain.

### **4.3 Governance of ESG Risk Contagion in the Supply Chain**

Following the 2010 Foxconn suicide incidents that triggered ESG risk contagion along the supply chain, enterprises within the chain and external stakeholders addressed the issue through a governance framework centered on “internal remediation → social oversight”.

#### **4.3.1 Internal Governance within the Supply Chain**

Foxconn, as the origin of the ESG risk, responded promptly to the crisis. On 26 May 2010, the company held a press conference and introduced a series of internal remedial measures from a corporate social responsibility perspective:

First, it installed safety nets and other protective facilities across factory premises and improved physical safety measures in employee dormitories. Second, it raised base wages for frontline workers and overhauled the compensation and benefits system. Third, it established a dedicated Employee Care Center with a 24-hour hotline, enabling any employee experiencing emotional distress, disputes, or personal difficulties to seek assistance at any time.

Apple, as the downstream client affected by the transmitted ESG risk, implemented governance measures across three dimensions: ESG management, information disclosure, and supply-chain structural optimization.

In terms of ESG governance, in January 2012, Apple Inc. announced its membership in the Fair Labor Association (FLA), thereby introducing an independent third-party auditing mechanism to conduct social responsibility audits of its suppliers. At the information disclosure level, in response to public expectations and oversight from external stakeholders, Apple has annually published its Supplier Responsibility Progress Report since 2012, thereby enhancing supply chain transparency. With respect to supply chain structure optimization, following the outbreak of the Foxconn suicide cluster, Apple diverted a portion of its iPhone and iPad orders from Foxconn to other contract manufacturers, thereby reducing reliance on a single supplier and strengthening overall supply chain resilience.

#### **4.3.2 External Governance**

Following the ESG risk incident, potential stakeholders such as the media and regulatory authorities also imposed corresponding demands, establishing an effective supervisory system that further strengthened governance effectiveness. Sustained media exposure and public opinion oversight not only prompted Foxconn and Apple to respond promptly to societal concerns but also sustained a high level of public attention toward brand supply chain responsibility, thereby generating continuous external pressure. Concurrently, regulatory authorities actively intervened proactively. At the end of May 2010, the Shenzhen Human Resources and Social Security Bureau stationed personnel at Foxconn to conduct a comprehensive investigation into its labor practices, overtime policies, and social insurance contributions. Upon completion of the investigation, Foxconn was required to implement corrective measures within a specified timeframe.

## **5. Conclusion and Discussion**

This study takes the 2010 Foxconn suicide incidents and the ensuing reputational crisis at Apple as a focal case to systematically examine the economic consequences, contagion pathways, and governance mechanisms of ESG risks within supply chains. The analysis reveals that ESG risk originating with an upstream supplier can be transmitted downstream to the end-brand enterprise through a sequential process of event trigger →

public opinion amplification → short-term valuation loss → capital market response. These findings underscore the pronounced transmissibility and externality of supply-chain ESG risks.

Once such risks materialize and propagate, enterprises across the supply chain, together with external stakeholders, addressed the crisis through a governance framework combining internal remediation and social oversight, yielding demonstrably positive outcomes. The case illustrates that effective management of supply-chain ESG risks cannot rely solely on the efforts of individual firms. Instead, it demands the coordinated operation of internal self-regulation mechanisms within the supply chain, reputational incentives, and formal regulatory oversight.

Based on the above findings, this study offers the following policy recommendations from the perspectives of firms, investors, and regulatory authorities. For firms, this study provides practical guidance for assessing and managing ESG risks within complex supply chains. Downstream client firms should extend ESG due diligence deep into upstream suppliers to identify latent risks across the supply chain. They should establish contingency mechanisms that incorporate independent third-party audits and transparent disclosure to interrupt risk contagion. Furthermore, ESG criteria should be systematically embedded throughout the entire supplier selection, evaluation, and monitoring process, thereby constructing a more resilient and sustainable supply chain system. For investors, this study highlights that, when valuing a firm, investors should not focus solely on the focal firm's own ESG performance but must also examine the degree of ESG risk at the supply-chain level. For regulatory authorities, this study aligns with the global trend toward increasingly stringent ESG regulation. Regulators should accelerate the development of mandatory ESG disclosure and audit frameworks that encompass the entire supply chain, thereby compelling firms to elevate their ESG standards and performance.

## 6. Research Limitations and Future Directions

This study has several limitations. First, it relies on a single case, so the conclusions may not be universally applicable across different industries or supply-chain configurations. Second, when using the event study method to examine whether the Foxconn suicide incidents produced a short-term negative impact on Apple's stock price, a relatively narrow event window was selected to minimize confounding factors. Nevertheless, it remains difficult to entirely rule out the influence of contemporaneous market-wide events or firm-specific news on cumulative abnormal returns.

To address these shortcomings, future research may proceed along the following lines. First, researchers could systematically compile data on publicly disclosed ESG violations by listed companies, construct large-scale supplier–client paired samples, and conduct empirical analyzes to test the generalisability of supply-chain ESG risk contagion and governance patterns. Second, scholars could select cleaner cases with fewer confounding events and apply the event study methodology to more precisely measure the market reactions triggered by supply-chain ESG risks.

## References

- Benson, J. K. (1978). The external control of organizations. *Administrative Science Quarterly*, 23(2), 358–361. <https://doi.org/10.2307/2392573>
- Bi, N., & Geng, X. D. (2012). Research on corporate reputation capitalization based on business model. *Jiangnan Tribune*, (7), 12–16. <https://doi.org/10.3969/j.issn.1003-854X.2012.07.002>
- Chen, H. H., & Jia, S. H. (2004). Empirical research on stakeholders' 3-dimension classification in Chinese enterprises. *Economic Research Journal*, (4), 80–90.
- Chen, H. Y., Shi, G. L., & Xie, Z. Y. (2019). The research on the causal relationship between investor sentiment index and stock return rate: Taking the apple stock as an example. *Price: Theory & Practice*, (2), 96–99. <https://doi.org/10.19851/j.cnki.cn11-1010/f.2019.02.027>.
- Chen, Y. Q. (2009). Establishment and maintenance of corporate reputation capital. *Enterprise Economy*, (12), 77–79. <https://doi.org/10.13529/j.cnki.enterprise.economy.2009.12.030>



- Gârleanu, N., Panageas, S., & Yu, J. (2015). Financial entanglement: A theory of incomplete integration, leverage, crashes, and contagion. *American Economic Review*, 105(7), 1979–2010. <https://doi.org/10.1257/aer.20131076>
- Li, Y., Wu, Y., & Tian, X. (2023). Enterprise ESG performance and supply chain discourse power. *Journal of Finance and Economics*, 49(8), 153–168. <https://doi.org/10.16538/j.cnki.jfe.20230617.101>
- Lin, Z. G., & Wei, W. T. (2023). ESG performance and the reduction of customer concentration. *Journal of Anhui University(Philosophy and Social Sciences Edition)*, 47(1), 121–132. <https://doi.org/10.13796/j.cnki.1001-5019.2023.01.013>
- Liu, J. G., Zhao, Y. T., Li, J., & Gong, Y. (2025). Supply chain ESG: Research framework, challenges and future research directions. *Chinese Journal of Management Science*, 33(1), 185–196. <https://doi.org/10.16381/j.cnki.issn1003-207x.2024.1775>
- Su, J. X., & Zhou, L. G. (2024). The impact of ESG performance on customer default risk from the perspective of supply chain. *Chinese Journal of Management*, 21(9), 1392–1400. <https://doi.org/10.3969/j.issn.1672-884x.2024.09.014>
- Surdu, G. (2011). The internationalization process and the asset-light approach. *Romanian Economic & Business Review*, 6(1), 184–188. <https://research.ebsco.com/linkprocessor/plink?id=a911b6ba-a846-3d32-887a-8015d6e19d4a>
- Tadelis, S. (1999). What's in a name? Reputation as a tradeable asset. *American Economic Review*, 89(3), 548–563. <https://doi.org/10.1257/aer.89.3.548>
- Tan, J. S., Huang, R. Y., & Zhang, J. X. (2022). ESG performance and corporate risk: An explanation from a resource acquisition perspective. *Journal of Management Science*, 35(5), 3–18.
- Wang, Y. G., & Hu, Z. Q. (2024). Empirical test of the impact of corporate ESG performance on supply chain resilience. *Statistics & Decision*, 40(8), 179–183. <https://doi.org/10.13546/j.cnki.tjyjc.2024.08.032>
- Xiao, H. J., Shen, H. T., & Zhou, Y. K. (2024). Customer digitalization, supplier ESG performance and supply chain sustainability *Economic Research Journal*, 59(3), 54–73.
- Xin, C. H., Zhang, X. Y., & Wang, X. Y. (2024). Can corporate ESG performance contribute to supply chain partnership stability? *Research on Economics and Management*, 45(1), 35–54. <https://doi.org/10.13502/j.cnki.issn1000-7636.2024.01.003>
- Yan, B., Cheng, M., & Wang, N. H. (2024). ESG green spillover, supply chain transmission and corporate green innovation. *Economic Research Journal*, 59(7), 72–91.
- Yuan, Y., Dai, H., & Ma, J. Q. (2025). The impact of corporate ESG performance on supply chain resilience: A mediation analysis based on new quality productive forces. *Sustainability*, 17(10), Article 4418, Article 4418. <https://doi.org/10.3390/su17104418>
- Zhai, S. B., Cheng, Y. T., Xu, H. R., Tong, L. J., & Cao, L. (2022). Media attention and the enterprises' ESG information disclosure quality. *Accounting Research*, (8), 59–71. <https://doi.org/10.3969/j.issn.1003-2886.2022.08.005>

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## Conflicts of Interest

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