

What have we Learned about Green and Climate Finance?

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Abstract

The growing urgency of climate change has brought green and climate finance to the forefront of public discourse and academic inquiry. As governments, corporations, and investors seek to mitigate climate impacts and advance sustainable development, the financial system is increasingly recognized as a key enabler of the low-carbon transition. This Special Issue of the *British Accounting Review* presents cutting-edge research that explores the evolving interplay between public policy priorities and the expanding body of academic literature on green and climate finance. The commentary provides an overview of current theoretical perspectives and empirical developments (particularly since 2020) and introduces the seven papers featured in this “Special Issue on Green and Climate Finance.” In doing so, it addresses the central question: what have we learned about green and climate finance? Our goal is to take stock of the evidence to date, synthesizing insights from the academic literature and placing the contributions of this Special Issue within a broader context. We organize our review into five areas: sustainable investing and shareholder activism; climate risk disclosure; green bonds and sustainable finance instruments; the real effects of climate risk on firms and the economy; and the measurement of climate risk and exposure. Before turning to these themes, we first consider the evolving public discourse and policy context that motivates and frames much of this research.

Keywords: Sustainable Investing and Shareholder Activism, Climate Risk Disclosure, Green Bonds and Sustainable Finance Instruments

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What Have We Learned about Green and Climate Finance?

Editorial for *British Accounting Review* Special Issue on “Green and Climate Finance”

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Abstract

Financial markets are increasingly central to addressing climate change, yet their impact hinges on credible information and aligned incentives. This review synthesizes recent advances in green and climate finance across five themes: (i) sustainable investing and shareholder activism, where investor preferences and stewardship affect pricing and corporate behavior but raise concerns over credibility and greenwashing; (ii) climate risk disclosure, moving from voluntary to mandatory regimes that improve transparency and market discipline; (iii) green bonds and related sustainable instruments, which have scaled rapidly, exhibit a modest “greenium,” and—when well-designed—can catalyze measurable environmental improvements; (iv) the real effects of climate risk on firms and the economy, encompassing physical and transition risks that reshape valuations, financing, and innovation; and (v) measurement of climate exposure, where emissions data are indispensable but incomplete, and newer textual and market-based metrics contend with persistent ESG rating divergence. We conclude with cautious optimism: harmonized standards, auditable metrics, and stronger enforcement can help markets translate climate objectives into real environmental outcomes, while poorly designed practices risk symbolic compliance.

Keywords: green and climate finance; sustainable investing; shareholder activism; climate risk disclosure; green bonds; measurement & ESG ratings.

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Section 1: Introduction

The growing urgency of climate change has brought green and climate finance to the forefront of public discourse and academic inquiry. As governments, corporations, and investors seek to mitigate climate impacts and advance sustainable development, the financial system is increasingly recognized as a key enabler of the low-carbon transition. This commentary provides an overview of current theoretical perspectives and empirical developments (particularly since 2020). In doing so, it addresses the central question: **what have we learned about green and climate finance?** Our goal is to take stock of the evidence to date and synthesizing insights from the academic literature. We organize our review into five areas: sustainable investing and shareholder activism; climate risk disclosure; green bonds and sustainable finance instruments; the real effects of climate risk on firms and the economy; and the measurement of climate risk and exposure. Before turning to these themes, we first consider the evolving public discourse and policy context that motivates and frames much of this research.

Section 2: Framing the Public Discourse on Green and Climate Finance

Recent public discourse has expanded beyond the mitigation of climate-related risks to emphasize the mobilization of private capital for climate adaptation and resilience. International milestones such as the Paris Agreement, net-zero commitments by governments and corporations, and the European Union's Green Deal have amplified expectations for the financial sector to align with broader sustainability goals. Concepts such as a “just transition” and “inclusive finance” have gained prominence, reflecting a growing recognition that financing strategies must balance environmental imperatives with social equity considerations,² and ensure that vulnerable communities are not left behind. This evolving narrative signals a shift in expectations for the financial sector, where stakeholders increasingly call for credible transition pathways that move beyond superficial greenwashing toward verifiable decarbonization. Civil society organizations, regulators, and market participants have pressed for greater transparency and accountability, spurring debates over the adequacy of voluntary ESG initiatives versus the need for mandatory disclosure regimes. The rapid growth of green bonds, the formalization of sustainable finance taxonomies, and the integration of environmental, social, and governance (ESG) criteria into investment decision-making and governance processes reflect tangible progress. Collectively, these developments indicate a paradigm shift

² For the purpose of this manuscript, we define “just transition” as a framework for managing the shift to a low-carbon economy in a way that ensures fairness for workers, communities, and regions affected by the transition. It emphasizes the creation of sustainable jobs, social protection, and equitable distribution of costs and benefits. We define “inclusive finance” as an approach to financial system design and capital allocation that ensures equitable access to financial products and investment opportunities, particularly for underserved or marginalized groups, so that the benefits of sustainable development and climate action are broadly shared.

in financial markets, where sustainability is becoming embedded in core practices related to risk management, capital allocation, and long-term value creation. They also frame the central questions that underpin current academic debates: how sustainable investing and shareholder activism affect pricing and credibility; how disclosure standards influence market transparency; how green financial instruments mobilize capital for environmental goals; how climate risks shape corporate outcomes and innovation; and how these phenomena can be measured with rigor.

Section 3: Insights from Recent Literature on Green and Climate Finance

While scholars in finance and related disciplines have produced several influential reviews on corporate social responsibility, ESG, and climate-related finance (e.g., Hong, Karolyi, and Scheinkman, 2020; Giglio, Kelly, and Stroebe, 2021; Liang and Renneboog, 2021; Stroebe and Wurgler, 2021), the field has witnessed a notable acceleration in research output over the past five years. This surge reflects heightened policy urgency, growing investor interest, and the increasing availability of climate-related data. A striking example of this urgency is the withdrawal of major insurers such as State Farm and Allstate from high-climate-risk markets in California and Florida, where escalating wildfire and hurricane risks have rendered traditional underwriting unsustainable. The retreat of insurers not only leaves households and businesses exposed but also threatens to destabilize real estate and mortgage markets, illustrating how localized climate shocks can trigger systemic financial risks. In view of these developments, an updated synthesis of the literature is both timely and necessary to highlight emerging themes, assess evolving methodologies, and identify new frontiers in green and climate finance research. Our discussion begins with recent work on sustainable investing, focusing on investor demand, pricing effects, and the credibility of ESG investment products.

Section 3.1: Sustainable Investing

Sustainable investing has become a central pillar of climate finance, driven by growing investor interest in aligning capital allocation with ESG goals. As capital increasingly responds to sustainability criteria, a large body of research now examines how investor preferences influence asset pricing, whether ESG-aligned investments deliver competitive financial returns, and whether such strategies achieve their intended environmental outcomes. This section synthesizes two strands of this literature: the pricing effects of investor demand and the performance and credibility of ESG investment products.

Pricing Effects of Investor Demand: One prominent strand of the literature explores the growing influence of investor preferences for sustainability in capital markets. Sustainable investing has become increasingly mainstream as investors allocate capital based on ESG considerations, motivated by a combination of

ethical values, reputational concerns, and financial risk-return expectations. A central question in this line of research is how these preferences influence asset prices. The evidence is mixed, but the prevailing view in economics and finance has long been that incorporating ESG either reduces or does not enhance shareholder value (Friedman 1970; Freeman 1984). Recent empirical research supports this perspective. For example, Gantchev, Giannetti, Li (2024) find that sustainability-driven trades generally underperform, negatively affecting the funds' overall performance. In contrast, other recent studies identify contexts in which green or ESG stocks may outperform their brown counterparts (Khan, Serafeim, Yoon, 2016; Welch and Yoon, 2023; Ardia, Bluteau, Boudt, Inghelbrecht, 2023). Pastor, Stambaugh, and Taylor (2022) develop an equilibrium model showing that strong investor demand for green assets drives up their prices, resulting in lower expected returns. This dynamic, often referred to as the “green premium,” is confirmed by their empirical analysis. The recent outperformance of green stocks relative to brown stocks is largely attributable to rising investor demand rather than superior fundamentals. Once this preference is fully priced in, green assets are expected to deliver slightly lower risk-adjusted returns than brown assets. Importantly, this pricing mechanism plays a key role in sustainable finance: by lowering the cost of capital for environmentally responsible firms and raising it for high-emitting firms, the green premium creates market-based incentives for decarbonization.

Performance and Credibility of ESG Strategies: Beyond pricing dynamics, another important strand of the literature examines whether ESG-oriented investment strategies deliver superior financial performance. The relative performance of ESG investments compared to conventional strategies remains contested. Some studies find that high-ESG portfolios match or exceed the returns of low-ESG counterparts, often due to reduced downside risk or better management quality (Sautner and Starks, 2021). Others, including Pastor et al. (2022), report no persistent abnormal returns after adjusting for risk exposures and capital flows. These findings suggest that while ESG investing does not consistently generate outperformance, it can still shape corporate behavior by altering firms' cost of capital. In this sense, *doing good* may not always translate into *doing better* financially, but it can still contribute meaningfully to real environmental outcomes. The debate over financial returns also raises broader concerns about the credibility of ESG investment vehicles and the extent to which they fulfill their stated sustainability objectives. Raghunandan and Rajgopal (2022) document discrepancies between ESG fund marketing claims and the actual sustainability profile of underlying holdings. Similar concerns are reported by Kim and Yoon (2023) for U.S. mutual funds, Liang, Sun, and Teo (2022) for global hedge funds, and Gibson, Glossner, Krueger, Matos, and Steffen (2022) for asset managers more broadly. Berk and van Binsbergen (2025) argue that institutional investors' divestment from low-ESG firms exerts only limited influence on the cost of capital and, in most cases, is insufficient to induce substantial changes in corporate investment behavior.

Section 3.2: Shareholder Activism and ESG Engagement

Shareholder activism has emerged as a central mechanism through which investors seek to influence corporate responses to environmental and social challenges. Traditionally regarded as “passive” owners, institutional investors are now increasingly expected to exercise stewardship on climate and ESG issues. A growing literature examines whether such engagement strategies, ranging from private dialogues and shareholder proposals to public campaigns and coalition-building, can effectively alter corporate behavior. This section synthesizes three main areas of this research: (i) the evolution from passive ownership to active stewardship, (ii) evidence on the effectiveness and innovations in engagement practices, and (iii) the challenges and credibility concerns that accompany the rise of ESG activism.

From Passive to Active Ownership: Large index fund managers, including the widely-known Big Three, now actively engage portfolio companies on sustainability and governance issues. They focus on the heaviest carbon emitters and leverage their sizable stakes to advocate for change (Azar, Duro, Kadach, Ormazabal, 2021). Research indicates that active engagement, or voice, can be more effective than exit, or divestment, in influencing corporate behavior (Edmans, Levit, Schneemeier, 2022). Firms reduce carbon emissions when pro-environmental investors increase their ownership and press for cuts, whereas divestment alone has little impact as less socially minded investors fill the void (Kahn, Matsusaka, Shu, 2023). These findings support theoretical arguments that engagement can achieve what divestment cannot, namely directly influencing firm policies, particularly when coordinated by large, long-term shareholders (Broccardo, Hart, Zingales, 2022). In summary, mainstream institutions are moving beyond mere compliance to actively shape companies’ ESG practices, thereby blurring the boundary between shareholder and stakeholder value.

Effectiveness of Engagement: Research on the effectiveness of investor engagement shows mixed results. Some studies find that engagements are less impactful than often claimed and fail to produce meaningful changes in firm behavior (Heath, Macciocchi, Michaely, Ringgenberg, 2023; Michaely, Ordonez-Calafi, Rubio, 2024). Shareholder proposals on environmental and social issues rarely receive majority approval, but the level of support they attract can be informative. Firms facing high shareholder votes in favor of ESG resolutions, even when those resolutions fail, tend to experience more subsequent controversies and value declines, suggesting that investors are flagging real risks that management should address (He, Kahraman, Lowry, 2023). Proxy voting remains an important channel for investor influence, although agency frictions, such as reluctance to oppose management, often limit its effectiveness. On the other hand, evidence shows that engagement can lead to meaningful outcomes. Studies of private dialogues and negotiated

commitments report measurable improvements in firm performance and ESG ratings, especially when focused on material issues (Dimson, Karakas, Li, 2015; Bauer, Derwall, Tissen, 2023). Targeted firms have reduced toxic emissions, invested in abatement technologies, and improved local environmental conditions (Naaraayanan, Sachdeva, Sharma, 2021). Engagement can also mitigate downside risk: firms that reached agreements with shareholders experienced lower stock price volatility and fewer extreme negative events (Hoepner et al., 2024).

Innovations in Engagement Tactics: Building on the evidence of effectiveness, recent research indicates that engagement tactics are evolving to enhance impact. Large asset owners increasingly coordinate their efforts, delegate stewardship tasks to specialized ESG teams, or collaborate through investor coalitions. Some pension funds have even begun paying external index fund managers additional fees to engage more actively with portfolio companies. Early evidence suggests this unconventional incentive can improve ESG performance (Becht, Franks, Miyajima, Suzuki, 2023). Other investors combine engagement with the credible threat of exit, a strategy validated by a field experiment in which firms were warned they might be dropped from a sustainability index unless they adopted a climate policy, prompting many to comply (Heeb and Kölbel, 2024). Engagement-oriented funds also focus on high-impact firms where they have influence and set clear milestones, rather than divesting indiscriminately from all brown industries (Azar et al., 2021; Heath et al., 2025). When quiet diplomacy fails, investors increasingly escalate to public pressure by voting against directors, filing shareholder resolutions, or rallying co-investors to press management on ESG commitments. Not all funds, however, follow these strategies. Many adopt the ESG label without materially changing their engagement practices or portfolios, effectively free-riding on the broader shift toward sustainability (Lowry, Wang, Wei, 2025). This contrast underscores that genuine ESG activism requires commitment and resources, not just rhetoric.

Investor engagement in sustainability has grown from a niche practice into a key driver of corporate behaviour, though its effectiveness varies. Evidence shows that even seemingly cosmetic responses, such as adding directors with nonprofit expertise after ESG incidents, can reduce repeat controversies and strengthen oversight (Gertsberg, Jung, Zhang, 2024). Overall, while engagement is not a cure-all and risks of greenwashing remain, thoughtful activism can deliver gradual but meaningful improvements in corporate ESG performance. Taken together, the literature suggests that while ESG investing has the potential to reshape capital flows and influence firm behavior, its effectiveness ultimately depends on the alignment between investor intent, financial incentives, and the integrity of ESG measurement and implementation.

Section 3.3: Sustainability and Climate Risk Disclosure

As climate risk becomes a material factor in corporate valuation and strategy, climate-related disclosure has emerged as a core mechanism in sustainable finance. A growing body of research investigates how disclosure affects investor behavior, capital markets, and firm accountability. This section reviews two interrelated areas: investor demand and market responses to climate transparency; and the shift from voluntary disclosure toward standardized, mandatory reporting regimes.

Investor Demand and Market Discipline: Institutional investors have become key drivers of climate disclosure. Large asset owners not only support enhanced transparency but actively influence firm behavior. Ilhan et al. (2023) find that firms with more climate-conscious institutional ownership disclose higher-quality climate risk information, and that investor engagement plays a critical role in improving disclosure practices. Markets reward transparency accordingly: companies providing detailed emissions data and transition plans enjoy lower cost of equity capital, while those relying on boilerplate language face financial penalties. However, disclosure also exposes firms to reputational and capital market risk. Bolton and Kacperczyk (2021) show that following the disclosure of Scope 1 emissions, heavy emitters experienced lower stock returns and higher financing costs as ESG-focused investors exited. Climate disclosure therefore serves a dual function: it enables informed investor decision-making and acts as a mechanism of market discipline. Transparency can benefit firms with credible environmental strategies, but it also increases scrutiny and capital costs for firms with weak emissions performance. These dynamics may create financial incentives for emissions reductions, provided firms perceive a material cost to inaction. Investor demand for climate information therefore reflects more than a preference for transparency; it represents an emerging force of accountability in sustainable finance.

From Voluntary to Mandatory Disclosure: Climate risk reporting has traditionally been voluntary, resulting in substantial variation in both the scope and quality of disclosures. Many firms provided generic language or omitted key metrics, such as carbon emissions or forward-looking transition risks, often citing uncertainty or competitive sensitivity. This lack of comparability limited the usefulness of climate disclosures for investors and regulators alike. In response, a growing number of jurisdictions have moved to mandate climate-related disclosures. The United Kingdom and European Union have adopted reporting requirements aligned with the Task Force on Climate-related Financial Disclosures (TCFD), compelling large firms to disclose climate risks, governance frameworks, and emissions data. In the United States, the Securities and Exchange Commission (SEC) introduced new rules in 2024 requiring standardized climate disclosures in annual filings. At the global level, the International Sustainability Standards Board (ISSB) has launched efforts to develop harmonized sustainability reporting standards, aiming to reduce

fragmentation and increase consistency across jurisdictions. A key question is whether mandatory climate-related or broader ESG disclosures lead to real changes. Significant carbon reduction following mandatory carbon disclosure have been documented by Downar et al. (2021) and Tomar (2023). Regarding broader ESG issues, Ioannou and Serafeim (2019), Krueger et al. (2024) and Fiechter et al. (2022) provide international evidence that ESG-related mandatory disclosure requirements are associated with more CSR engagements, greater firm value and other beneficial real outcomes. Nevertheless, the transition to mandatory disclosure also raises concerns. Questions remain regarding the comparability of disclosures across jurisdictions, the quality of firms' climate risk assessments, and whether increased regulation will lead to substantive changes in firm behavior or simply more sophisticated forms of obfuscation. Still, the broad regulatory momentum marks a pivotal shift: climate risk disclosure is no longer optional, but an integral component of corporate accountability and financial reporting.

The body of evidence on investor demand and regulatory change reveals that climate risk disclosure, once peripheral, is now central to financial decision-making, with transparency functioning both as a market signal and a mechanism of accountability in the transition to a low-carbon economy.

Section 3.4: Green Bonds and Sustainable Finance Instruments

Green bonds have emerged as the flagship instrument in the rapidly evolving landscape of sustainable finance. Designed to fund environmentally beneficial projects, these bonds have seen explosive growth over the past decade and are increasingly viewed as a core component of the global climate finance architecture. In parallel with their expansion, a new generation of instruments, such as sustainability-linked bonds (SLBs), green loans, and transition bonds, has further embedded environmental considerations into financial markets. This section examines two key dimensions of these instruments: (i) the growth and environmental impact of green bonds and (ii) their pricing and performance implications.

Growth and Environmental Impact: One of the most significant developments in climate finance has been the rapid expansion of green bonds—debt instruments whose proceeds are explicitly designated for environmental or climate-related projects. Global outstanding green bond volume reached approximately \$2.9 trillion by 2024, representing a nearly six-fold increase since 2018. Annual issuance exceeded \$700 billion in 2024 alone (Demski, Dong, McGuire, and Mojon, 2025), driven by strong investor demand for sustainable assets. Initially pioneered by development banks and a few corporations, green bonds are now issued by sovereigns, municipalities, financial institutions, and corporations across a broad range of sectors. This diversification signals the mainstreaming of green finance and reflects its growing institutional legitimacy.

The fundamental promise of green bonds is to channel capital into areas such as renewable energy, energy efficiency, clean transportation, and climate adaptation. Empirical studies suggest that this promise is being partially fulfilled. Tracking data indicates that issuers generally allocate proceeds to stated green objectives, although transparency and reporting rigor remain uneven. A central policy concern is whether green bonds generate additional environmental benefits or merely relabel existing financing. Encouragingly, recent evidence suggests a causal link between green bond issuance and subsequent improvements in environmental performance. Flammer (2021) and Demski et al. (2025) find that firms, particularly high emitters, reduce carbon intensity following their first green bond issuance. These reductions may stem from strengthened internal governance, reputational incentives, or heightened external scrutiny associated with being a green bond issuer. The green bond market has also catalyzed innovation in sustainable finance. Instruments such as SLBs tie interest rates to the achievement of firm-specific environmental or social performance targets. Unlike green bonds, SLBs do not restrict the use of proceeds but penalize issuers through coupon step-ups if targets are not met. The SLB market grew rapidly to nearly \$100 billion in annual issuance by 2021, though growth has since moderated amid concerns over target credibility.

The proliferation of these sustainability-related financial instruments reflect a broader trend toward embedding sustainability commitments directly into financial contracts. The broad consensus is that ESG risk represents a downside tail risk that investors cannot ignore (e.g., Sautner and Starks, 2021; Ilhan et al., 2023; Park et al., 2025). Academic research on these newer instruments is still nascent but growing, with increasing attention to how ESG risk is priced, and how this pricing reflects the credibility of their embedded targets and whether such instruments genuinely incentivize behavioral change or merely give rise to new forms of greenwashing (e.g., Aleszczyk, Loumiotis, and Serafeim, 2022; Berrada, Engelhardt, Gibson, and Krueger, 2022; Feldhütter, Halskov, and Krebbers, 2024; Shimauchi, Fukui, Yamamoto, Taura, and Kameda, 2025).

Pricing and Performance: In parallel with market growth, green bonds have garnered sustained academic interest for their distinctive pricing and return characteristics. A consistent empirical finding is the existence of a “greenium”—a yield discount investors accept in exchange for the nonpecuniary benefits of holding green-labeled securities (e.g., Karpf and Mandel, 2017; Baker, Bergstresser, Serafeim, and Wurgler, 2018). Studies by Pastor et al. (2022) and Tang and Zhang (2020) report yield spreads ranging from 5 to 20 basis points relative to comparable conventional bonds. This premium tends to be larger when issuers demonstrate credible environmental commitments or when bonds carry third-party certification. For issuers, the potential for lower financing costs creates a strong incentive to label bonds as green and allocate

capital to qualifying projects. However, the existence and persistence of the greenium remain subject to debate. Larcker and Watts (2020) argue that, once firm-level risks and expected returns are accounted for, green and non-green bonds issued by the same entity are nearly perfect substitutes. Similarly, Ehlers, Mojon, and Packer, (2020) highlight that many early green bonds lacked disclosure regarding the issuer's broader climate strategy, raising concerns about superficial labeling or "greenwashing." In response to these credibility concerns, market standards have evolved. Frameworks such as the ICMA Green Bond Principles and the forthcoming EU Green Bond Standard require greater transparency in the use of proceeds and more rigorous impact reporting. These regulatory and voluntary efforts aim to enhance market integrity, improve transparency, and strengthen investor confidence.

The literature on green and sustainable finance instruments highlights both their promise and their limitations. Although challenges remain, particularly around standardizing impact metrics and ensuring additionality, the emerging body of research paints a cautiously optimistic picture. Green and sustainable bonds appear to mobilize capital at scale, provide a modest cost-of-capital advantage to issuers, and in many cases are associated with measurable improvements in corporate environmental performance.

Section 3.5: Real Effects of Climate Risk on Firms and the Economy

Climate change is no longer a distant or purely ethical concern; it has become a material financial risk with immediate implications for firms and the broader economy. A growing body of research highlights how climate-related risks manifest in three interconnected ways: (i) direct physical disruption of assets and operations; (ii) financial consequences of the transition to a low-carbon economy, particularly through the risk of stranded assets; and (iii) strategic shifts in investment and innovation in response to evolving climate exposure. This section reviews emerging empirical evidence across these three domains.

Physical Risks and Firm Performance: A growing body of empirical research documents the real effects of physical climate hazards on firm performance. Case studies of wildfires, hurricanes, floods, and droughts show that extreme weather events can disrupt operations, damage assets, and impair supply chains. At the macroeconomic level, Cevik and Miryugin (2022) find that climate-induced environmental changes impose measurable economic costs, including slower growth in regions experiencing elevated temperatures or more frequent natural disasters. Similarly, Addoum, Ng, and Ortiz-Bobea (2020) show that extreme heat reduces industrial output and labor productivity, with adverse consequences for corporate earnings and regional GDP growth. These risks are increasingly reflected in asset valuations. Properties located in flood-prone or coastal areas vulnerable to sea-level rise tend to trade at discounted prices, particularly for long-maturity assets (e.g., Bernstein, Gustafson, and Lewis, 2019; Baldauf, Garlappi, and Yannelis, 2020; Murfin and Spiegel, 2020). Firms with substantial physical exposure to climate-vulnerable regions also face rising

insurance premiums and elevated capital expenditures for infrastructure adaptation—costs that directly erode profitability (e.g., Krueger, Sautner, and Starks, 2020; Allman, 2022; Pankratz and Schiller, 2024; Boomhower, Fowlie, Gellman, and Plantinga, 2024).

Transition Risks and Stranded Assets: The transition to a low-carbon economy introduces substantial financial risks, particularly for carbon-intensive sectors such as energy, utilities, mining, and heavy industry. Regulatory interventions, including carbon pricing, emissions caps, and outright bans on high-emission activities, have the potential to render certain assets economically obsolete. For example, fossil fuel reserves may become stranded if global climate targets, such as the 2°C warming threshold, are strictly enforced, leading to a rapid devaluation of assets in the coal, oil, and gas sectors. An emerging body of research seeks to quantify this “stranded asset” risk and its implications for firm valuation and capital structure. Bolton and Kacperczyk (2021, 2023) find that firms with higher emissions earn a return premium, consistent with investors requiring compensation for elevated transition risk. Similarly, Huang, Kerstein, Wang, and Wu (2022) show that firms more exposed to climate policy face higher borrowing costs, as lenders incorporate transition-related risks into credit pricing. These financial frictions can constrain investment capacity among carbon-intensive firms, incentivizing divestment from vulnerable assets, increased investment in low-carbon technologies, and preemptive emissions reductions. Recent studies provide evidence that some firms are undertaking such strategic adjustments in anticipation of regulatory tightening and rising investor scrutiny.

Investment and Innovation Responses: Recent literature highlights the pivotal role of green financing in driving green innovation. Empirical studies find that instruments such as green bonds (Flammer, 2021; Dong, Zhang, and Zheng, 2024) and green credit policies (Fan, Peng, Wang, and Xu, 2021; De Haas, Martin, Muûls, and Schweiger, 2024) significantly boost firms’ green patenting and adoption of cleaner technologies by alleviating financing constraints and shifting capital allocation. However, ESG-oriented investment strategies may inadvertently underfund major contributors to green innovation if they exclude high-emitting but innovative firms (Pless, 2023; Cohen, Gurun, and Nguyen, 2024). Regulatory mandates, such as carbon disclosure requirements, are also shown to stimulate innovation responses, although sometimes of lower private value (Bratten, Cheng, and Kleppe, 2024). Theoretical contributions and cross-country analyses further underscore the complementary roles of carbon pricing, R&D subsidies, and venture financing in shaping green technological change (Aghion, Boneva, Laeven, Martin, and Mueller, 2022). Collectively, these studies suggest that well-designed green financial instruments and policy frameworks can effectively catalyze the transition toward environmentally sustainable innovation.

On balance, the literature indicates that climate risk has tangible and multifaceted effects on firms and the economy. Physical hazards disrupt operations and erode profitability, transition risks alter valuations and capital costs, and financial and policy frameworks influence investment and innovation pathways. While challenges remain in measuring exposures and ensuring credible responses, the evidence demonstrates that climate risks are material financial factors shaping both firm strategy and broader economic outcomes.

Section 3.5: Measuring Climate Risk and Carbon Exposure

Accurately measuring a firm's exposure to climate-related risk remains a central challenge for researchers, investors, and regulators. Unlike conventional financial metrics, climate risk is multidimensional, laden with externalities, and difficult to express in monetary terms. Its components, ranging from emissions intensity to physical vulnerability, vary across sectors, time horizons, and geographic contexts. Recent academic work has explored a range of approaches to measurement, while also highlighting significant limitations in data availability, methodological consistency, and interpretability.

Carbon Emissions and the Limits of Footprint Metrics: Carbon emissions constitute the most widely used and systematically reported indicator of firm-level climate exposure, particularly for transition risk. Most firms disclose Scope 1 emissions, which reflect direct operational emissions, and Scope 2 emissions, which account for indirect emissions resulting from the use of purchased energy. An increasing number of studies are also estimating Scope 3 emissions, which encompass upstream and downstream activities across the value chain. These data are frequently used by investors, regulators, and rating agencies to evaluate exposure to future carbon pricing regimes, regulatory constraints, and the potential for capital reallocation through divestment. Despite their prevalence, carbon footprints provide only a partial view of a firm's climate-related risk profile. Scope 3 emissions are particularly problematic, as they are often based on estimates with limited verification and are subject to considerable reporting inconsistency. More broadly, emissions data capture only one aspect of climate exposure: the potential liabilities associated with the transition to a low-carbon economy. They offer little insight into physical vulnerability, such as geographic exposure to extreme weather events, or the firm's adaptive capacity. As such, emissions-based metrics, while essential to current assessments, represent only one dimension of a more complex and multifaceted risk landscape. This limitation leads to potential biases in using stock returns to infer the pricing of carbon risks (Aswani, Raghunandan, and Rajgopal, 2024; Zhang, 2025).

Emerging Climate Risk Metrics and the Problem of ESG Divergence: Beyond raw emissions data, researchers have been developing composite and alternative measures of firm-level climate exposure that aim to capture risk dimensions not reflected in traditional carbon footprint metrics. One prominent line of

work applies textual analysis to earnings calls, corporate filings, and regulatory disclosures to identify how frequently and substantively firms address climate-related issues. For instance, Sautner, Van Lent, Vilkov, and Zhang (2023) construct a metric based on the frequency of climate-related terms in earnings calls, interpreting greater mention as an indicator of heightened exposure to climate risk. Li, Shan, Tang, and Yao (2024) build on this approach by distinguishing between physical and transition risk references, enabling a more granular classification of risk types. Other studies leverage market-based proxies to assess climate exposure through firm valuation dynamics. Engle, Giglio, Kelly, Lee, and Stroebele (2020), for example, estimate a “climate beta” to capture the sensitivity of firm-level stock returns to climate news shocks. Their hedge portfolio methodology enables the dynamic estimation of exposure based on real-time market reactions. While still evolving, these approaches represent promising advances in capturing latent dimensions of climate risk that are difficult to observe using emissions data alone.

These academic innovations stand in contrast to the tools widely used in practice. Many investors rely on third-party ESG and climate risk ratings as simplified indicators of firm sustainability performance. However, ESG scores often diverge substantially across providers, even for the same firm. Berg, Kölbel, and Rigobon (2022) attribute this divergence primarily to measurement disagreement: different agencies often rely on distinct indicators and data sources when assessing similar dimensions of performance. For example, one rating may emphasize carbon intensity while another prioritizes stated environmental policies, resulting in inconsistent evaluations. Stock prices react to variations and uncertainties of ESG ratings (Avramov, Cheng, Lioui, and Tarelli, 2022; Serafeim and Yoon, 2023). Such variability undermines the reliability of ESG ratings for informed decision-making and introduces considerable noise into portfolio construction, capital allocation, and regulatory compliance. In response, some institutional investors have begun to aggregate ratings across providers or rely directly on firm-reported data, such as emissions disclosures, rather than opaque composite scores (Christensen, Serafeim, and Sikochi, 2022). The broader academic implication is clear: despite growing interest in climate risk measurement, the field continues to lack standardized, transparent, and comparable tools. This ongoing gap highlights the importance of harmonized disclosure frameworks and improved methodological clarity in ESG evaluation.

In summary, the literature indicates that while significant progress has been made in developing measures of climate risk, current approaches remain fragmented and incomplete. While emissions data remain indispensable, newer methods such as textual analysis and climate betas expand the toolkit, even as divergent ESG ratings highlight enduring problems of inconsistency and subjectivity. The central implication is clear: without standardized, transparent, and multidimensional tools, financial markets will struggle to price climate risks accurately or allocate capital effectively to support the low-carbon transition.

Section 4: Conclusion

Over the past five years, scholarship in green and climate finance has grown exponentially and advanced our understanding of how financial markets internalize environmental risks and objectives. Across domains as diverse as sustainable investing, disclosure, sustainable debt markets, and macroeconomic impacts, a unifying theme emerges: credible information and aligned incentives are the essential levers through which markets can convert climate objectives into corporate action. When credibility is absent, whether in the form of weak disclosure, unverifiable claims, or misaligned incentives, market mechanisms risk devolving into relabeling, misallocation, or greenwashing equilibria.

The evidence reviewed here makes clear that credibility, comparability, and enforcement matter as much as ambition. Harmonized disclosure standards, auditable metrics (including Scope 3 emissions), and rigorous reporting on use-of-proceeds and realized outcomes are not merely desirable; they are essential for market functioning. Without them, even well-intentioned strategies such as divestment, sustainability-linked bonds, or voluntary disclosure may yield symbolic rather than substantive change. With them, markets can amplify policy signals, direct capital to effective abatement and adaptation, and discipline corporate strategies.

Collectively, these studies point to a field moving beyond the question of whether markets respond to climate risks, toward the more challenging task of designing institutions and incentives that deliver measurable environmental outcomes. They demonstrate that climate risks are increasingly priced, that firms are adjusting financing and innovation portfolios, and that policy design critically shapes the effectiveness of market-based tools. The accumulated evidence justifies cautious optimism: with credible standards, aligned incentives, and robust accountability, financial markets can serve as powerful, though not sufficient, mechanisms for advancing an efficient and equitable low-carbon transition. For researchers, practitioners, and policymakers alike, the challenge now is to move from identifying responses to developing tools and strategies that reliably convert climate objectives into real environmental progress.

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