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Climate Related Financial Risks and Their Implications on Investment Portfolios

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Abstract

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This study reviews how climate related financial risks shape asset pricing and portfolio management. Climate change generates physical and transition risks that affect expected cash flows, discount rates, and risk premia, making climate risk a material driver of portfolio performance and financial stability. Using a systematic literature review of peer reviewed studies, the paper synthesizes evidence on how climate risk is priced across equities, bonds, real estate, and derivatives, and how green and brown assets exhibit distinct return patterns. The findings show that climate risk is reflected in cross section returns, option implied tail risk, and time varying green brown performance differentials driven by policy, technology, and investor sentiment. Climate aware portfolio strategies such as tilting toward low emission firms, excluding high carbon sectors, and constructing climate hedge factors can reduce exposure to transition risk but may alter expected returns and diversification benefits. The review identifies a key gap in holistic multi asset frameworks and calls for integrated portfolio models that embed climate scenarios, cross asset hedging opportunities, and long horizon uncertainty. These insights provide guidance for constructing resilient, climate aware portfolios across investment horizons.

1. Introduction

Climate related financial risks have moved from the periphery to the core of investment decision making as climate change increasingly affects macroeconomic outcomes, firm fundamentals, and the stability of the financial system. These risks are typically classified into physical risks such as more frequent and severe floods, heatwaves, and storms that damage real assets and disrupt supply chains and transition risks, arising from policy changes, technological shifts, and evolving consumer preferences in the move toward a low carbon economy. Both channels can alter expected cash flows, discount rates, and risk premia, meaning that climate risks are now widely recognized as material drivers of portfolio performance rather than purely ethical or reputational concerns (Karydas & Xepapadeas, 2022; Campiglio et al., 2023).

Recent advances in climate finance highlight multiple mechanisms through which climate related risks are priced in financial assets. Campiglio et al. (2023) synthesize evidence showing that investors adjust required returns and the cost of capital in response to exposure to both physical and transition risks, leading to cross sectional differences in valuations across sectors, regions, and emission profiles. In a dynamic asset pricing framework, Karydas and Xepapadeas (2022) demonstrate that climate change can be modeled as a rare disaster risk that affects asset prices and interest rates through time varying risk premia, implying that climate shocks can trigger abrupt repricing episodes in financial markets. These insights suggest that portfolios which ignore climate risk may be exposed to under compensated

downside risk, while those that integrate climate scenarios and exposures may better manage tail risk and long horizon uncertainty.

At the same time, a growing body of empirical work on green versus brown assets reveals that climate related financial risks and opportunities are reflected in relative performance patterns. Pástor et al. (2021) show that in equilibrium, investors' nonpecuniary preferences for "green" assets and their role as hedges against climate risk can lead to lower expected returns for green securities, even though realized returns may temporarily be high when climate concerns increase unexpectedly. Extending this logic, Pástor et al. (2022) decompose recent "green outperformance" and find that much of it is attributable to unexpected surges in environmental concern rather than a persistent "green premium." Complementary evidence from global equity markets documents that the existence and magnitude of a carbon premium, that is, higher expected returns for carbon intensive ("brown") firms, is mixed and sensitive to sample period, region, and methodology (Bauer et al., 2022; Campiglio et al., 2023).

For portfolio managers, these findings translate into a complex and evolving set of tradeoffs. On the one hand, climate aware strategies such as tilting toward firms with lower emissions, excluding high carbon sectors, or constructing green minus brown factors can reduce exposure to transition risk and align portfolios with investors' sustainability preferences. On the other hand, shifts in climate sentiment and policy can generate time varying performance differentials, as illustrated by the sensitivity of green versus brown stock returns to changes in climate change concerns (Ardia et al., 2023). Much of the existing literature still concentrates either

on asset pricing or on specific asset classes, so it does not fully address how climate related financial risks can be systematically embedded into multi asset portfolio design, risk budgeting, and strategic asset allocation.

Building on this gap, this article explores climate related financial risks and their implications for investment portfolios, linking theoretical asset pricing insights with the practical realities faced by both institutional and individual investors. By synthesizing recent evidence on the pricing of physical and transition risks, the behavior of green and brown assets, and the role of investor preferences, the study aims to clarify how climate risk reshapes portfolio return distributions, diversification benefits, and long term investment policy. In doing so, it contributes to the growing climate finance literature by highlighting not only whether climate risks are priced, but also what this pricing implies for constructing resilient, climate aware investment portfolios over different horizons.

2. Literature Review

Climate related financial risks have shifted from a niche concern to a central determinant of financial stability and portfolio performance, as climate change increasingly shapes macroeconomic outcomes, firm level cash flows, and the resilience of the financial system. Recent survey and review papers emphasize that both physical risks (e.g., extreme weather, chronic temperature rise) and transition risks (e.g., policy tightening, technological disruption, changing preferences) can transmit to asset prices through their effects on expected cash flows, discount rates, and risk premia, making climate risk a financially material factor rather than a purely

ethical or reputational issue (Giglio et al., 2021). From a macro prudential perspective, climate risk is now viewed as a source of systemic risk that motivates climate stress testing and scenario analysis by central banks and supervisors, highlighting potential nonlinearities and amplification mechanisms within the financial system (Acharya et al., 2023).

In parallel, a fast growing asset pricing literature investigates how climate risk is priced across different asset classes. Giglio et al. (2021) document that climate risk exposures are reflected in the cross section of returns on equities, bonds, and real estate, and that investors can use these assets to construct portfolios that hedge climate risk. Engle et al. (2020) build dynamic hedge portfolios based on climate news shocks and show that portfolios sorted on climate risk exposures can effectively hedge innovations in climate change news, indicating that climate information is a priced source of systematic risk. At the firm level, Bolton and Kacperczyk (2021) find that carbon emissions and emission intensity are associated with higher expected stock returns, consistent with a carbon risk premium required by investors exposed to transition risk. Complementing this, Ilhan et al. (2021) show that carbon risk manifests as "tail risk" in option implied distributions, with firms that are more exposed to carbon risk exhibiting fatter downside tails, suggesting that climate risk is priced not only in mean returns but also in higher moments of the return distribution.

Empirical evidence on green versus brown assets further illustrates how climate related financial risks and opportunities map into relative performance patterns. Bernardini et al. (2021), studying European electric utilities, document a

significant "low carbon premium," where portfolios tilted toward low carbon firms earn higher risk adjusted returns during periods of accelerated decarbonization, implying that carbon intensive business models can be penalized in investors' required returns. At the same time, research on green and brown energy stocks shows that climate policy uncertainty is an important state variable: Bouri et al. (2022) find that shocks to climate policy uncertainty significantly affect the relative performance of green versus brown energy equities, especially during crisis periods, with implications for style rotation and asset allocation strategies. This evidence suggests that climate aware portfolio strategies such as tilting toward low emission firms, incorporating climate policy uncertainty, or constructing hedge portfolios based on climate news exposures can materially alter a portfolio's exposure to both physical and transition risks. Yet, most existing studies still focus on pricing effects within specific markets or single asset classes, while relatively fewer contributions examine how to embed climate risk systematically into multi asset portfolio construction, risk budgeting, and long horizon strategic asset allocation.

3. Methods

This study employs a systematic literature review (SLR) approach to synthesize and critically evaluate academic evidence on climate related financial risks and their implications for investment portfolios. The review follows a transparent, protocol based procedure that begins with the formulation of clear research questions focused on how physical and transition climate risks are priced in financial assets and incorporated into portfolio strategies. Relevant studies are identified

through structured searches in major scholarly databases such as Scopus, Web of Science, ScienceDirect, JSTOR, SSRN, and Google Scholar, using combinations of keywords including "climate related financial risk," "physical risk," "transition risk," "green assets," "brown assets," "carbon risk," "climate finance," and "investment portfolios," along with terms related to asset pricing and portfolio management. The search is limited to peer reviewed journal articles published in English and excludes conference papers, book chapters, policy notes, and non refereed "open journal" outlets to ensure the quality and reliability of the evidence base.

After removing duplicates, titles and abstracts are screened against predefined inclusion and exclusion criteria, followed by full text assessments to retain only those studies that explicitly examine the interaction between climate risks, asset prices, and portfolio decisions. A structured data extraction template is then used to capture information on research objectives, data and markets studied, measures of climate risk (e.g., emissions, climate news, policy uncertainty), asset classes considered, methodological approaches, and main findings. Finally, the selected articles are synthesized through a combination of descriptive mapping (e.g., by asset class, risk measure, and methodological design) and thematic analysis, allowing the review to identify converging and diverging results, methodological gaps, and future research opportunities related to integrating climate related financial risks into multi asset portfolio construction, risk budgeting, and strategic asset allocation.

4. Results and Discussion

The results of the systematic literature review show a strong convergence that climate related financial risks have become materially relevant for both asset pricing and portfolio management. Across the reviewed studies, physical and transition risks consistently emerge as channels that affect expected cash flows, discount rates, and risk premia, confirming the shift of climate risk from a peripheral ethical concern to a core financial driver (Giglio et al., 2021; Karydas & Xepapadeas, 2022; Campiglio et al., 2023). From a system wide perspective, the evidence that climate risk can propagate through balance sheets and funding conditions has motivated the development of climate stress tests and scenario analysis by central banks and supervisors, highlighting the potential for nonlinear amplification and systemic instability (Acharya et al., 2023). Taken together, these findings indicate that ignoring climate risk can lead to systematic underestimation of both firm level and macro financial vulnerabilities.

At the level of asset pricing, the review finds robust support for the idea that climate exposures are reflected in the cross section of returns across multiple asset classes. Giglio et al. (2021) show that climate risk factors help explain return patterns on equities, bonds, and real estate and can be used to build hedging portfolios, while Karydas and Xepapadeas (2022) frame climate change as a rare disaster shock that operates through time varying risk premia, implying the possibility of abrupt repricing episodes. Engle et al. (2020) further demonstrate that portfolios sorted on sensitivity to climate news can hedge innovations in climate information, reinforcing the view that climate is a priced systematic risk. At the firm level, evidence of a

carbon risk premium appears in studies showing that higher emissions and emission intensity are associated with higher expected stock returns (Bolton & Kacperczyk, 2021), and that carbon risk shows up as fatter downside tails in option implied distributions for highly exposed firms (Ilhan et al., 2021). However, the magnitude and stability of a "carbon premium" remain mixed across markets and methodologies, with some studies documenting context dependent results that vary by region, sector, and sample construction (Bauer et al., 2022; Campiglio et al., 2023). This suggests that while climate risk is clearly priced, its exact compensation is heterogeneous and sensitive to measurement choices.

The review also reveals nuanced patterns in the performance of green versus brown assets. Pástor et al. (2021) show that when investors exhibit nonpecuniary preferences for green assets and perceive them as hedges against climate risk, equilibrium expected returns on green securities can be lower, even if realized returns occasionally surge when climate concerns intensify unexpectedly. In a follow up analysis, Pástor et al. (2022) find that recent episodes of green out performance are largely driven by unexpected increases in environmental concern rather than a stable, structural "green premium," implying that performance differentials are strongly state dependent. Consistent with this, Bernardini et al. (2021) report a "low carbon premium" among European electric utilities during periods of accelerated decarbonization, while Bouri et al. (2022) show that shocks to climate policy uncertainty significantly influence the relative performance of green and brown energy stocks, especially in crisis periods. Ardia et al. (2023) further document that green brown return spreads are highly sensitive to shifts in climate change concerns,

reinforcing the view that climate sentiment and policy dynamics are key drivers of time varying style performance. Overall, these results indicate that green and brown assets provide different exposures to climate risk, but that the associated return premia are unstable and closely tied to the evolution of policy, technology, and investor preferences.

From a portfolio management perspective, the synthesis points to both opportunities and challenges in integrating climate related risks. Climate aware strategies such as tilting toward low emission firms, excluding high carbon sectors, or constructing green minus brown and climate hedge factors appear effective in reducing exposure to transition risk and aligning portfolios with investors' sustainability preferences (Engle et al., 2020; Bernardini et al., 2021; Pástor et al., 2021). At the same time, the evidence of state dependent green performance and context specific carbon premia implies that such strategies may alter expected returns, risk contributions, and diversification properties in ways that are not constant over time (Bauer et al., 2022; Ardia et al., 2023). A key gap exposed by the review is that most studies still examine climate risk within single asset classes or narrow market segments, paying relatively less attention to how climate exposures should be managed in a coherent multi asset framework, how they interact with long horizon return distributions, and how they should be reflected in risk budgeting and strategic asset allocation (Giglio et al., 2021; Acharya et al., 2023; Campiglio et al., 2023). Consequently, while the literature provides strong evidence that climate risks are priced and that green and brown assets carry distinct climate exposures, there remains substantial scope for future research to develop integrated portfolio

frameworks that combine climate scenarios, cross asset hedging opportunities, and investor preferences into robust, climate aware investment policies

5. Conclusion

This study concludes that climate related financial risks have become a core determinant of both asset pricing and portfolio performance rather than a peripheral ethical concern. Physical and transition risks are consistently shown to affect expected cash flows, discount rates, and risk premia, while systemic analyses highlight their potential to propagate through balance sheets and funding structures, creating macro financial vulnerabilities. Empirical evidence confirms that climate risk is priced across multiple asset classes and at the firm level, although the magnitude and stability of any "carbon premium" are heterogeneous across regions, sectors, and methodologies. The performance of green versus brown assets is likewise state dependent: green assets can benefit during periods of rising environmental concern or accelerated decarbonization, but their expected returns and hedging properties vary with policy, technology, and investor sentiment. Overall, the literature demonstrates that climate risk is a material financial factor and that portfolios which ignore it are likely to face under compensated downside risk and mismeasured diversification.

At the same time, the review reveals that integrating climate related risks into portfolio management remains a work in progress. Climate aware strategies such as tilting toward low emission firms, excluding high carbon sectors, or constructing green minus brown and climate hedge factors can reduce exposure to transition risk

and better align portfolios with sustainability preferences, but they also introduce time varying effects on returns, risk contributions, and correlation structures. A key gap is the limited development of holistic, multi asset frameworks that incorporate climate scenarios, cross asset hedging opportunities, and investor preferences into coherent risk budgeting and strategic asset allocation. Future research should therefore move beyond single asset pricing tests toward integrated portfolio models that explicitly account for long horizon climate uncertainty, scenario based stress testing, and the interaction between regulatory developments, technological change, and market behavior. By closing this gap, the climate finance literature can provide more actionable guidance for constructing resilient, climate aware investment portfolios over different investment horizons.

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