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Pricing of climate risks in financial markets: a summary of the literature

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Abstract

This paper summarises the academic literature on the financial market pricing of physical and transition risks related to climate change. While studies find that these risks are starting to be priced, concerns are growing that current prices do not fully reflect the risks. Investors grapple with three major challenges when seeking to price climate risks adequately. First, the aggregate nature of climate risks limits the availability of risk-sharing arrangements and hedging instruments. Second, the high degree of uncertainty about climate risks and concrete policy actions to address them heightens modelling and measurement challenges. Third, the information available to investors about climate risks and their consequences is often incomplete or imperfect.

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Introduction

A fast-growing body of literature examines whether physical and transition risks related to climate change are adequately priced in financial markets. While there is growing evidence that financial markets have started to price in climate risks, many have expressed concerns that current prices do not fully reflect these risks (BIS (2020), IMF (2020), NGFS (2022), ECB (2021), OECD (2021), Campiglio et al (2022)). Uncertainty and imperfect information complicate pricing. Also, externalities associated with climate change and greenhouse gas emissions can lead to a disconnect between market prices and the true social costs (Nordhaus (2019)).

Uncertainty across multiple dimensions and the long-run nature of climate risks present significant challenges to accurately modelling these risks (Hansen (2022), Barnett et al (2020)). Investors grapple with uncertainty about the future path of climate change, and about the energy transition, policy parameters and adaptation by firms and households. Market pricing is also hampered by a lack of historical data, consistent methodologies, standardised metrics, and comparable disclosures around climate risks (BIS (2020)). Even if investors had perfect information, risks far into the future may not be reflected in asset prices unless discount rates are sufficiently low.

A survey of finance academics and professionals, public sector regulators and economists in July 2021 identified regulatory risk as the top risk over the next five years and physical risk as the top one over the next 30 years (Stroebel and Wurgler (2021)). An overwhelming majority of survey respondents believed that asset prices underestimated climate risks.

This paper summarises the main findings of the literature on the pricing of climate risks in financial markets, including some unpublished work not yet subjected to peer review. More comprehensive reviews of the literature can be found in BCBS (2021), ECB (2021), NGFS (2022) and Giglio et al (2021a).

Physical risks

Several microeconomic studies find evidence that physical risks are priced in certain markets. However, that evidence is often mixed and insufficiently comprehensive to conclude that physical risks are broadly and consistently priced across markets. According to the International Monetary Fund, the impact of large disasters on equity markets, bank stocks, and non–life insurance stocks has generally been modest over the past 50 years. In addition, as of 2019, aggregate equity valuations did not reflect predicted changes in physical risks under various climate change scenarios (IMF (2020)).

While there is some indication that physical risks are priced in credit and equity markets, the evidence is preliminary and sometimes mixed. In credit markets, investors seem to pay a premium for corporate bonds that tend to do better when bad news about climate arrives (Huynh and Xia (2020)). In addition, there are some signs of physical climate risks being priced in sovereign debt markets: for example, extreme weather conditions cause borrowing conditions to deteriorate for sovereigns in the Caribbean (Mallucci (2022)). On the pricing of municipal bonds, there is conflicting evidence. Some authors find that, since 2013, the bonds of US municipalities exposed to rising sea levels have sold at a slight discount (Goldsmith-

Pinkham et al (2022)), while others find no climate risk premium for municipal bonds (BlackRock Investment Institute (2019)). In equity markets, the elasticity of equity prices to temperature risks across global markets appears to be negative and increasing in magnitude over time along with the rise in temperature (Bansal et al (2016)). Acharya et al (2022) find that heat stress has been robustly priced in municipal and corporate debt, and equity markets since 2013, but do not find evidence of pricing for other physical risks.

There is microeconomic evidence for the pricing of physical risks in housing markets, but the findings are not always consistent. Following Hurricane Sandy, the relative prices of properties in flood zones in New York City fell and stayed low, even if they were not damaged by the hurricane (Ortega and Taspinar (2018)). Similarly, among houses with equivalent observable characteristics, those exposed to sea level rise sold at a 7% discount, suggesting that inundation risks are priced (Bernstein et al (2019)). However, another study using a different sample and a similar methodology finds no effect of inundation risk being priced into residential real estate valuations (Murfin and Spiegel (2020)). Some studies found that attention paid to climate risks and beliefs in climate change affect the pricing of physical risks in housing markets (Giglio et al (2021b), Baldauf et al (2020)).

Transition risks

Transition risks present challenges for firms operating in high-carbon sectors as they might erode valuations, increase operating expenses and lead to balance sheet deterioration through reduced collateral values and stranded assets. Even though there is some evidence that transition risks are priced in financial markets, it is unclear whether this pricing is sufficient to address transition risks effectively (Weder di Mauro (2021)).

Several papers find evidence that transition risks are being priced in equity markets. For example, Bolton and Kacperczyk (2021) find that stocks of firms with higher total CO_2 emissions (and changes in emissions) earn higher returns, which cannot be explained through differences in size, book-to-market ratio or other return predictors. This suggests that investors demand compensation for their exposure to these carbon-intensive companies. In a follow-up study using a broader sample of firms, Bolton and Kacperczyk (2022) corroborate this evidence. The authors also find that the short-term transition risk is greater for firms located in countries with a lesser degree of economic development, greater reliance on fossil energy, and less inclusive political systems. The long-term transition risk is higher in countries with stricter domestic, but not international, climate policies. In European equity markets, "greener" stocks trade at a premium, but only if the companies are transparent about environmental performance (Alessi et al (2021)).

Several studies document that investors are sensitive to transition risks in fixed income markets as well. Some evidence suggests that the bonds of firms with less room to mitigate transition risks trade at a discount (Seltzer et al (2022)). Moreover, firms with higher greenhouse gas emissions (mostly due to CO_2 emissions) and poorer environmental scores exhibit greater credit risk as measured by bond yield spreads and distance-to-default (Capasso et al (2020), Barth et al (2022)). Green bonds trade at a premium versus similar bonds without the green designation (Baker et al (2018), Zerbib (2019)) and can offer diversification benefits without forgoing returns (Fender et al (2019)). Finally, evidence suggests that issuing green bonds acts as a signalling device for firms' commitment toward the environment (Flammer (2021)).

The pricing of transition risks reacts to climate policies. Some studies link the spread in average returns between high- and low-emission firms to uncertainty about environmental policy (Hsu et al (2022)). Similarly, the equity prices of firms exposed to transition risk are negatively affected when the likelihood of climate policy action is higher (Barnett (2019)). After the Paris Agreement, the firms most exposed to climate transition risk saw their credit ratings deteriorate whereas other comparable firms did not, with a larger effect for European than US firms, which might in part reflect different expectations around climate policy (Carbone et al (2021)). There is also evidence that, since the Paris Agreement, transition risks are priced in the syndicated loan market (Ehlers et al (2022)).

The salience of climate risks also impacts the pricing of transition risks. Carbon-intensive firms underperform during times with abnormally warm weather, when investor attention is high (Choi et al (2020)). The cost of option protection against downside tail risks is larger for firms with more carbon-intense business models, and this is magnified when the public's attention to climate change spikes (Ilhan et al (2021)). On the flip side, news about transition risks positively impacts the returns of renewable energy companies (Batten et al (2016)).

Studies also suggest that market participants are pricing the risk of stranded assets to a certain degree. They penalise oil exploration firms in the United States for expanding their undeveloped oil reserves, which suggests that these investments are expected to have lower returns than existing production or even that they may not be expected to pay off over the long run (Atanasova and Schwartz (2019)). Climate risks and the uncertainty of the energy transition appear to have already had major effects on capital expenditures. For example, investment in coal, gas and oil dropped from over $1.3 trillion in 2015 to $750 billion in 2020 (Americano et al (2022)). Underinvestment in fossil fuels is not compensated for by investment in renewable energies, which might lead to energy scarcity and more volatility in energy prices in the medium term. Jung et al (2022) create a stress-testing procedure to test the resilience of financial institutions to climate-related risks using information on the return on stranded assets.

While the literature has focused primarily on the impact of transition risks on firms in high-carbon sectors, several authors have highlighted the risks of a "green bubble" emerging if the scope and the speed of the transition are overestimated (Borio et al (2022)). Such mispricing could lead to misallocations and affect the trajectory of the transition.

ESG ratings

Environmental, social and governance (ESG) ratings are frequently used as a tool to provide information to investors about the alignment of company objectives with actions to mitigate climate risks. In particular, the 'E' pillar is increasingly used as a proxy for selecting assets aligned with a low-carbon transition (NGFS (2022)). However, opaque and unstructured methodologies make it hard for investors to extract information from ESG ratings. In addition, ESG ratings have attracted criticism for their "catch-all" nature, by attempting to capture varied elements (from social benefits to biodiversity loss) in a single rating.

Investors seeking to extract information from ESG ratings often face a substantial amount of uncertainty about a firm's true ESG profile. The ESG ratings of different rating agencies vary substantially and persistently (Avramov et al (2022)). Moreover, ESG rating providers appear to give a higher weight to the existence of corporate policies rather than forward-looking climate metrics, such as reductions in greenhouse gas emissions and intensity (OECD (2022)). To ensure that relevant information is better incorporated into prices, it is important to have effective tracking and verification processes to ensure that market participants can verify and assess progress in line with a low-carbon transition. As a step towards improving information on climate risks, a new international sustainability standards board focused on climate-related disclosures was set up in 2021 (Reichlin (2021)).

Recent research shows that ESG ratings and green innovation may not fully align. In the United States, firms with lower ESG scores, which are excluded from the investment universe of ESG funds, tend to be important green innovators (Cohen et al (2022)). This misalignment might have implications for pricing and efficient capital allocation.

Hedging climate risks

Developed financial markets allow market participants to effectively hedge climate risks. Advanced economies tend to have deeper financial markets that allow investors to hedge a variety of risk exposures. Evidence from the United States indicates that some derivatives markets are being used to hedge climate risks. For example, US options markets are sensitive to climate regulation uncertainty (Ilhan et al (2021)) and to hurricane forecasts (Kruttli et al (2021)). A cross-sectional study finds that firms using weather contracts to hedge climate risks have higher valuations than others, especially among firms that are exposed to climate risks (Pérez-González and Yun (2013)). In financial markets elsewhere instruments to protect against climate risks are substantially less developed (Lesmond (2005) and Domowitz et al (2002)).

Financial losses due to natural catastrophes can be covered by insurance, although coverage rates vary across countries. According to Swiss Re (2020), only around half of global economic losses from natural catastrophes has been covered by insurance in recent years. The protection gap is wider for emerging markets, where insured losses are less than 10% of total damages (Munich Re (2022)). The insurability of catastrophe-related risks is of increasing concern in the light of climate change, which could result in a widening of the protection gap (BIS (2020), ECB (2021)).

Hedging climate risks presents unique challenges for insurance companies and investors. Many effects of climate change are so uncertain or so far in the future that neither financial derivatives nor specialised insurance markets are available to directly hedge these risks. Furthermore, while heterogeneity across exposures can in principle allow for certain risk-sharing arrangements, some climate risks are considered uninsurable (Charpentier (2008), BIS (2020)). For example, insurers retreated from some areas of the Caribbean after severe weather events that undercut mortgage lending and home prices (Carney (2015)). A loss in the availability of insurance might lead to further volatility in financial markets.

Insurance and reinsurance companies have developed insurance-linked securities (ILS) and catastrophe bonds to overcome some of the challenges in providing insurance. These instruments transfer the risks associated with natural disasters to investors through global capital markets. The investments from the proceeds as well as insurance premiums are then used to make coupon payments to investors (World Bank (2020)). Prominent examples of ILS include those with parametric payouts, where payouts are based on a trigger event, for example a measure of wind speed or rainfall, rather than a measure of loss. While the number of parametric catastrophe bonds is limited, their triggers can be determined quickly and with a lesser degree of technical expertise (Polacek (2018)). This allows their issuers to pay out quickly and cover the financial impact. The total size of outstanding catastrophe bonds and ILS risk capital was around $40 billion in 2020 (FSB (2020)).

Investors can partially overcome the lack of insurance through proxy hedges. The stocks of firms that score high on the environmental portion of ESG ratings have higher returns during periods with negative news about the future path of climate change (Engle et al (2020)). Using this information, investors can dynamically hedge their portfolios against climate risk through investments in companies that score high on the environmental portion of ESG ratings and continuously update the hedging portfolio using new information on climate risk exposures. Investing in a low-carbon index can also provide a hedge for investors (Andersson et al (2016)). Alternatively, investors can construct hedging portfolios that exploit information on the observed trading decisions of mutual fund managers. Portfolios comprising long positions in industries that mutual fund managers are disproportionately likely to buy after a localised extreme weather event combined with short positions in opposite industries can help investors hedge the arrival of bad national climate news (Alekseev et al (2022)).

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