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CORPORATE COST OF DEBT IN THE LOW-CARBON TRANSITION: THE EFFECT OF CLIMATE POLICIES ON FIRM FINANCING AND INVESTMENT THROUGH THE BANKING CHANNEL

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ABSTRACT/RÉSUMÉ

Corporate cost of debt in the low-carbon transition: The effect of climate policies on firm financing and investment through the banking channel

This paper assesses to what extent markets with sophisticated investors and large firms price transition risks due to climate policies. The analysis exploits longitudinal data on firms' economic and environmental performances - as measured by emission intensity, patenting activity in mitigation technologies, and ESG scores – and syndicated loan data. It provides three main results. First, firms with good environmental performance (in terms of emission intensity or patenting activity in mitigation technologies) benefit from a significantly lower cost of debt as climate-change mitigation policies become more stringent. Second, ESG scores and their environmental pillar are not sufficiently informative to assess and price domestic climate policy risks. Third, more stringent mitigation policies encourage investment in green firms by reducing the cost of debt: an increase of about EUR 10/t CO2 in carbon taxes raises investment by about 12% for firms with high patenting activity in mitigation technologies while it decreases investment by about 11% for firms with high emission intensity. The paper discusses policies to improve the available information on firms' environmental performance metrics so as to enable investors who are smaller and less sophisticated than those participating in the syndicated-loan market to assess firms' climate transition risks and to allocate capital in line with emission reduction targets.

JEL codes: D22; G10; G38; O32; Q50; Q58

Keywords: Green finance, climate policy, ESG, cost of capital, corporate investment.

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Coût de la dette des entreprises dans la transition bas-carbone : l'effet des politiques climatiques sur le financement et l'investissement des entreprises par le canal bancaire

Cet article évalue dans quelle mesure les marchés avec des investisseurs sophistiqués et de grandes entreprises évaluent les risques de transition dus aux politiques climatiques. L'analyse exploite des données longitudinales sur les performances économiques et environnementales des entreprises – telles que mesurées par l'intensité des émissions, l'activité de brevetage dans les technologies d'atténuation, et les scores ESG – et les données sur les prêts syndiqués. Il fournit trois résultats principaux. Premièrement, les entreprises ayant de bonnes performances environnementales (en termes d'intensité d'émissions ou d'activité de brevetage dans les technologies d'atténuation) bénéficient d'un coût de la dette nettement inférieur à mesure que les politiques d'atténuation du changement climatique deviennent plus strictes. Deuxièmement, les scores ESG et leur pilier environnemental ne sont pas suffisamment informatifs pour évaluer et chiffrer les risques liés aux politiques climatiques nationales. Troisièmement, des politiques d'atténuation plus strictes encouragent l'investissement dans les entreprises vertes en réduisant le coût de la dette : une augmentation d'environ 10 EUR/tonne de CO2 des taxes sur le carbone augmente l'investissement d'environ 12% pour les entreprises ayant une forte activité de brevetage dans les technologies d'atténuation, tandis qu'elle diminue l'investissement d'environ 11% pour les entreprises à forte intensité d'émissions. L'article examine les politiques visant à améliorer les informations disponibles sur les indicateurs de performance environnementale des entreprises afin de permettre aux investisseurs plus petits et moins sophistiqués que ceux qui participent au marché des prêts syndiqués d'évaluer les risques de transition climatique des entreprises et d'allouer des capitaux conformément aux objectifs de réduction des émissions.

JEL classification: D22; G10; G38; O32; Q50; Q58

Mots clés : Finance verte, politique climatique, ESG, coût du capital, investissement des entreprises

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Corporate cost of debt in the low-carbon transition: The effect of climate policies on firm financing and investment through the banking channel

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1. Introduction

Reaching the climate-change mitigation goals of the Paris Agreement will require substantial investment in low-carbon infrastructure and technologies over the next decades. Global annual investments in low-carbon energy alone need to increase to USD 4.4 trillion by 2030, more than three times the level in 2022 (IEA, 2022[1]). Private sector firms are expected to play a key role in the net-zero transition as they account for more than half of all climate-change mitigation finance (Climate Policy Initiative, 2021[2]; D'Arcangelo et al., 2022[3]).

The contribution of the private sector to the net-zero transition hinges on the capacity of markets to efficiently aggregate information on mitigation policies and their possible effects on firms. Investors responsible for capital-allocation decisions need to be capable of assessing and correctly pricing firms' transition risk, i.e. the risk that mitigation policies cause costly adjustments for firms, due to – for instance – technology changes, the stranding of emitting assets or lower demand. (De Haas and Popov, 2019[4]; Levine et al., 2018[5]). However, not all financial intermediaries may have the information and capacity to assess the environmental profile of their investments and transition risks.

Countries' mitigation strategies often comprise a variety of policy instruments (e.g. direct and indirect carbon prices, standards and regulations, incentives for the development and deployment of clean technologies) that have the potential to affect firms based on a host of characteristics at the firm level. These characteristics may be more or less difficult to observe and monitor and include their emission

[1] Mauro Pisu, Filippo Maria D'Arcangelo and Tobias Kruse are members of the OECD Economics Department. Marco Tomasi is a member of the University of Trento. We are grateful to Luiz de Mello, Alain de Serres, Douglas Sutherland, Riccardo Boffo, Hélia Costa, Lilas Demmou, Dennis Dluglosch, Anna Fava, Guido Franco, Tomasz Kozluk, Catriona Marshall, Giulio Mazzone, Paolo Simeoni, Lukasz Rawdanowicz and delegates of Working Party No.1 (WP1) of the OECD Economic Policy Committee for their valuable suggestions and comments. We also thank Antoine Dechezleprêtre for facilitating access to the patent data. Special thanks are due to Sisse Nielsen (OECD Economics Department) for her editorial assistance.

profile, degree of green innovation, corporate climate plans, and others. The metrics most used by investors to categorise firms and assets in this area, i.e. the Environmental, Social, Governance (ESG) ratings and its Environmental pillar score, are often opaque and only weakly correlated with firms' emissions or other material environmental performance measures and are inconsistent across providers. As a result, they might not convey sufficient information on the actual exposure of firms to changes in business conditions due to mitigation policies (Boffo and Patalano, 2020[6]; OECD, 2022[7]; OECD, 2022[8]).

This paper assesses to what extent markets with sophisticated investors and large firms price transition risks. It investigates empirically the relationship between loans' interest rates, firms' environmental performance and climate-change mitigation policies. The analysis uses longitudinal data on syndicated loans and firms' economic and environmental performance, including emission intensity, green innovativeness (measured by patenting activity in mitigation technologies) and ESG and Environmental pillar scores. It then looks at the effect of mitigation policies on investment through their impact on the cost of capital as measured by the syndicated loan spreads.

Syndicated loans are a widespread debt financing instrument involving several lenders, mostly banks. Data on syndicated loans contains exact loan spreads and is thus well suited to study how investment decisions affect firms' cost of debt. The data covers 40 OECD and G20 countries between 2000 and 2018, although a large share is concentrated in countries with larger financial markets, such as the United States. The paper employs the OECD Environmental Policy Stringency (a composite policy stringency measure comparable across countries and years), as well as two more granular sub-components covering carbon tax (i.e., market pull) and green technology support (i.e., technology push) policies.

A first result of the analysis is that firms with good environmental performance (measured by low emission intensity or high patenting activity in mitigation technologies) benefit from a lower cost of capital, as measured by syndicated loan spreads. This effect is economically large when mitigation policy is stringent but disappears when it is not. Market-pull policies (i.e., carbon taxes) increase loan spreads for firms with high emission intensity and decrease them for green innovators. Technology-push policies (i.e., green technology support) decrease loan spreads for green innovators but do not have a significant effect on emission intensive firms. These effects are sizeable when mitigation policy is stringent, underlining the importance of the financial sector in pricing transition risks as mitigation policy intervention ramps up. For example, when carbon prices are above EUR 50/t CO_2, firms in the top quartile by patents in mitigation technology enjoy a loan spread 30% lower than firms at the bottom quartile, equivalent to 41 basis points or EUR 1.5 million less in yearly interest payments for the median syndicated loan deal. However, this difference disappears if domestic mitigation policy stringency is low.

A second set of results indicates that the ESG scores and their environmental pillar are not sufficiently informative to assess the potential impact of climate-change mitigation policies on firms. Companies disclosing an ESG score benefit from lower loan spreads and this advantage increases with better scores. However, contrary to the actual firms' environmental performance (as measured by firms' green innovativeness and emission intensity), the effect of ESG scores on loan spreads is disconnected from mitigation policy stringency. This result, together with the low correlation of ESG scores with environmental performance, corroborates the view that ESG scores are weak proxies of firms' actual environmental performance (Berg, Kölbel and Rigobon, 2022[9]; OECD, 2022[7]) and suggests that they are not used by investors in the syndicated loan market to assess and price domestic climate policy risks. Banks may still reward firms with high ESG scores with lower loan spreads, irrespective of mitigation policy stringency, because of societal and shareholder pressures to incorporate ESG criteria in lending and investment decisions or because of ESG-related investment mandates (Giglio et al., 2023[10]).

A third set of results shed light on how mitigation policies affect capital reallocation, stimulating investment in green firms and reducing it in brown firms. A EUR 10/t CO_2 increase in CO_2 taxes (equivalent to the average increase between 2002 and 2018 for countries that have a CO_2 tax or about a unitary increase in the underlying CO_2 tax index) raises investment by 12% for firms with green innovativeness one standard deviation above the mean. It decreases investment by 11% for firms with emission intensity one standard deviation above the mean. These effects are economically significant also for technology-push policies. Increasing technology support policy in line with the 2002-2018 increase is associated with a 5.2% increase in investment for top green innovators and a 2.7% decline in investment for top emitters.

Overall, these results suggest that the investors operating in the syndicated loan market assess transition risks and therefore take mitigation policies and firms' environmental performances into account in their capital allocation decisions. However, the results also point to the need to reduce informational asymmetries around firms' environmental performance, as ESG ratings and their Environmental pillar score do not provide sufficient information to assess transition risks. Progress in this area is especially important for less sophisticated and smaller investors. The ability to make financial decisions based on a thorough assessment of transition risks can be a prerogative of larger and sophisticated investors (as those considered in this analysis) because of the large information requirement and analytical capacity needed. Less sophisticated or passive investors may not have access to detailed information on firms' environmental performance metrics and the capacity to analyse them.

Improving the available information of firms' environmental performance metrics is important to enable investors to allocate capital in line with emission reduction targets. Adopting mandatory emission reporting and extending the scope of existing requirements can reduce the information gap. The harmonisation of emission accounting standards and the improvement in data quality can be further encouraged. In addition, improving the transparency and credibility of ESG rating methodologies or other similar metrics is key to guide the financial assessment of climate policies on firms and firms' transition risks (OECD, 2022[11]) and contribute to the stability of the financial system (Giglio, Kelly and Stroebel, 2020[12]; NGFS, 2022[13]). Going beyond ESG scores, it is crucial to increase the availability and reliability of financially material environmental information, including firms' climate risk assessments and transition plans, and ensure their quality through third-party verification.

The paper is structured as follows. Section 2 discusses how this paper contributes to the previous literature; section 3 provides details on syndicated loans and presents the construction of the data set; section 4 describes the empirical approach and presents the estimation results; section 5 estimates the effect of mitigation policies on investments through the cost of capital; section 6 discusses the policy options to improve climate finance and to reduce environmental information asymmetries for different kinds of investors.

2. Literature

Several studies have focused on financial markets, environmental performance and climate-change mitigation policies. One branch of the literature analyses how financial markets incorporate information on firms' environmental performance by adjusting required returns and, in turn, the cost of capital. Investors require a premium when investing in firms with worse environmental performance, as evidenced by both stock returns (Chava, 2014[14]; Bolton and Kacperczyk, 2021[15]) and loan spreads (Kleimeier and Viehs, 2016[16]; Ehlers, Packer and de Greiff, 2022[17]). This is the case for several measures of environmental performance, including emissions and emission intensities, fossil fuel reserves (Delis, de Greiff and Ongena, 2019[18]), or green innovation (Dechezleprêtre, Muckley and Neelakantan, 2020[19]).[2] Bolton and

[2] A related, but distinct, strand of the literature investigates the value of disclosing green financial information. Firms that volunteer environmental performance are generally rewarded with lower cost of equity and debt (Dhaliwal et al., 2011[76]; Matsumura, Prakash and Vera-Munoz, 2014[30]; Raimo et al., 2021[77]). Similarly, mandating disclosure of ESG information had a positive effect on firm value and investment, although more polluting or financial constrained firms were relatively penalised (Ioannou and Serafeim, 2019[75]; Grewal, Riedl and Serafeim, 2019[74]; Allmann and Won, 2022[73]).

Kacperczyk (2020[20]) interpret the higher cost of capital these firms face as evidence that investors price-in transition risk.

Other studies show that environmental performance affects investment decisions, but they are inconclusive on the underlying causes. If climate policy is stringent or investors expect it to strengthen over time, policy-exposed firms may face a higher transition risk, as stricter policies and regulation will impact their business model. However, it is also possible that environmental sustainability concerns enter the objective of investors beyond risk-return considerations. Financial intermediaries with environmental commitments (such as 'green banks') have a stronger preference for green loans (Degryse et al., 2020[21]; Kacperczyk and Peydro, 2021[22]). Degryse et al. (2022[23]) offer an additional explanation through banks portfolio management: banks might be discouraged in investing in new green technologies if these undermine the legacy position held in polluting firms.

Studying variations in climate policy stringency is a promising approach to understand the underlining cause of differentiated cost of capital for greener firms and to isolate transition risk. Fard et al. (2020[24]) provide evidence of loan spreads changing with environmental regulation, although they do not differentiate firms by environmental performance. Several papers compare loan conditions pre- and post-Paris Agreement (2015) showing that the cost of capital for carbon-intensive firms increased relative to less carbon intensive firms (Delis, de Greiff and Ongena, 2019[18]; Seltzer, Starks and Zhu, 2022[25]; Mésonnier, 2021[26]). Related work on stock market performance of firms shows that following the Paris Agreement greener firms benefited from higher returns (Kruse, Mohnen and Sato, 2020[27]).

This paper contributes to this literature in several ways. First, it relies on country-by-year continuous variation in climate policy stringency interacted with firm-level performance measures to isolate the effect of mitigation policies on loan spreads. In contrast with event studies, looking at before and after of the implementation of one individual policy (or set of policies), this provides deeper insights on the role of mitigation policies. For example, the Paris Agreement was preceded and followed by climate policies varying in nature and stringency across countries and time. This paper instead employs an internationally comparable measure of environmental policy stringency to study the effect of these policies on loans, rather than idiosyncratic event. Second, the paper differentiates between market-pull policies, such as emission pricing, and technology-push policies, such as technology support subsidies. Third, it considers together two environmental performance metrics (green innovativeness and emission intensity) within the same framework.

The paper also contributes to the literature on the impact of Environmental, Social and Governance (ESG) scores on investments decisions (Houston and Shan, 2022[28]). Unlike financial reporting, ESG reporting does not rely on well-defined quantitative metrics and is therefore less standardized. This makes it harder to assess and compare different ESG scores, which may be a poor proxy of environmental performances (Bingler et al., 2022[29]). Low correlation and inconsistencies of firms' ESG score across providers (Boffo and Patalano, 2020[6]; OECD, 2022[7]; Berg, Kölbel and Rigobon, 2022[9]) raise questions on the quality and their relevance to investors (OECD, 2022[7]).[3] Several papers suggest that ESG ratings affect investment decisions and that firms that do not disclose them face a penalty in terms of higher financing costs (Matsumura, Prakash and Vera-Munoz, 2014[30]; Pástor, Stambaugh and Taylor, 2022[31]). Bingler (2022[29]) offer a different view, suggesting that ESG disclosure is mostly "cheap-talk" and is associated with cherry-picked disclosure of information that is not relevant to the firm's exposure to climate change risks and policies. Giglio et al. (2023[10]) argue that investors holding ESG assets do that principally because return-driven or because of ethical reasons and less because they hedge climate risk.

This paper contributes to this strand of the literature showing that banks operating in the syndicated loans markets respond to ESG scoring and disclosure, but ESG does not mediate the effect of the actual

[3] This relates to the literature on bank financing and intangibles, which has shown that as banks find it difficult to price intangibles (Demmou and Franco, 2021[90]).

environmental performance metrics on loans' interest rate. This result is consistent with sophisticated investors taking into account the possible effect of mitigation polices on firms based on their environmental performances.

Finally, the paper also relates to a strand of literature focusing on the role of finance in providing the resources to the net-zero transition. There is a large literature investigating how firms responds to mitigation policies by investing to reduce emissions or to adapt to changing business conditions.[4] This literature is mostly concerned with studying the aggregate investment effects of introducing a new environmental policy. In contrast, this paper focuses exclusively on the cost of capital channel, helping to quantify the role of the financial sector in allocating capital in response to mitigation policies. Despite its importance, evidence on this channel is scant. Two related papers are Cohn and Deryugina (2018[32]) and Goetz (2019[33]), studying how two specific shocks to access to credit in the United States affected investment in technology to avert environmental spills and abate emissions. Instead, this paper produces more general back-of-the-envelope calculations on the effect of mitigation policies on investment through the cost-of-capital channel, differentiating between green and brown firms.

3. Data sources and sample construction

Syndicated loans: background and data

Syndicated loans involve several lenders. Lenders can be banks or non-bank financial institutions, such as finance companies and institutional investors. Loan syndication is a major contributor of debt finance, particularly of large-scale debt used, for instance, in project finance, infrastructure investment and leverage buyouts. It is an alternative source of finance to bilateral loans, corporate bonds and private debt placement. Because of their size, syndicated loans are a prerogative of sophisticated investors and large companies. Their main advantage is to spread the risk of borrower default across multiple lenders in addition to addressing a number of typical issues arising in lending markets, such as market matching problems, information asymmetry, and moral hazard (European Commission, 2019[34]).

In syndicated loans, one or more lenders (the lead arranger and its co-agents) take on information collection and monitoring responsibilities and negotiate the contract terms (Sufi, 2007[35]). As in other areas of the lending market, the monitoring of borrowers plays an important role in the syndicated loan market, with banks making considerable and costly efforts to overcome the information asymmetry between the borrower and lenders. Gustafson, Ivanov and Meisenzahl (2021[36]) measure how banks monitor borrowers receiving syndicated loans. They show that for twenty percent of loans banks engage in costly active monitoring, meaning that the lender or a third party regularly visits the borrower. Fifty percent of lenders require borrowers to provide information at least on a monthly basis, and 5% of lenders require this information daily. The monitoring activity of banks can significantly affect lending conditions, with more active monitoring being associated with significantly lower margins as the monitoring reduces asymmetric information. Banks issuing syndicated loans are thus sophisticated investors expending significant monitoring efforts for investment decisions, which may be different from other investors without the ability or capacity for extensive monitoring.

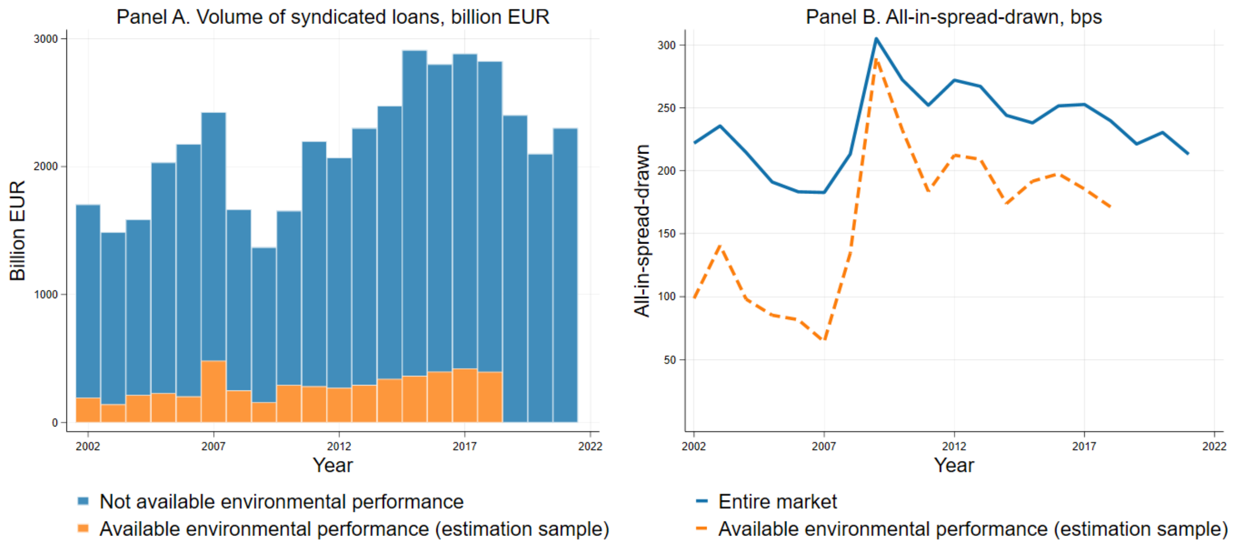
Syndicated loans are a large and increasingly important source of corporate finance. Over the past two decades, the volume of syndicated loans increased to about EUR 2.3 trillion in 2021 (Figure 1, panel A). For comparison, new corporate bonds averaged to about USD 1.8 trillion (around EUR 1.4 trillion) a year between 2008 and 2019 (Çelik, Demirtaş and Isaksson, 2020[37]). The syndicated loan volumes increased markedly during the second half of the 2000s to above EUR 2 trillion but then declined by more than a third

[4] Examples include OECD (2021[71]), D'Arcangelo and Galeotti (2022[83]) and Dechezleprêtre, Nachtigall and Venmans (2023[84]) to name a few.

in the wake of Global Financial Crisis (GFC). Afterwards, they recovered gradually to reach their current level.

Syndicated loans can play an important role in the low-carbon transition by providing the financing for low-carbon energy infrastructure. For example, the Dogger Bank wind farm, one of the world's largest offshore windfarms has been financed through a USD 5.5 billion syndicated loan in 2020, financed by a group of lenders comprising of 31 banks and credit agencies. When completed, it is estimated to supply 5% of the United Kingdom power demand and provide electricity for six million homes. Other examples include the Northvolt battery factories built in Sweden, financed via a USD 1.6 billion syndicated loan, the Canberra Light Rail project, an electrified urban rail project, was financed through a USD 280 billion syndicated loan and the 75MW Ishinomaki Hibarino Biomass Power Generation Project in Japan has been financed through a syndicated loan.[5]

Figure 1. Cost of debit and new syndicated loan volume in the syndicated loan market and estimation sample



Note: Panel A shows the total tranche value of loans (in billion EUR at current prices) for the entire syndicated loan market (blue + orange bars) and for the firms with available environmental performance employed for estimation (orange bars). Panel B shows the average all-in-spread-drawn (in bps) in the entire syndicated loan market (blue solid line) and in the sub-sample of firms with available environmental performance metrics employed for estimation (dashed orange line). The all-in-spread drawn describes the amount the borrower pays in basis points over LIBOR for each dollar drawn down; it adds the spread of the loan with any annual (or facility) fee paid to the bank group.
Source: Authors calculations based on LPC Loan Connector Dealscan database.

Data on syndicated loans is sourced from the Refinitiv LPC Loan Connector Dealscan database (Dealscan hereafter), which provides comprehensive loan-deal information at a global level. Dealscan contains detailed information about loan terms (e.g. loan amount, fees and spreads, maturity, loan type and purpose, and other features of the contracts). Refinitiv LPC combines different sources to produce this dataset, including information submitted directly by lenders, regulatory filings of borrowers, and financial news. Influential rankings based on the market share of lenders ("league tables") provide strong incentives to banks to report their loans to Refinitiv LPC and attract clients (Cohen, Gurun and Nguyen, 2020[38]; Ivashina, 2009[39]). For the analysis below, only the origination of new loans is considered while loan

[5] Further information on the deal closings for the examples of syndicated loans is available via the following articles: Dogger Bank wind farm (Dogger Bank, 2020[86]), Northvolt battery plant (NIB, 2020[89]), the Canberra Light Rail project (ANZ, 2020[87]) and the Ishinomaki Hibarino Biomass Power Generation Project (Renova, 2020[88]).

extensions are excluded. An important benefit of using data on syndicated loans is that it provides precise information on the loan spreads and fees. Estimating the cost of financing from equity, another source of financing for firms, requires stronger assumptions and estimates can differ substantially depending on the chosen estimation method (Frank and Shen, 2016[40]).

The average spread to the benchmark rate (LIBOR) rose during the GFC by more than 100 basis points (from 183 in 2007 to about 305 in 2009) and it has hovered at a higher level since (Figure 1, panel B). Reasons of this persistent increase in the syndicated loan spreads following the GFC include responses to Basel III regulation (Ma, 2016[41]), increased market power in lending (Gao, Kong and Thia, 2022[42]), and changes in lenders' risk aversion (Lee, Liu and Stebunovs, 2017[43]).

The syndicated loan market is most developed in the United States (accounting for 45% of total loan amount), followed by Japan (12%), United Kingdom (4%), France, Canada, Germany and Australia each at 3% (Figure A.1, panel A). Firms across a large range of sectors use syndicated loans, the largest ones being manufacturing, financial services and utilities (Figure A.1, panel B).[6]

Sample construction

The dataset employed for the empirical analysis consists of micro-data combining loan-, firm-, sector- and country-level information. Loan-level information on syndicated loans from Dealscan is merged with several other data sources (Annex A). The environmental performance metrics considered are firms' green innovation and emission intensity. Green innovation is measured by the stock of patents in mitigation technologies issued by the firm, sourced from PATSTAT. Firm-level emissions come from Refinitiv EIKON and are measured in CO_2 equivalents.[7] These emissions include both direct emissions from company-owned resources (Scope 1) and indirect emissions from the generation of purchased energy (Scope 2). Country-level data on policy comes from the OECD Environmental Policy Stringency (EPS) index and its sub-components (Botta and Koźluk, 2014[44]; Kruse et al., 2022[45]). Annex A contains additional details about each source.

The panel dataset for the regression analysis consists of just above 6 000 observations (loans) across nearly 1 400 firms for the years 2002-2018, distributed in 33 countries and 71 sectors. The regression sample is unbalanced, as some firms do not receive a loan each year (90% of firms receive less than 10 loans over the period), while a few have more than one. The summary statistics of the main variables in the estimated sample are reported in Table A.1 in Annex A.

Firms distribute across countries similarly in the universe and estimation samples with the most remarkable differences being Japan, a large market for syndicated loans where environmental disclosure is not common, and other countries, including Hong Kong and Singapore, for which EPS data is unavailable. Firms from the United States represent a large share of syndicated loans (45% of the universe and 69% and estimation sample), although results are not driven by these firms, as discussed below. The distribution of firms across sectors is also similar in our estimation sample compared the universe of syndicated loans.

The availability of data on firms' emission intensity (from Refinitiv's EIKON database) that are included in the merged Dealscan-Orbis sample explains the limited number of observations in the estimation sample compared with the raw data. The estimation sample covers about 10% of the total loan value of the syndicated loan market. The size of the estimation sample is compared with the full sample in Figure 1.

[6] To compare the distribution of firms between the estimation sample and the raw data, the Refinitiv Major Industry Group classification is used, which is available in the Dealscan database. Other sectoral classifications are not available for the raw loan-level data.

[7] We use the variable ENERDP123 in the Refinitiv database, which is used widely in the literature to measure firms CO_2 equivalent emissions (Reghezza et al., 2021[78]; Hege, Pouget and Zhang, 2022[72]; Homroy, 2023[85]).

Table 1. Data sources

Type of data	Datasets
Deal-level data on the universe of syndicated loans • All in spread drawn, deal amount, maturity, etc.	LPC Loan Connector Dealscan
Firm-level financial data • Assets, return on assets, debt etc.	BvD Orbis
Country-level environmental- policy indicators	OECD EPS indicators
Firm-level exposure variables • Green innovativeness • Emission intensity • ESG scores (ESG and Environmental Pillar)	Green innovativeness: Climate-change mitigation patents (PATSTAT Y02 classification) ESG scores, CO_2 emission (Refinitiv EIKON)

Source: Authors.

Data incompleteness could in principle induce sample selection, making the estimation sample not representative of all the firms receiving engaged in syndicated loans. Indeed, the estimation sample is characterised by larger deals (by tranche and number of lenders) and by a larger share of covenants and performance pricing provisions, when compared to a sample including all merged Orbis and Dealscan data. Firms have higher returns on assets and general patenting activity (Table A.2 in Annex A). Reassuringly three main variables of interest: the all-in-spread-drawn, emission intensities and mitigation patent stock are not very different.

Adding some of these observable variables as controls helps assuaging concerns about sample selection, but it admittedly cannot account for potential sample selection based on unobservables. For example, disclosure of environmental performance is voluntary at least for some firms. This sample selection could affect the results if voluntary disclosure and environmental performance correlate. For example, if the available data is limited to those firms that have the highest benefit from disclosing environmental performance. This selection on unobservable cannot be credibly addressed with the available data and empirical setting and thus results should be interpreted with care when generalised to the full population of firms.

4. The effect of mitigation policies on cost of debt by firm greenness

Empirical strategy

The empirical model relates loan spreads to firms' environmental performance and its interaction with mitigation policies. The main hypothesis tested is whether or not mitigation policies affect the green premium (i.e. the loan spread of brown firms minus that of green firms, everything else equal). The analysis differentiates between technology-push and market-pull policies (Jaffe, Newell and Stavins, 2005[46]). Technology-push policies encourage for the development and adoption of green technologies and practices. Market-pull policies increase the demand for these technologies. Moreover, the analysis differentiates between two measures of environmental performance: emission intensity and green innovation. This yields four interactions between policies and firms' environmental performance metric, as shown in Table 2.

First, market-pull policies (Table 2, column 1) are expected to increase the green premium. Market-pull policies can reduce spreads for firms that are green innovators. Green innovators could deploy their innovations to reduce their emissions, thus reducing due carbon taxes. Moreover, green innovators might benefit from the rise in the demand for clean technology that higher carbon prices engender. Thus, carbon taxes could reduce loan spreads for green innovators more than for firms that little or no green innovation (panel A). A carbon tax raises costs for high emitting firms. These higher costs worsen the financial and economic prospects of emitting firms, raising the risks of banks' lending to them. If these risks are priced in, they should be reflected in lower loan spreads for green firms relative to brown firms. These costs and risks can be expected to rise with the firm's emission intensity and the carbon tax (panel C).

Table 2. Expected effects of mitigation policy by firms' degree of green innovation and emission intensity

Technology-push versus market pull factors and firms' environmental performance metrics

	Policies	
Firm environmental performance	**CO_2 tax** *Market-pull effect* (1)	**Green technology support policy** *Technology-push effect* (2)
Innovation in green technologies	(Panel A) Ability to innovate to abate CO_2 or sell abatement technology is priced-in Expected sign of effect on loan spreads (-); the green premium increases	(Panel B) Ability to capitalize on technology support policies is priced-in Expected sign of effect on loan spreads (-); the green premium increases
Emission intensity	(Panel C) Additional cost from CO_2 tax is priced-in Expected sign of effect on loan spreads (+); the green premium increases	(Panel D) Opportunity cost and ability to capitalise on technology support policies is priced-in Expected sign of effect on loan spreads (+/-); the green premium may increase or decrease

Note: The table describes the two main hypotheses tested in the paper, the technology-push and the market-pull effects. It also shows the expected signs of the coefficient for the respective interaction of the policy variable with the firm characteristic.
Source: Authors.

Second, technology-push policies (Table 2, column 2) can also be expected to increase the green premium. Green technology support policies may reduce the spread for green innovators as banks can price into loans their increased opportunities to benefit from technology support policies (panel B). The effect of technology support policies on emission intensive firms is instead more ambiguous. The policy could increase the cost of debt for emissions intensive firms, reflecting the opportunity cost of not benefitting from subsidies (for example wind or solar feed-in tariffs) or other technology support policies. Indeed, emission intensive firms may not be eligible or have the expertise to reap the benefits from technology support policies, for example because they do not have the knowledge or capacity to use or develop low-carbon technologies eligible for subsidy payments. However, technology support policies could also lower the spread for emission intensive firms if they are seen as an opportunity and financial incentive for such firms to lower their emission intensity (panel D).

To test these hypotheses, we use the following empirical model:

$$AISD_{dfct} = \beta^1 \boldsymbol{E}_{ft} + \beta^2 \boldsymbol{P}_{ct} \times \boldsymbol{E}_{ft} + \beta^3 \boldsymbol{X}_{dft} + \delta_{ct} + \delta_{it} + \varepsilon_{dfct} \qquad (1)$$

where d denotes the loan deal, f the firm, c the country, t the year, and i the industry. The dependent variable, $AISD_{dfct}$, is the all-in-spread-drawn (in logs). It is the loan interest rate spread over LIBOR for each dollar drawn down from the loan, measuring the cost of the syndicated loan (Chava, 2014[14]). $\boldsymbol{E}_{ft}$ denotes the firm-level environmental performance metrics; $\boldsymbol{P}_{ct}$ is the domestic climate mitigation policy indicator.[8] In line with the existing literature (Delis, de Greiff and Ongena, 2019[18]; De Haas and Popov,

[8] The model does not evaluate whether investors assess the exposure to foreign policy stringency. If multinationals systematically relocate production in jurisdictions with lower policy stringency (the 'pollution haven' hypothesis) to

2019[4]), the vector $\boldsymbol{X}_{dft}$ collects both firm level controls (such as log total assets, return-on-assets, debt-to-total-assets), deal-level controls (log tranche amount, tenor or maturity, secured deal, number of lenders, provisions, covenant) and deal-type dummy variables, controlling for the deal seniority, the type (term loan, credit line, other), and one of 28 primary purposes (e.g. acquisition, back-up line of credit, etc.). The deal-level controls also include country of syndication by year dummies, controlling for differences and changes in the rule of law across countries.

We include in the baseline two sets of fixed effects to control for unobservable shocks: δ_{ct} is a vector of country-by-year fixed effects to control for country-specific shocks that may be correlated with both mitigation policy and the loan spread. More generally, country-specific time fixed effects allow us to control for macro-economic shocks at the country-level, for example the effects of increasing globalisation and trade openness. δ_{it} are industry by year fixed effects, controlling for sector-specific shocks, such as global changes in demand for products coming from a particular sector and shifts in technological adoption. In the robustness checks, country-sector-year fixed effects are included to control for country-sector specific shocks, such as country-specific shifts to low-carbon technologies. Finally, ε_{dfct} is an error term assumed independent to the covariates of interest. It is allowed to correlate within firm: while this provides conservative estimates, it is important to allow firm-level dependence of disturbances to take into account unobservables.

The coefficient of interest is β^2, as the main variable of interest is the interaction between policies and firms' environmental performances ($\boldsymbol{P}_{ct} \times \boldsymbol{E}_{ft}$). $\boldsymbol{P}_{ct}$ contains information on mitigation policy stringency, including the OECD Environmental Policy Stringency (EPS) index and its sub-components relating to CO_2 taxes and green technology support. $\boldsymbol{E}_{ft}$ contains information on firm-level environmental performance (i.e., green innovativeness and emission intensity), which is interpreted as the exposure to such policies. These variables vary by firm and year. To compare the relative magnitude of the effects of the main variables of interest $\boldsymbol{E}_{ft}$, we standardize these variables, so that the coefficient can be interpreted as the approximate percentage change in cost of debt associated with one standard deviation in the variables.

An advantage of interacting mitigation policy stringency with firm-level green innovativeness and CO_2 intensity is that it reduces concerns of omitted variable bias in our estimation. Any omitted variable that correlates with the country-level policy variables would only pose a problem if it were also similarly correlated to the firm-specific environmental exposure variables. For example, unobserved managerial quality could correlate with environmental performance, but firms with different managerial quality would not be affected differently, conditional on environmental performance, by changes in mitigation policy. In the robustness checks, we also estimate the model with firm-specific fixed effect and time-invariant environmental performance metrics to account for potential endogeneity.

Baseline results

The estimation starts with a simple specification including only firm-level environmental performance metrics ($\boldsymbol{E}_{ft}$), namely green innovativeness and emission intensity. Further regressions add progressively policy variables and interaction terms to yield the baseline specification as presented in Equation (1).

The specification with no policy variable interaction (Table 3, column1) shows that the environmental performance variables are not significantly different from zero.[9] The coefficients on the control variables

reduce their exposure to domestic policies, then domestic policy might be of limited importance for investors. It is Reassuringly for the analysis, the empirical results below show that this is not the case and that exposure to domestic mitigation policy is taken into account by investors.

[9] This specification without policy interactions raises concerns about the endogeneity of the variable of interest. In particular, firm-level unobservables like managerial quality might determine both the environmental performance and the loan spread. If these unobservables correlate positively with the dependent and independent variable, the bias

show the expected sign. They are also stable across different specifications (columns 2 – 5). Larger, more profitable and more innovative firms (as measured by general patenting) pay a lower cost on their capital, while firms with a high debt-to-asset ratio have a higher spread. Larger tranche amounts and loans with performance pricing provisions are associated with a lower spread. Secured loans, loans with longer tenors, loans with covenants, and loans with a larger number or lenders have higher spreads. [10]

The coefficients on firms' environmental performance variables (green innovativeness and firms' emission intensities) and their interactions with the EPS index are the main parameters of interest in Table 3, column 2. The coefficient of the linear terms should be interpreted as the effect on loan spreads of increasing green innovation or emission intensity by one standard deviation, when EPS is zero (i.e. minimum level of policy environmental policy stringency). A positive significant coefficient for green innovation suggests that, when mitigation policy is absent, green innovators face higher loan spreads. The negative and significant coefficient on the interaction between EPS and green innovativeness means that this effect is reversed when mitigation policy is sufficiently stringent. The next section quantifies the size of this effect. On the contrary, the interaction term between the EPS index and emission intensity is very close to zero and not statistically significant, suggesting that higher emissions intensity is not significantly associated with the loan spread even for high level of EPS.

The bottom rows of the table show the marginal effect on loan spreads of green innovativeness and emission intensity i.e., the overall change in loan spreads for a unitary change in each of these variables. In this specification, the point estimates of these marginal effects are not statistically different from zero. In aggregate, this suggests that firms' environmental performance have no bearing on loan spreads unless mitigation policy is sufficiently strong.

When the EPS index is replaced by the two specific policy variables: carbon taxes (to capture market-pull effects) and clean technology support measures (to capture technology-push effects), the results are consistent with the hypothesis described in Table 2 that the syndicated loan market is a conduit for technology-push and market-pull effects (Table 3, columns 3 and 4).

Carbon taxes are associated with a higher loans' spread for emission intensive firms and lower spreads for green innovators, as shown by the significant interaction terms and consistently with Table 2, panel C (Table 3, column 3). This is suggestive that sophisticated investors, such as banks operating in syndicated loan markets, can appraise the potential impact of market-pull policies on firms based on their level of emission intensity and green innovation.

Market-pull policy affect loan spreads through the syndicated loan markets (Table 3, column 4). The statistically significant negative coefficient on the interaction of technology support and green innovation suggests that green innovators face lower loan spreads when technology support is high, as banks might assess that these firms can capitalise on such support polices (Table 2, panel B). Similarly, the effect of the green technology support policies for emission intensive firms is positive, although only marginally significant.

The baseline estimate, which will be used later, considers the two policy dimensions (technology-push and market-pull factors) at the same time (Table 3, column 5). The estimates reflect those in columns 3 and 4.

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should be away from zero. Interestingly, the estimated effect is instead precisely estimated around zero. This concern is assuaged in the other specifications because other potential omitted variables should be equally correlated with the mitigation policy variable.

[10] The positive correlation between secured loans and the spread is discussed in previous research, showing that secured loans tend to be riskier loans and tend to be issued by younger firms with lower cash flows, explaining the positive correlation (Erel et al., 2012[79]; Lim, Minton and Weisbach, 2014[80]). Similarly, many lenders on a deal could be caused by the necessity to share a higher risk among many participants. The positive correlation between loan spread and number of lenders may also be explained by higher loan fees that may be associated with more lenders.

More generous technology support policies lower the spread for green innovating firms and increase the spread for emission intensive firms, although the latter result is only marginally significant. Higher carbon taxes increase the spread for emission intensive firms and lower it for green innovating firms.

The marginal effects of the environmental performance variables, reported at the bottom of the table along their p-values (Table 3), provide additional insights. In particular, the average marginal effect masks heterogeneity across firms depending on the level of countries' policy stringency. The marginal effect of green innovativeness is very close to zero across specifications. This means that, given the policy stringency level in the countries and period covered by the dataset, green innovativeness has on average no effect on spreads. In contrast, the marginal effect of emission intensity is positive and different from zero at a 5% confidence level, at least in the richer specifications (columns 3 and 5), though it is quantitatively small.[11] This latter finding is consistent with previous papers reporting small or no carbon premia associated with emission intensity (Bolton and Kacperczyk, 2021[15]). More stringent policy across countries would further induce banks operating in the syndicated loan markets to discriminate between them, resulting in larger marginal effects.

The difference in the average marginal effects of green innovation and emission intensity could be explained as follow. Given the average mitigation policy stringency, in the countries and period covered in this study, firms' green innovation is still too difficult to assess for banks to offer a green premium to green-innovating firms. On the contrary, emission intensity of firms and the ease with which banks can observe and assess this information allows them to price in higher transition risks when offering loans to high emission firms, given the average mitigation policy stringency in the sample.

The results in this section are generally robust to alternative specifications (presented in Annex B). First, firm-fixed effects control for unobservable time-invariant characteristics of the firm, such as management quality, which could invalidate the identification strategy. Results are largely robust to including firm-fixed effects, although the interpretation slightly changes as effects are now related to departures from firm-level averages (within-firm effects, Table B.1 in Annex B). A second robustness check consists in using a time-invariant (within-period average) measure of policy exposure to account for the possibility that cheaper access to credit may encourage firms to invest in green innovativeness or emission abatement, potentially introducing reverse causality in the estimation.

Results are also robust to including a richer fixed effect structure (industry × year × country), using value added to compute emission intensity instead of total assets, and including energy prices as additional control (Table B.2 in Annex B). One additional robustness check replicates the analysis without the firms from the United States (which make up around two thirds of the sample) yielding similar quantitative results (Table B.2 in Annex B). Finally, results are robust to alternative transformations of the green innovativeness variable (i.e. number of patents relating to mitigation technologies), including the use of alternative constants and of the invers hyperbolic sine transformation, to avoid the problem of missing values in case of zero patents (Table B.3 in Annex B).

[11] One standard deviation above the mean emission intensity is associated with -4% in loan spreads. For the median deal (137bps), this is equivalent to -5bps.

Table 3. The effect of mitigation policy on syndicated loans' spread

Dep. Var.: (log) All-in-spread-drawn	No policy variable	EPS	CO_2 tax	Tech. support	Tech. support & CO_2 tax
	(1)	(2)	(3)	(4)	(5)
Green innovativeness	0.001	0.162***	0.006	0.160***	0.136***
	(0.024)	(0.063)	(0.024)	(0.047)	(0.047)
Green innovativeness × EPS		-0.067***			
		(0.024)			
Green innovativeness × Tech. support				-0.073***	-0.061***
				(0.019)	(0.019)
Green innovativeness × Carbon tax			-0.176***		-0.117***
			(0.050)		(0.040)
Emission intensity	0.021	0.033	0.017	-0.030	-0.039
	(0.017)	(0.054)	(0.017)	(0.033)	(0.033)
Emission intensity × EPS		-0.006			
		(0.022)			
Emission intensity × Tech. support				0.028*	0.031**
				(0.015)	(0.016)
Emission intensity × Carbon tax			0.131***		0.107***
			(0.041)		(0.039)
(Log) Tranche amount	-0.043***	-0.043***	-0.043***	-0.043***	-0.043***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Tenor or maturity	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Secured	0.406***	0.405***	0.407***	0.404***	0.405***
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Number of lenders	0.004**	0.003**	0.003**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Performance pricing provisions	-0.063**	-0.062**	-0.059**	-0.063**	-0.060**
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Presence of covenants	0.078***	0.080***	0.075***	0.079***	0.077***
	(0.027)	(0.027)	(0.027)	(0.026)	(0.026)
(Log) Total Assets	-0.100***	-0.101***	-0.101***	-0.103***	-0.103***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
ROA	-1.329***	-1.302***	-1.317***	-1.332***	-1.323***
	(0.165)	(0.165)	(0.165)	(0.165)	(0.165)
Debt to Asset	0.462***	0.454***	0.461***	0.455***	0.456***
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
General patenting	-0.098***	-0.100***	-0.095***	-0.102***	-0.100***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Observations	6029	6029	6029	6029	6029
Number of firms	1384	1384	1384	1384	1384
Degrees of freedom lost due to f.e.	1101	1101	1101	1101	1101
Green innovativeness marginal effect	0.001	0.007	-0.028	0.018	-0.004
p-value	0.962	0.783	0.274	0.433	0.860
Emission intensity marginal effect	0.021	0.020	0.042**	0.024	0.042**
p-value	0.215	0.239	0.018	0.153	0.017

Note: *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. The environmental performance variables (emission intensity and green innovativeness) are standardized to have mean 0 and standard deviation 1. For these variables, the coefficient estimated can be interpreted as the % change in AISD corresponding to 1 standard deviation change in the independent variable. All specifications contain country×year, industry×year and deal-type fixed effects. The marginal effects reported are the average (across observations) predicted change in the dependent variable to a unit change in the independent variable, keeping the other variables at the observational value. Standard errors clustered at the firm level in parenthesis.
Source: Authors.

Magnitude of the effects

The effects in Table 3 are economically meaningful. As regards green innovativeness as mediated by EPS (column 2), a unit increase in the EPS is associated with a 7% decline in the cost of debt for firms with a green innovativeness one standard deviation above the mean (or the 87th percentile of the green innovativeness distribution) and with average emission intensity. For the median deal (spread: 137bps, size: EUR 366 million), this is equivalent to a decline in 9bps or EUR 0.3 million in annual interests.

Figure 2 shows the effect of carbon taxes and technology support policies using the baseline specification in column 5 of Table 3. Firms are divided into two groups: top 25% and bottom 25% based on the in-sample distributions of the emission intensity and green innovativeness measures. The other loan and firm-level controls are fixed at their mean.[12] For ease of interpretation, a unitary increase in the two policy sub-indices is about equal to the in-sample average change between 2002 and 2018, although some countries have increased their policy stringency more than others. The figures show the predicted values of the loan's spread (re-scaled to 100 for the greenest firms in absence of policy).

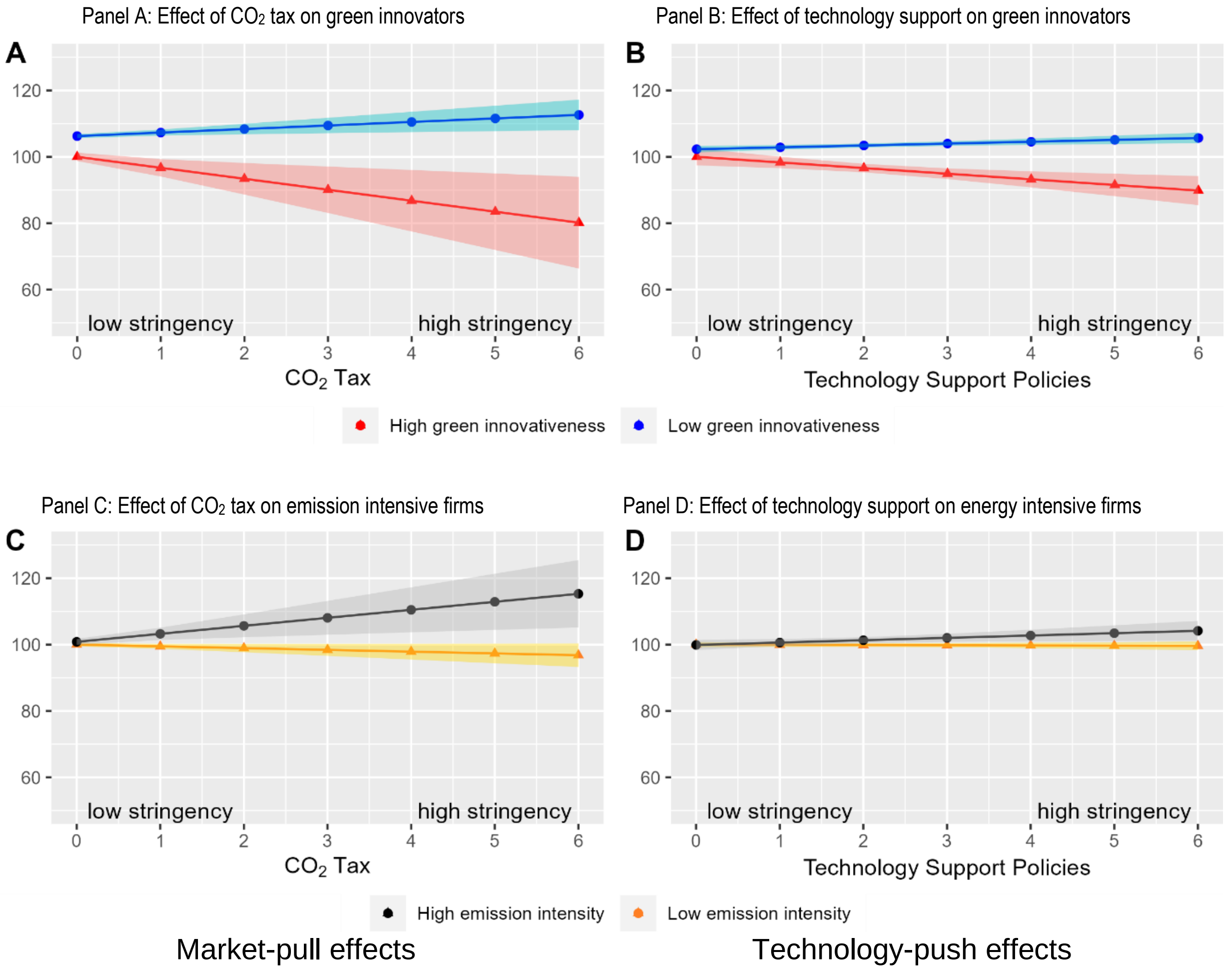
Overall, the results in Figure 2 indicate that green innovators enjoy lower loan spreads due to both market-pull and technology-push policies, while emission intensive firms face higher loan spreads due to carbon taxes but not technology-push policies:

- The predicted loans' spread for the most green-innovative firms is almost 20% lower with a high carbon tax (score of six, equivalent to a carbon price above EUR 50/t CO_2) than with no carbon tax (Figure 2, panel A). Even for relatively low carbon prices, i.e. from an indicator score of two onwards (equivalent to a carbon price above EUR 10/t CO_2), the loan spread is significantly lower for firms with the highest green innovation level. For firms in the bottom 25% of the green innovativeness distribution, the loan spread increases by about 8% as the carbon tax increases from no carbon tax to a carbon tax score of six. With high carbon prices (score of six on the CO_2 tax sub-index), the difference in the predicted spread between top and bottom green innovators is about 30%. For the median deal (spread: 137bps, size: EUR 366 million) this difference is equal to 41 bps or EUR 1.5 million of annual interest payments.
- Regarding technology support policies, at the highest level of the technology support sub-index, top green innovators benefit from a 15% lower spread than the bottom green innovators. The average change in the technology support policy stringency over the sample period is equal to a one unit increase in the index.
- The predicted effects on loan spreads for firms with a high and low emission intensity at different levels of carbon tax are shown in panel C. Higher carbon pricing is associated with a significantly higher spread for the most emission intensive firms (top 25% of the emission intensity distribution). For these firms, increasing the carbon tax score from zero to six is associated with a 15% higher spread. The effect on firms with a low emission intensity is markedly lower with the spread declining by only 6% (and statistically only weakly significant). Together with the results of CO_2 taxes on green innovators (panel A), this shows how market-pull policies can have significant effects on the syndicated loans' spreads, lowering the cost of debt for firms innovating in green technologies and increasing the cost for the most emission intensive firms.

[12] This helps to isolate the effect of policies for comparisons keeping constant all the other variables. Because green innovativeness correlates negatively with emission intensity, the two effects reinforce each other. For example, a firm that is in the top 25% of firms by green innovativeness is more likely to be in the bottom 25% of emission intensive firms. For that firms, the policy effects discussed here should be summed.

Figure 2. Effects of carbon taxes and technology support policies on loans' spreads

Loan spreads (index = 100 for top 25% clean patenting firms, top 25% emission intensive firms, zero policy stringency)



Note: The figure shows the linear predicted effects of the policy interactions from Equation 1, based on the baseline regression results shown in Table 3, column 5. The effects are re-scaled to 100 for the green firm (high green patenting share or low emission intensity, respectively) at zero policy stringency. All other variables are fixed at their mean. Confidence bands at 95% level are calculated with the delta method and reflect the estimation uncertainty on $\hat{\beta}^1$ (coefficient of the environmental performance variable) and $\hat{\beta}^2$ (coefficient of the interaction term between the environmental performance and policy variables). As usual in these cases, the prediction is mechanically more imprecise for higher levels of the changing variable in the interaction term (the policy variable in this case). **Panel A and B** show the linear predicted effects for firms among the top 25% and the bottom 25% of green innovators for different levels of the CO_2 tax and technology support. **Panel C and D** show the linear predicted effects for higher emission intensive firms (top 25%) and low emission intensive firms (bottom 25%) at different levels of a CO_2 tax and technology support.
Source: Authors.

- The effect of green technology support policies on firms with different emission intensity is small, although statistically significant, with small positive effects only on the spread for the most emission intensive firms (panel D). Comparing these results with those in Panel B indicates that the effect of technology-push policies is larger when discriminating among firms based on their green innovativeness (panel B) than emission intensity (Panel D). This is to be expected, as technology support do not aim at penalising high-emission firms.

These results lead to the following policy insights. First, strengthening mitigation policies can be an effective way to reduce the cost of debt of green innovators. Both market-pull and technology-push policies have large positive effects on green innovators, reducing their loan spreads substantially (Figure 2, panel

A and B). These policies are also associated with a moderate increase in the loans' spread of firms that do not engage or engage only to a limited extent in green innovation. Second, raising carbon taxes increases the cost of debt of highly emitting firms. Higher carbon taxes penalise firms with high emissions by raising their tax burden and banks operating in the syndicated loan markets respond to this by increasing loan spreads.

Increasing the carbon tax index will have widely different effects across firms (within and between sectors), depending on firms' environmental performance. The majority of firms in each sector will experience an increase in loan spreads following a one unit increase in the carbon tax index (around 10 EUR/tCO_2) (Figure 3).[13] The median predicted change in loan spreads (the dot in Figure 3) is above zero in each sector. Some sectors, such as Energy and Water, Transport, and Fossil fuel extraction, feature a large share of firms with low environmental performance. However, even in these industries, there are firms with high environmental performance, which could benefit from higher carbon taxes though lower loan spreads. Firms in the Manufacturing sector show stark heterogeneity in environmental performance and thus in the predicted change in loan spreads. Most firms are predicted to experience an increase in loan spreads (as the median change, i.e. the dot, is above zero), but a significant share of firms in this sector have good environmental performance and could enjoy lower loan spreads due to higher carbon taxes.

Overall, these results suggest that sophisticated investors, such as banks participating in syndicated loan markets, are forward-looking and price-in transition risk. Green innovation captures firms' future exposure to more stringent mitigation policies (in addition to exposure to existing policies), as green technologies will be key to reducing emissions and keeping abatement costs low. That green innovation is an important mediating factor of the effect of mitigation policies on loan spreads point to the ability of sophisticated investors, such as banks operating in the syndicated loan market, to incorporate expectations on future effects of current policies and future policy changes in their decision making. Banks issuing syndicated loans make considerable efforts to monitor corporate borrowers, reflecting large loan volumes and their associated risks (Gustafson, Ivanov and Meisenzahl, 2021[36]). Detailed monitoring of corporate borrowers – including site visits, and regular information sharing – can enable large banks to effectively monitor firms' actual environmental performance (as measured by carbon emissions and green innovativeness) and their exposure to environmental policies.

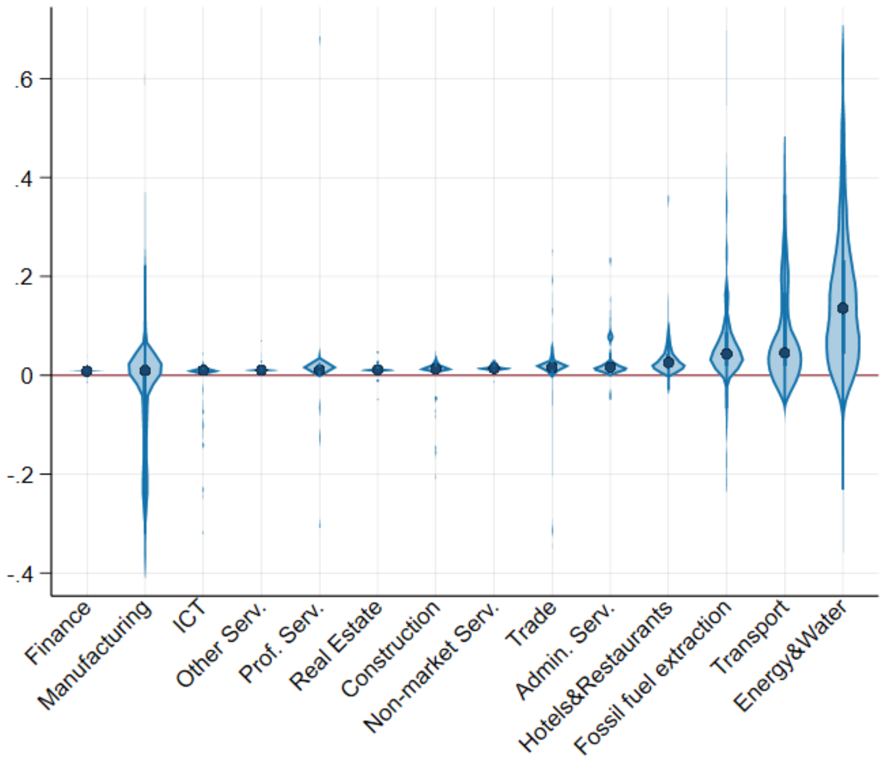
[13] The deal-level predicted percentage change in loan spread associated with an increase in the carbon tax index is calculated as $\widehat{\Delta}_{\%} = \left(\exp\left(\widehat{AISD}_{dfct}(CO2_{ct}+1)\right) - \exp\left(\widehat{AISD}_{dfct}(CO2_{ct})\right)\right) / \exp\left(\widehat{AISD}_{dfct}(CO2_{ct})\right)$

where $CO2_{ct}$ is the observed value of CO_2 tax and

$$\widehat{AISD}_{dfct}(x) = \hat{\beta}_1^1 EI_{ft} + \hat{\beta}_2^1 Pat_{ft} + \hat{\beta}_1^2\left(x \times EI_{ft}\right) + \hat{\beta}_2^2\left(x \times Pat_{ft}\right) + \hat{\beta}_3^2\left(TS_{ct} \times EI_{ft}\right) + \hat{\beta}_4^2\left(TS_{ct} \times Pat_{ft}\right) + \hat{\beta}^3 \boldsymbol{X}_{dft} + \hat{\delta}_{ct} + \hat{\delta}_{it}$$

Figure 3. Distribution of effects of a carbon tax across firms and industry

Predicted % change on loan spreads



Note: The figure shows the distribution of percent predicted changes in loan spreads (using the baseline regression results shown in Table 3, column 5) from increasing the carbon tax index by one unit (around 10 EUR/tCO_2). The blue dots represent the median predicted change in firms' loan spreads within each industry. Differences across and within industries are driven by the variation in deal- and firm-level characteristics (including environmental performance).
Source: Authors.

The effect of ESG information on loan spreads

Investors are increasingly incorporating environmental, social and governance (ESG) factors into asset allocation and risk decisions. The environmental (i.e. E pillar) score of ESG ratings has gathered increasing attention as investors' concerns about exposure to climate risks intensify. In principle, investors could use reliable E pillar scores as a screening device to easily assess firms' climate transition risks and make investment decisions in light of those risks. In the absence of informative E pillar scores banks and investors would need to expend more efforts and resources in monitoring firms so as to assess firms' transition risks.

However, ESG and E pillar scores capture only imperfectly firm's environmental performance and their exposure to climate and policy-related risks. Firms with an ESG score may devote substantially more financial resources to information disclosure than firms without an ESG score while having similar environmental performances. ESG scores can be unrelated to environmental performance, in terms of emission or green innovativeness, raising questions on the quality and usefulness of the information provided by ESG (OECD, 2022[7]).

This section investigates whether ESG scores (sourced from Refinitiv) alter the impact of environmental performance measures (i.e. firms' green innovativeness and emission intensity) on loans spread with respect to the baseline specification. If the impact of firm's environmental performance metrics on the loan spread is entirely or partially explained by the introduction of the ESG or E-pillar scores, then one could conclude that banks use these scores as a tool to assess firms' environmental performance and transition risks in their loan disbursement decisions. For this to happen, the following three conditions must realise: 1) ESG scores need to correlate with environmental performance; 2) ESG scores need to correlate with spreads; 3) the magnitude on the coefficients of the environmental performance variables needs to decrease (in absolute value) with respect to the baseline specification.

Overall, the results suggest the following. First, firms with higher ESG or E pillar scores are rewarded by the market with lower interest rates. Second, ESG and E pillar variables do not correlate (or correlate weakly) with green innovativeness and emission intensity. Third, mitigation policies do not mediate the effect of ESG scores. Put together these results suggest that ESG information is financially material to investors, but as they may provide little information on a firms' actual environmental performances and their transition risks, they are not useful instruments to price the effect of mitigation policies in loan decisions.

The data suggests that ESG scores weakly correlate with green innovation. The main coefficients from regressing the aggregate ESG score and the E pillar on green innovativeness and emission intensity are reported in Table 4. Contrary to expectations, high emission intensities are associated with higher ESG and E scores (columns 1 and 3). Green innovativeness correlates with higher ESG and E Pillar scores, although this correlation is weak. Overall, green innovativeness and emission intensity explains little of the variation in ESG and E scores, as shown by the low regression R^2. Estimations reported in columns 2 and 4 also include the firm-level controls employed in the baseline regression (Table 3), as well as year by country and year by industry fixed effects. The positive correlation of emission intensity with both ESG scores disappears, while the overall correlation of environmental performance with ESG and E Pillar is even more tenuous.

Table 4. ESG scores relate only weakly with firms' environmental performance

Main regression coefficients

Dep. Var:	ESG		E Pillar	
	(1)	(2)	(3)	(4)
Green innovativeness	0.175***	0.043	0.249***	0.119***
	(0.021)	(0.039)	(0.023)	(0.035)
Emission intensity	0.070***	0.024	0.119***	0.018
	(0.025)	(0.034)	(0.026)	(0.032)
Observations	3083	2878	3080	2875
R2	0.04		0.08	
Firm-level controls		Yes		Yes
Fixed effects		Yes		Yes

Note: An observation is a firm-year. *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. Both dependent and independent variables of interest are standardized to have mean 0 and standard deviation 1. The regression coefficients are approximately equal to the coefficient of variation. Regressions in column (2) and (4) include the following controls: (log) total assets; ROA; debt to asset ratio; general patenting activity, as well as country×year and industry×year fixed effects. For consistency with the main results, these regressions are performed on the same observations of the baseline regressions, keeping one observation by firm-year. Standard errors clustered at the firm level in parenthesis.
Source: Authors.

The effect of ESG scores on the loan spreads is analysed in Table 5. Column 1 reports the baseline estimates (from Table 3, column 5) to facilitate comparison. Two variables (and their interactions) are added to the baseline: an ESG (or E-pillar) disclosure dummy variable (equals to 1 for firms with an ESG (or E-pillar) score and zero otherwise) and the level of the (standardized) ESG (or E-pillar) score. Adding a disclosure dummy has two purposes: 1) capturing the effect of disclosing information about firms' environmental metrics regardless of the actual score; 2) imputing an ESG (or E-pillar) score of zero to firms that do not have one, so as to preserve the baseline dataset and compare results.

Table 5. The effect of ESG scores on the loan spread

Main regression coefficients

Dep. Var.: (log) All-in-spread-drawn	Baseline	General ESG	Environmental Pillar
	(1)	(2)	(3)
Green innovativeness	0.136***	0.157***	0.165***
	(0.047)	(0.047)	(0.048)
Green innovativeness × Tech. support	-0.061***	-0.068***	-0.072***
	(0.019)	(0.020)	(0.020)
Green innovativeness × Carbon tax	-0.117***	-0.117***	-0.116***
	(0.040)	(0.040)	(0.040)
Emission intensity	-0.039	-0.028	-0.030
	(0.033)	(0.034)	(0.033)
Emission intensity × Tech. support	0.031**	0.027*	0.027*
	(0.016)	(0.016)	(0.016)
Emission intensity × Carbon tax	0.107***	0.101**	0.100**
	(0.039)	(0.040)	(0.041)
Discloses ESG (dummy)		-0.078**	-0.088**
		(0.040)	(0.040)
ESG score		-0.134***	-0.152***
		(0.042)	(0.049)
ESG score × Tech. support		0.046**	0.058**
		(0.019)	(0.023)
ESG score × Carbon tax		0.014	0.000
		(0.015)	(0.019)
Green innovativeness marginal effect	-0.004	0.002	0.004
p-value	0.860	0.951	0.869
Emission intensity marginal effect	0.042**	0.042**	0.042**
p-value	0.017	0.017	0.018
ESG marginal effect		-0.042***	-0.039**
p-value		0.006	0.016

Note: *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. The environmental performance variables (emission intensity, green innovativeness and ESG score) are standardized to have mean 0 and standard deviation 1. For these variables, the coefficient estimated can be interpreted as the % change in AISD corresponding to 1 standard deviation change in the independent variable. Each regression includes the following deal-level controls: (log) tranche amount; tenor or maturity; number of lenders; performance pricing provisions; presence of covenants; dummies at the deal level (seniority, loan type, primary purpose); in addition to the following firm-level controls: (log) total assets; return on assets; debt to asset ratio; general patenting activity, and the following fixed effects: 1) firm; 2) country×year; 3) industry×year; 4) year×origination country. Observations: 6029; number of firms: 1384; degrees lost by fixed effects: 1101. The marginal effects reported are the average (across observations) predicted change in the dependent variable to a unit change in the independent variable, keeping the other variables at the observational value. Full table available on request. Standard errors clustered at the firm level in parenthesis.
Source: Authors computations.

Firms that disclose an ESG score (Table 5, column 2) or E pillar (Table 5, column 3) in addition to their green innovativeness and emission intensity face lower syndicated loan spread. Also, among the firms with an ESG or E pillar score, a higher score is associated with a lower spread. The interactions of the ESG or E pillar scores with the policy variables indicate that carbon pricing does not mediate the effect of the ESG or E pillar score on firms' cost of debt of firms. Against expectations, more generous green technology support is associated instead with a higher spread for firms with a better ESG score.

The marginal effects at the bottom of the table are the average predicted change in loans when ESG or E pillar scores increase by one (i.e. one standard deviation), keeping policies at their observational value. Firms with an ESG score one standard deviation above the mean experience a 4% reduction in the loan spread, equal to 5 bps for a median loan. The findings are similar when replacing the ESG score by the E pillar score. Higher ESG scores are associated with lower firms' loan spreads, regardless of mitigation policy. Banks may reward firms with high ESG or E pillar scores with lower loan spreads, irrespective of mitigation policy stringency, because of banks' corporate plans, ESG investing mandates or other factors (i.e. shareholder pressures) pushing them to shift investment and activity towards such firms. In these regards, portfolio management could be targeting ESG or E pillar scores as an 'output', rather than as an input to manage transition risk.

The results also show that adding the ESG or E pillar scores does not significantly alter the impact of the environmental performance variables (i.e. green innovativeness and emission intensity) on loan spread as compared with the baseline regression in column 1. The interactions of the environmental performance variables with the policy variables remain significant and similar to the baseline results. The marginal effect of green innovativeness and emission intensity also remain similar across specifications. Sophisticated investors, such as banks, do not rely exclusively on ESG scores as a proxy for environmental performance in their loan disbursement decisions.

Overall, these findings are consistent with viewing banks operating in the syndicated loan marker as sophisticated investors. They are able to assess firms transition risks based on the level of mitigation policy stringency and firms' actual environmental performance but use ESG scores for other motives than managing borrowers' transition risks. For example, certain banks maintain ESG targets in their portfolio for commercial reasons or they might actively seek investments that have a positive sustainability impact, regardless of price-risk considerations.

5. The effect of mitigation policy on investment by firm greenness

Empirical strategy and estimation

The previous section quantified the effect of mitigation policies on syndicated loan spreads; this section investigates the additional investment that mitigation policies can engender through lower spreads. To quantify this effect, this section estimates the investment elasticity to loan spreads using firm-level data on investments and syndicated loans. The main challenge consists in isolating firms' demand elasticity of investments with respect to cost of debt from supply effects. Higher interest rates decrease firms' demand for debt and increase banks supply. The observed investment and loan spread are the equilibrium outcome of this system of demand and supply. Linear regressions that do not address this endogeneity problem would be biased. Table C.1 in Annex C (Columns 1 and 5) confirms this. In a simple OLS regression of investment (or alternatively investment over capital) on loan spreads, the coefficients of loan spreads are positive, counter-intuitively suggesting that higher interest rates are positively associated with investments (even after controlling for firm-level variables and including fixed effects). [14]

To address the endogeneity problem, this paper adopts an instrumental variable approach. Firms with different debt maturity are affected differently by fluctuations in access to credit, such as those caused by changes in monetary policy interest rates. Investors adapt portfolios maturity in response to changes in interest rates. Moreover, firms with a large share of loans close to expiration and looking for refinancing opportunity might have lower bargaining power when negotiating new loans and are thus more affected by policy interest rates.[15] The exclusion restriction for an instrumental variable requires that it affects investment only through loan spreads i.e., the instrumental variable correlates with spreads but does not correlate directly with investments. The interaction of monetary policy interest rates with the average

[14] In these OLS regression the dependent variables (investment or investment over capital) are in logarithms. Investment over capital is defined as the investment in year *t* divided by the capital in year *t-1* approximated by fixed assets, as in Sorbe and Johansson (2017[67]).

[15] There is a vast literature on heterogeneous response to monetary policy driven by firms' characteristics and particularly maturity. See for example recent work from Jeenas (2019[81]) and Ottonello and Winberry (2020[82]).

duration of syndicated loans provides a valid instrument. Arguably, monetary policy interest rates transmits to investments only through loans spreads.[16] The instrument exogeneity is ensured by the fact that the debt structure is pre-determined with respect to announcements of changes in monetary policy.[17] To reinforce exogeneity of the debt structure to loan spreads, the instrument is constructed using a one-year lagged debt duration so as to reduce the likelihood of firms' adjusting the debt structure in response to announced future changes in monetary policy.

The analysis relies on two instruments: the interaction of the duration of the firm's syndicated loans with the change in monetary policy interest rates and the interaction of the duration with the level of interest rates. Interest rate volatility could affect a loan's interest rate based on the firm's debt duration; for example, firms with short debt duration that are in the process of bargaining refinancing conditions could be more affected by a change in interest rates. Similarly, periods of tight (or loose) monetary policy could affect refinancing conditions based on a firm's debt duration: one possible channel is investors restructuring their portfolios in response to changes in monetary policy. Duration is calculated as the weighted average of the observed maturity for syndicated loans, weighted by tranche amount. As the model is overidentified (two instruments and one endogenous variable) and heteroskedasticity is probably present, the Instrumental Variable-Generalised Method of Moments (IV-GMM) provides a more efficient alternative to a standard two-stage least square.

One limitation of this approach is that omitted variables might exist that correlate both with the loan spreads and the instrument. The cost of other forms of investment financing, such as the cost of other types of debt and the equity returns, are likely to correlate with the instrument and with loans spread. To assuage these concerns, the observed capital and shareholders' funds are included in some specifications below but even including these variables is unlikely to fully control for the cost of all forms of financing. However, a possible approach consists in considering loan spreads as a good proxy for the unobserved average cost of capital. In other words, the average cost of capital is observed through loan spreads up to an error, which is assumed to be independent of the instruments conditional on the observables. This is a potentially strong assumption, for example if the cost of equity and the cost of debt do not correlate, but it provides a more prudent and general interpretation of the estimates. In particular, the elasticity estimate can be intended as the elasticity of investment to the average cost of capital, rather than exclusively to the cost of syndicated loans.

The results of regressing investment on loan spreads by IV-GMM are reported in Table C.1 in Annex C. The main estimate of interest is the investment elasticity with respect to cost of debt, which ranges from -1 to -1.4, suggesting that a 10% increase in loan spreads causes a 10 to 14% decrease in investments. The coefficients are statistically different from zero, although confidence intervals are large, possibly because loan spreads are a noisy proxy of the average cost of capital. The point estimates are similar to previous findings: Schaller and Voia (2017[47]) favour -0.8, Gilchrist and Zakrajsek (2007[48]) estimate -0.75 in the short run and -1 in the long run, Wen et al. (2020[49]) get -1.3 specifically for equipment; finally, the review of Hassett and Glenn Hubbard favours -1 (2002[50]).

[16] It could be argued that general equilibrium effects of monetary policy could affect investments via other channels, for example stimulating aggregate demand. The fixed effects control for these aggregate channels. Moreover, monetary policy announcements could also convey the central banks assessments of the economic outlook influencing investors, although these effects are short-lived (Jarociński and Karadi, 2020[91]) compared to the timeframe considered here.

[17] Cohn and Deryugina (2018[32]) and Goetz (2019[33]) provide similar arguments in the context of access to credit and environmental performance.

Quantification of the investment effect on green firms

These elasticity estimates can be used to perform back-of-the-envelope calculation on the effects of changes in mitigation polices on investment. In practice, the change in investment can be calculated as follows:

$$\widehat{\Delta}_{\%} I_{fct} = \hat{\gamma} \times \widehat{\Delta}_{\%} AISD_{fct} = \hat{\gamma} \times \hat{\beta}^2 \times \Delta \boldsymbol{P}_{ct} \times \boldsymbol{E}_{ft} \qquad (2)$$

where $\widehat{\Delta}_{\%}$ denotes a predicted percentage change in the variable of interest ; I_{fct} is investment of firm f, in country c and year t; $\hat{\gamma}$ is the estimated elasticity of investments to cost of debt; $AISD_{fct}$ is the average loan spread of firm f in year t; $\hat{\beta}_3$ is the estimated coefficient of interest from equation (1), multiplying the observed environmental performance $\boldsymbol{E}_{ft}$ and the considered change to policy $\Delta \boldsymbol{P}_{ct}$.

As $\boldsymbol{E}_{ft}$ are standardised to have mean zero and standard deviation one, the estimated percentage change in investment attributable to a unitary change in the policy variables for firms with environmental performance one standard deviation above the mean is $\hat{\gamma} \times \hat{\beta}^2$. A unitary increase in both policy variables is approximately equal to the average change observed between 2002 and 2018. Table 6 shows these calculations using the estimate $\hat{\beta}^2$ in Table 3 (columns 2 for EPS and 5 for the other two policies) and $\hat{\gamma}$ in Table 6 (column 2).

Table 6. The investment effect of mitigation policies through cost of debt for top and bottom environmental performers

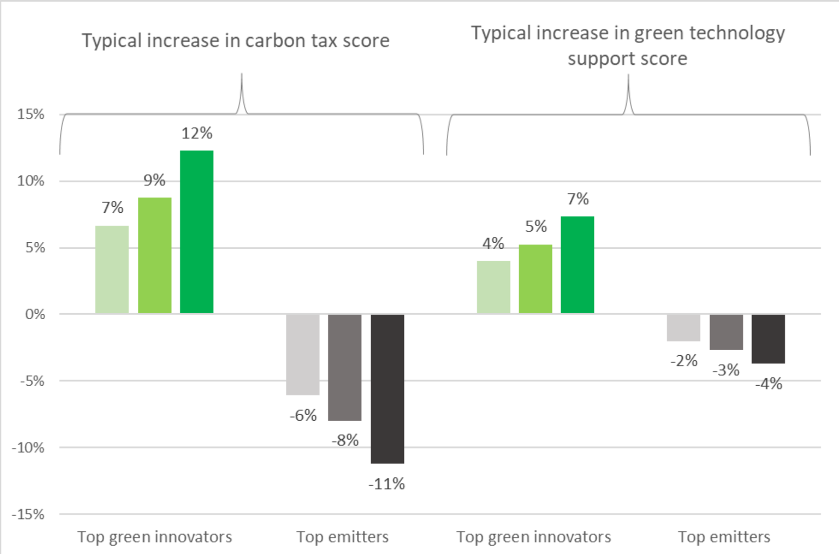
Policy	Firms	Change to cost of debt	Change to investment
(1)	(2)	(3)	(4)
EPS	Top green innovators	-6.7% [±4.0 ppt]	+6.6% [±7.4 ppt]
	Top emitters	*not significant*	
CO_2 Tax	Top green innovators	-11.7% [±6.7 ppt]	+11.5% [±12.6 ppt]
	Top emitters	+10.7% [±6.4 ppt]	-10.5% [±11.7 ppt]
Technology support	Top green innovators	-6.1% [±3.1 ppt]	+6.0% [±6.4 ppt]
	Top emitters	+3.1% [±2.6 ppt]	-3.1% [±3.8 ppt]

Note: 'Green innovators' are firms with (log) green innovativeness 1 standard deviation above the median (84th percentile), 'Top emitters' are firms with emission intensity 1 standard deviation above the mean (88th percentile). Column 3 shows the semi-elasticity of loan spreads (AISD) to a unit change in the policy of column 1 for the type of firm of column 2. The semi-elasticities are the baseline coefficient estimates from Table 3, columns 2 and 5. Column 4 shows the semi-elasticity of investments to a unit change in the policy, obtained multiplying the coefficient in column 3 with the elasticity of investment to loan spreads (-0.99, Table C.1. in Annex C column 2). Confidence errors at 90% confidence level in parenthesis; calculated for column 4 with delta method assuming independence of the coefficients.
Source: Authors.

Mitigation policies can have a large positive effect on top green innovators investments and an equally large negative effect on investments of large emitters. With an estimated $\hat{\gamma}$ of -0.99, a unit increase in Environmental Policy Stringency decreases the cost of debt of green innovators by 6.7%, increasing their investments by 6.6%. As regards carbon taxes and technology support, both can foster investments in top green innovators (+11.5% and +6%, respectively), while reducing investments by heavy emitters (-10.5% and -3.1%, resp.). The confidence errors of the investment effects are large, mostly because the elasticity of investments to cost of debt is not precisely estimated.

Figure 4 shows a range of estimates for a change in investment for a typical (one standard deviation) increase in the carbon tax and the technology support policy scores, using an upper- and a lower-bound for elasticity (taken from Table C.1. in Annex C and the literature (Gilchrist and Zakrajsek, 2007[48])). A typical increase in the carbon tax score is associated with a 7 to 12% increase in investment for top green innovators and a 6 to 11% decline in investment for the top emitters. A typical increase in the green technology support score is associated with a 4 to 7% increase in investment for top green innovators and a 2 to 4% decline in investment for top emitters.

Figure 4. The investment effect of mitigation policies through cost of debt



Note: The Figure shows the range of changes in investment associated with a one standard deviation increase in the carbon tax and the technology support score for top green innovators and top emitters. The darker shades show the effects estimated with the upper bound elasticity estimated in this paper (-1.38). The medium-light shades show the effects estimated with the lower elasticity estimated in this paper (-0.99). The light shades show the effects estimated with the lower bound elasticity from Gilchrist and Zakrajsek (2007[48]) (-0.75).

6. Policy discussion

Sustainable finance, including the growing range of climate-related financial products, is attracting the attention of investors, policy makers and stakeholders because of its potential to deliver long-term benefits. Reducing investors' information asymmetries with reliable information covering climate policies and firms' environmental performance can help to mobilise capital towards firms that are green or intend to become green, for example by developing and deploying green technologies and production practices. Investors need such information to assess and manage climate-policy transition risks of investees so as to avoid locking investment in stranded assets and contribute to the financial sector net-zero pledges.

This paper shows that investors react to information on environmental performance, but this information is often lacking, partial or incomplete. The analysis is limited to firms that disclose emissions and ESG ratings, but these represent a tiny fraction of the firms' population. These information asymmetries are arguably larger for less sophisticated investors than those considered in this study. Less sophisticated investors likely face stronger barriers to collect or process information on investees' transition risks or their alignment with climate targets. Indeed, studies have reported the limited capacity of investors to process large and complex amounts of information, which may delay their reactions. Information reported in a non-standard format can be particularly difficult for investors to incorporate in investment decisions (Hirshleifer, Lim and Teoh, 2009[51]; DellaVigna and Pollet, 2007[52]; DellaVigna and Pollet, 2009[53]). Mandating minimum environmental disclosure requirements and working with the private sectors to develop and implement metrics providing consistent, transparent and reliable information on firms' environmental performance can ameliorate this problem.

To this end, this section discusses available policy options. These include: disclosure and comparability of emission data; enhancing the trustworthiness of ESG and E pillar scores; encouraging firms to produce corporate transition plans.

Improving emission disclosure

A large proportion of firms do not disclose emissions. Disclosing emissions is a basic requirement to establish a firm's contribution to climate change and constitutes a main component of ESG and E pillar scores. In 2020, only 58% of firms included in the FTSE All-World (or about 3700 firms, 95% of investable capital) disclosed direct emissions from company-owned sources (i.e. Scope 1 emissions) and indirect emissions from the generation of purchased energy (i.e. Scope 2 emissions). The disclosure rate is larger among big firms (98% in FTSE 100) and in developed countries (73%, against 39% in emerging economies) (Simmons et al., 2022[54]).

Adopting mandatory emission reporting and extending the scope of existing requirements can reduce the information gap. Some form of reporting requirement has been adopted in over 40 countries, including the United States, the European Union, the UK, and Australia. However, the scope of these requirements is often uneven and broadly insufficient. They apply only to specific firm categories, such as listed companies and larger emitters. While exemptions to smaller firms are motivated by reporting costs, more inclusive criteria should be envisaged to accelerate progress.

Since 2014, emission disclosure has increased by a mere 8 percentage points in FTSE All-World companies, from 50% to 58% (Simmons et al., 2022[54]). Broad exemptions within jurisdictions and the absence of requirements in many countries, notably China, have stymied progress towards better coverage within and across countries. Scope 3 emissions (i.e., those generating from the value chain of the firm), are more costly and difficult to obtain and for this reason are rarely subject to reporting requirements.

The harmonisation of emission accounting standards and the improvement in data quality need to be encouraged. Emission reporting varies across jurisdictions and across firms within a jurisdiction and often lacks third-party verification. The GHG Protocol is a widespread emission reporting standard providing requirements and guidance for companies and organisations preparing GHG emission inventories. It provides a framework for businesses, governments, and other entities to measure and report their greenhouse gas emissions. Several other protocols, standards, and frameworks exist, including ISO 14064, GRI 305, and SASB (LoPucki, 2022[55]). Several competing non-binding frameworks to collect and standardise communication of emission and climate-related information have been put forward by organisations such as CDP (formerly the Carbon Disclosure Project), the Global Reporting Initiative, and the Task Force on Climate Related Financial Disclosures. The EU Corporate Sustainability Reporting Directive (CSRD), which entered into force in early 2023, extends and amends the rules for corporate environmental and social reporting currently in place. Under the CSRD, approximately 50 000 firms (large firms as well as listed SMEs) have to report environmental and social information. Companies will have to report information according to European Sustainability Reporting Standards (ESRS) developed by the European Financial Reporting Advisory Group (EFRAG), a private independent body comprising different stakeholders. The European Commission should adopt the first set of standards developed by EFRAG by mid-2023.

These disparate initiatives attest to the rising importance of emission reporting and monitoring activities across private-sector firms, but they also hamper comparability. Protocols differ in what emissions excludes from reporting standards (e.g. limiting the scope to certain activities or geographical scope) and in how they define the firms' boundaries, reducing comparability of reported emissions across firms and standards. Furthermore, though standards favour transparency, accuracy and completeness, they do not always ensure comparability across emitters evaluated with the same methodology (Gillenwater, 2022[56]).

Encouraging data comparability both between and within standards and requiring third-party verification performed by an accredited auditor would improve the usefulness and credibility of emission data. Discussions and coordination among standard setters would contribute to avoid the multiplication of competing standards and aid comparability.

Enhancing the usefulness of ESG scores

ESG investing has raised in prominence over the recent past. ESG scores, and particularly the E pillar subcomponent, synthesize a wealth of information on a firm's environmental impact and resource use. As such, at least in principle, they can provide useful information to assess firms' transition risks linked to the increasing stringency of mitigation policies.

ESG rating providers use a diverse range of metrics and methodologies to compute their scores. Metric categories employed in rating the E Pillar often include emissions, as well as other climate-related information such as energy and resource use, R&D in green technology and climate change adaptation. Both private and public market participants employ ESG scores to guide their investment decisions towards assets that are perceived as sustainable. As a synthetic measure of environmental performance, they offer a simple criterion for investment to less sophisticated market participants interested in sustainable investments. This paper offers evidence that firms merely disclosing ESG scores face lower spreads and that good ESG scores reduce them further (Table 5).

Yet, ESG scores have several shortcomings, undermining their usefulness as a tool to assess firms' transition risks. Score availability is fragmented and concentrated in larger firms (Boffo and Patalano, 2020[6]). Moreover, they correlate poorly with firms' emission intensity, changes in emissions or investment in renewable energy (OECD, 2022[7]). Despite similarities in broad name categories, the metrics underlining the final score vary in type, number and methods (Boffo, Marshall and Patalano, 2022[57]). The E pillar metrics often rely on binary variables, for example indicating the existence of an environmental management system at the firm without providing details on the quality or effectiveness of this system in reducing emissions.

Making strides in this area hinges on enhancing the availability and reliability of ESG scores along with the transparency and credibility of ESG rating methodologies (OECD, 2022[11]). Further guidance in assessing metric categories, especially with respect to fuel-efficient expenditures, R&D, and development of new products and services, would bolster comparability. Reducing the number of subjective judgements entering the ESG or E-pillar scores would support transparency and objectivity. Requiring alignment to the framework set out by the Task Force on Climate-related Financial Disclosure (TFCD, 2021[58]), a standardised approach to ESG reporting based on a sound set of recommendations and principles, is a good step in this direction (OECD, 2022[7]). Aligning ESG scores with net zero objectives is important to ensure reaching emission reduction targets.

Progress in this area would be especially beneficial to those investors who lack the analytical capacity and direct access to data needed to assess and manage of firms' transition risks. This is key to broadening the set of investors capable of making such assessments based on reliable information and therefore increase the size of investments in line with emission reduction goals.

Climate-related finance beyond ESG ratings

Some market participants adopt sophisticated investment strategies to guide investments towards emission reduction and to support the net-zero transition. These encompass both investors specialised in climate transition investment (e.g., climate transition portfolios, indices and funds) and conventional investors interested in managing transition risk (e.g., banks, central banks, institutional investors). Climate-related finance involve practices like asset screening through the definition of quantifiable impact targets and the verification of the portfolio alignment with climate-related scenarios. In some cases, this involves investors engaging with the invested firms to ensure their alignment with climate objectives through monitoring, reporting, and verification of targets.

The evaluation of climate transition plans is another fundamental practice to align financial decisions with emission reduction targets. Transition plans contain a firm's plan to mitigate its contribution to climate change and its exposure to climate policy, as well as its plan to adapt to mutated business conditions brought along by climate change and the net-zero transition.

Policy can help coordinating this process. Reinforcing and continuously updating investment principles established by international, such as the United Nations Principles for Responsible Investments (UN-PRI), can provide investors with a shared and credible set of criteria to guide their investment strategy. Several networks and initiatives aim to improve corporate reporting beyond ESG. For example, the Task Force on Climate-related Financial Disclosures (TCFD) provides guidance on the design of corporate transition plans (TFCD, 2021[58]) The Science Based Targets initiative (SBTi) aims to help firms identify how to reduce emissions to align with emission reduction goals. The Transition Pathway Initiative (TPI) assesses the alignment of listed equities, bond issuers and banks with decarbonisation objectives and helps investors align portfolios with net zero targets.

Financial regulation can encourage and support firms to publish detailed transition plans (Box 1) and to share good practices. In the banking sector, supervisory authorities could further promote and coordinate the formulation of climate scenarios, stress testing and the evaluation of climate value-at-risk. Several central banks perform this type of analysis and increasingly align or plan to align their policies with climate considerations (NGFS, 2019[59]), such as macroprudential policies and differentiated capital requirements.

Box 1. Ensuring credibility of corporate climate transition plans

Ten elements can ensure credibility of these plans: *i)* setting temperature goals, net-zero, and interim targets; *ii)* using sectoral pathways, technology roadmaps, and taxonomies; *iii*) measuring performance and progress through metrics and key performance indicators; *iv)* providing clarity on use of carbon credits and offsets; *v*) setting out a strategy, actions, and implementation steps, including on preventing carbon-intensive lock-in; *vi)* Addressing adverse impacts through the Do-No-Significant-Harm Principle; *vii*) supporting a just transition, considering how the company's transition is expected to impact workers, suppliers, local communities and consumers; *viii)* integration with financial plans and internal coherence with the company's business plan; *ix)* ensuring sound governance and accountability; *x)* transparency and verification, labelling and certification including through third parties.

In the European Union, the recently approved Corporate Sustainability Reporting Directive will soon require companies to publish detailed information on sustainability matters, including on climate plans and progresses. Switzerland, the United Kingdom and the United States are taking actions towards legally requiring transition plans. Ensuring comparability across metrics is key to be able to compare plans across firms.

Source: OECD (2022[60])

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Annex A. Data sources and descriptive statistics

Environmental performance metrics: Green innovativeness, emission intensity and ESG

The environmental performance of firms is measured through their green innovation and emission intensity. Green innovation is measured by the stock of patents in mitigation technologies issued by the firm, sourced from PATSTAT. PATSTAT contains the universe of patents filed by firms. It is a globally comprehensive database – including all patents filed in any of the major patent offices – is maintained and regularly updated by the European Patent Office. Numerous papers have used this data source to measure firms' green innovation e.g., Calel and Dechezleprêtre (2016[61]) and Dechezleprêtre and Kruse (2022[62]).

More specifically, this paper uses the number of patent applications in climate-change mitigation technologies, which are based on the "Y02" tagging system developed by the European Patent Office and available on all patent applications recorded in the global PATSTAT database. It includes inventions in climate-change mitigation technologies related to buildings (e.g. efficient home appliances), clean energy generation, smart grid technologies, transportation, as well as mitigation technologies in the production or processing of goods (e.g. metals, chemicals, minerals) among others (European Patent Office, 2016[63]).

The analysis uses the accumulated stock of low-carbon patents as the explanatory variable instead of the flow of patents. This is because it takes time for firms to benefit from innovation, which first need to be turned into marketable products. Similarly, the uptake of new technologies by the market may not be immediate. Firm's patent stock in low-carbon technologies is therefore a more suitable measure to assess the effect of low-carbon innovation on economic performance than patent flows.

To compute the knowledge stock, we follow the literature and apply an annual 15% depreciation factor to patent filings using the perpetual inventory method (Dechezleprêtre and Glachant (2014[64]); Franco and Marin (2017[65]). The patent stock is expressed in logarithm to limit the influence of extreme observations. A constant of one is added to the number of patents of all firms before applying the logarithmic transformation so as to avoid missing values for firms with zero patents. Results are robust to alternative transformation of the patent stock data to circumvent this problem (Annex B).

Firm-level emissions come from Refinitiv EIKON and are measured in CO_2 equivalents (in tons).[18] These emissions include both direct emissions from company-owned resources (Scope 1) and indirect emissions from the generation of purchased energy (Scope 2).[19] Emissions are reported either voluntarily or in compliance with existing regulation (for example the European Union Emission Trading System) and follow predominantly the GHG Protocol. Firms' emission intensity is computed as emissions over total assets. In the robustness check, emissions are alternatively divided by the firm's value added, although this variable is much sparser.

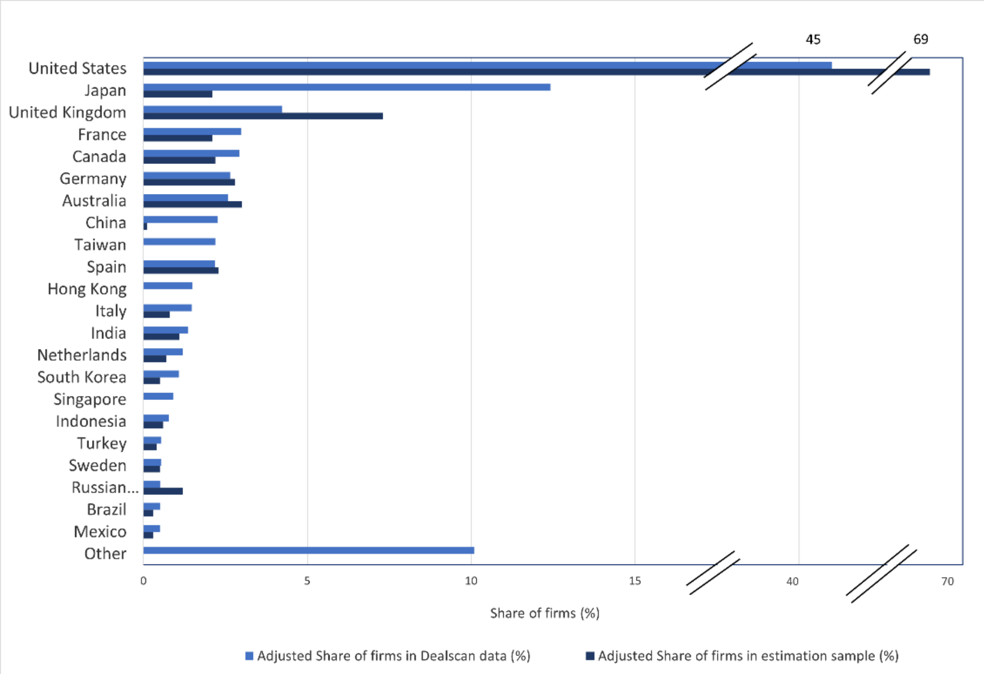
Environmental, social and governance (ESG) data is collected from the Refinitiv ESG database. The analysis uses both the total ESG score and its Environmental Pillar Score. ESG scores are industry-adjusted ranking of firms according to their relative performance on various environmental performance metrics, such as the presence of an environmental management system, their resource use policies, environmental expenditures and others.

[18] We use the variable ENERDP123 in the Refinitiv database, which is used widely in the literature to measure firms CO_2 equivalent emissions (Reghezza et al., 2021[78]; Hege, Pouget and Zhang, 2022[72]; Homroy, 2023[85]).

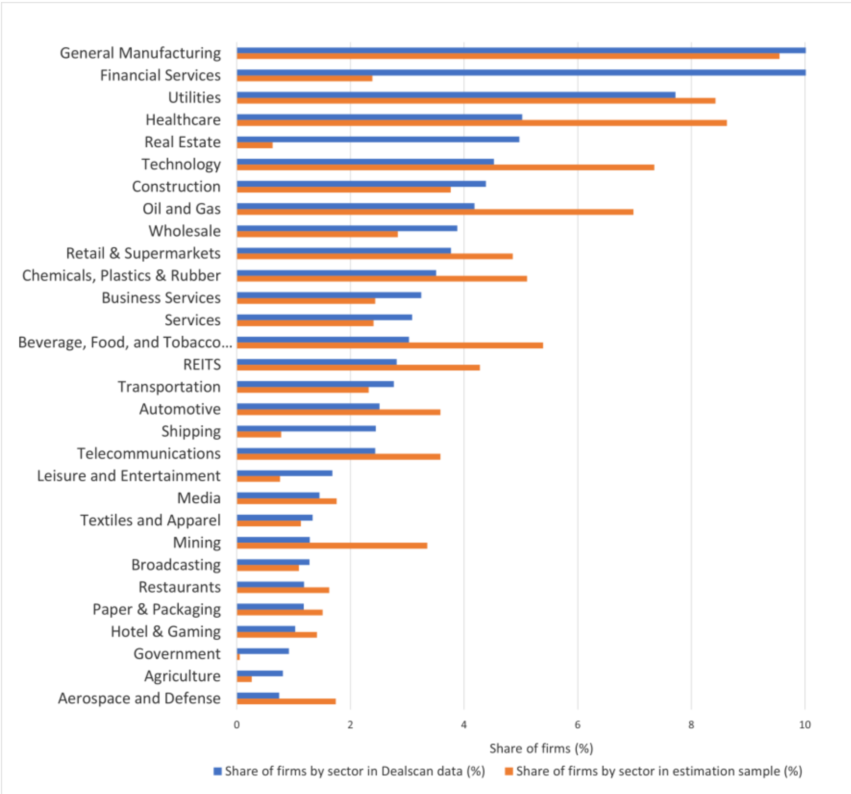
[19] Scope 3 emissions are excluded from the analysis as information on scope 3 emissions is largely imprecise and sparsely available.

Figure A.1. Share of firms using syndicated loans

Panel A: by country



Panel B. By sector



Note: The figures show the share of firms by countries and sectors in the Dealscan data compared to the share of firms in the estimation sample. The Refinitiv Major Industry Group classification is used to classify sectors.
Source: Authors calculations based on LPC Loan Connector Dealscan database and Oribis.

Firm-level financial data

The BvD Orbis database provides firm-level variables, including firms' total assets, profitability and leverage. The steps to obtain the clean firm-level Orbis database, include keeping accounts that refer to entire calendar years, keeping only consolidated accounts, dropping observations with missing information on key variables as well as outliers identified as implausible changes or ratios (Andrews, Criscuolo and Gal, 2016[66]). Investment data, employed to estimate the elasticity of investment to loan interest rates, are calculated at the firm level as the change in fixed assets (including both tangible and intangible assets) between t and t-1 corrected for depreciation both at book values (Sorbe and Johansson, 2017[67]; Millot et al., 2020[68]). The cleaned firm-level Orbis database is merged to the loan-level Dealscan via the linking table built by Bottazzi et al. (2020[69]), based on fuzzy text-matching algorithm.

Environmental policies

Country-level data on policy comes from the OECD Environmental Policy Stringency (EPS) index and its sub-components (Kruse et al., 2022[45]; Botta and Koźluk, 2014[44]). The OECD Environmental Policy Stringency (EPS) index is a widely used tool for policy analysis (Albrizio, Koźluk and Zipperer, 2017[70]; OECD, 2021[71]). One attractive feature of the EPS is that it compares policy stringency across countries and over time based on a homogeneous methodology. It focusses primarily on climate change and air pollution policies and covers 13 specific environmental policies. The index ranges from zero (least stringent policies) to six (most stringent policies) and is available from 1990 to 2020 for 40 countries.

To separate effects of technology-push and market-pull factors, the analysis uses two sub-components of the composite EPS index: 1) CO_2 tax; 2) green technology support. Green technology support policies include public research and development (R&D) expenditure for green technologies and pricing support (feed-in-tariffs and auctions) for wind and solar energy. The CO_2 tax sub-component is based on the tax rate for CO_2 emissions.

Descriptive statistics tables

Table A A.1. Descriptive statistics of the estimation sample

Variable	Count	Mean	SD	p25	p50	p75
Log (All-in-spread-drawn) (AISD)	6029	4.79	0.85	4.32	4.92	5.35
Loan-level variables						
Tranche amount (m EUR)	6029	771	1568	169	366	803
Tenor or maturity (months)	6029	48.6	30	36	60	60
Secured (*dummy*)	6029	0.25	0.43	0	0	0
Number of lenders	6029	12.4	9.28	6	10	17
Performance pricing provisions (*dummy*)	6029	0.38	0.49	0	0	1
Presence of covenants (*dummy*)	6029	0.44	0.5	0	0	1
Firm-level variables						
Mitigation patent stock	6029	0.53	1.14	0	0	0.36
Estimated intensity (tons CO_2 / EUR)	6029	0.32	0.71	0.02	0.05	0.23
(Log) Total Assets	6029	22.6	1.37	21.6	22.5	23.5
Return on assets	6029	0.08	0.09	0.04	0.07	0.11
Debt to Asset	6029	0.64	0.2	0.52	0.64	0.75
Discloses ESG score	6029	0.86	0.35	1	1	1
Discloses E pillar score	6029	0.86	0.35	1	1	1
Standardized firm-level variables						
Green patent stock sd.	6029	1.93e-09	1	-0.46	-0.46	-0.15
Emission intensity sd.	6029	-6.87e-10	1	-0.4	-0.35	-0.11
ESG score sd.	5184	6.00e-10	1	-0.81	-0.12	0.72
E pillar score sd.	5181	1.09e-08	1	-1.07	-0.22	0.86
General patenting sd.	6029	2.20E-09	1	-0.8	-0.5	0.65
Policy variables						
EPS	6029	2.32	0.76	1.67	2.42	2.94
Technology support policy	6029	1.93	0.87	1.5	2	2.25
Carbon tax	6029	0.19	0.76	0	0	0

Note: The table shows the descriptive statistics of the estimation sample. SD is the standard deviation. P25, the 25th percentile, p50 the median and p75 the 75th percentile. Monetary values expressed at constant 2005 prices.

Table A A.2. Difference between full sample and estimation sample

	Estimation sample		Full sample		Diff	
	Mean	N	Mean	N	Value	%
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Log (All-in-spread-drawn) (AISD)	4.790	6029	5.056	17157	-0.266	-6%
Loan-level variables						
Tranche amount (m EUR)	770.8	6029	228.5	33859	542.3	70%
Tenor or maturity	48.60	6029	50.89	35467	-2.302	-5%
Secured (*dummy*)	0.247	6029	0.307	36585	-0.061	-25%
Number of lenders	12.36	6029	6.262	36585	6.095	49%
Performance pricing provisions (*dummy*)	0.382	6029	0.148	36585	0.234	61%
Presence of covenants (*dummy*)	0.444	6029	0.286	36585	0.158	36%
Firm-level variables						
Mitigation patent stock	0.529	6029	0.511	36585	0.019	4%
Emission intensity (tons CO_2 / EUR)	0.303	6029	0.305	6517	0.000	-1%
(Log) Total Assets	22.56	6029	20.92	33576	1.637	7%
Return on assets	0.077	6029	0.050	33244	0.027	36%
Debt to Asset	0.644	6029	0.639	36008	0.005	1%
General patenting	1.849	6029	1.522	36585	0.327	18%

Note: Columns (1) and (3) show the mean in the estimation sample and full sample; columns (2) and (4) show the number of observations in the estimation sample and full sample; column (5) = (1) – (3); column (6) = (5)/(1). Monetary values expressed at constant 2005 prices.

Annex B. Robustness checks

Within-firm effects

The results with additional firm fixed effects remain stable (Table B.1). The coefficients on the interaction of technology support with green innovativeness is smaller and not significant anymore in the specification with firm fixed effects. The coefficients on the other policy interactions remain significant.

By adding firm fixed effects, the specification controls for non-observable time-invariant firm characteristics, for example management quality (to the extent that it is stable within the sample period). Management quality could impact both the loan spread and the firms' decision to patent in green technologies, introducing endogeneity in our baseline specification. Adding firm fixed effects addresses this potential endogeneity. The sample size decline by about 6% to include only firms that receive more than one tranche amount over the sample period.

Table B.1. The within-firm effect of mitigation policy on loan spread

Main regression coefficients with firm fixed effects

(log) All-in-spread-drawn	EPS	Tech. support	CO_2 tax	Tech. support & CO_2 tax
	(1)	(2)	(3)	(4)
Green innovativeness	0.011	0.032	-0.033	0.026
	(0.108)	(0.091)	(0.075)	(0.091)
Green innovativeness × EPS	-0.023			
	(0.033)			
Green innovativeness × Tech. support		-0.037		-0.030
		(0.028)		(0.027)
Green innovativeness × Carbon tax			-0.177***	-0.155**
			(0.061)	(0.062)
Emission intensity	-0.019	-0.060	0.007	-0.074
	(0.054)	(0.045)	(0.021)	(0.046)
Emission intensity × EPS	0.013			
	(0.024)			
Emission intensity × Tech. support		0.040		0.046*
		(0.026)		(0.026)
Emission intensity × Carbon tax			0.093**	0.112***
			(0.037)	(0.039)
Observations	5643	5643	5643	5643
Number of firms	1024	1024	1024	1024
Green innovativeness marginal effect	-0.043	-0.039	-0.064	-0.058
p-value	0.561	0.593	0.390	0.432
Emission intensity marginal effect	0.011	0.017	0.023	0.034
p-value	0.590	0.427	0.262	0.113

Note: *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. Each regression includes the following deal-level controls: (log) tranche amount; tenor or maturity; number of lenders; performance pricing provisions; presence of covenants; dummies at the deal level (seniority, loan type, primary purpose); in addition to the following firm-level controls: (log) total assets; return on assets; debt to asset ratio; general patenting activity, and the following fixed effects: 1) firm; 2) country×year; 3) industry×year; 4) year×origination country. Observations: 5643; number of firms: 1024; degrees lost by fixed effects: 1053; Full table available in Appendix. Standard errors clustered at the firm level in parenthesis.
Source: Authors

Further robustness checks

A concern in our baseline specification may be that the cost of debt can impact firms' green innovation activity for example if cheaper access to credit may encourage firms to invest in R&D, introducing reverse causality in our estimates. To account for this, we use a time-invariant (within-period average) measure of policy exposure. The time-invariant measure helps break the potential inverse causation. The results are robust to using time-invariant environmental performance measures (Table B.2, columns 1 and 2).

Table B.2. Robustness checks

Main regression coefficients

(log) All-in-spread-drawn	Time invariant	Time invariant	C×I×Y f.e.	Value added EI	Oil Prices	No USA
	(1)	(2)	(3)	(4)	(5)	(6)
Green innovativeness	0.152**	0.129***	0.270***	0.285**	0.666***	1.485***
	(0.064)	(0.048)	(0.061)	(0.125)	(0.155)	(0.415)
Green innovativeness × EPS	-0.065***					
	(0.024)					
Green innovativeness × Tech. support		-0.057***	-0.142***	-0.127**	-0.033	-0.068*
		(0.019)	(0.028)	(0.052)	(0.021)	(0.034)
Green innovativeness × Carbon tax		-0.128***	-0.173	-0.212***	-0.135***	-0.162**
		(0.045)	(0.106)	(0.081)	(0.040)	(0.064)
Emission intensity	0.079	0.013	-0.174*	-0.073	-0.471**	0.484
	(0.070)	(0.050)	(0.091)	(0.045)	(0.185)	(0.540)
Emission intensity × EPS	-0.022					
	(0.028)					
Emission intensity × Tech. support		0.008	0.093**	0.057**	0.034**	0.011
		(0.021)	(0.042)	(0.022)	(0.015)	(0.023)
Emission intensity × Carbon tax		0.091***	-0.023	0.115**	0.116***	0.202***
		(0.032)	(0.112)	(0.057)	(0.038)	(0.054)
Oil prices × Green innovativeness					-0.141***	
					(0.041)	
Oil prices × Emission intensity					0.101**	
					(0.042)	
Observations	6029	6029	5538	1977	6029	1718
Number of firms	1384	1384	1213	582	1384	464
Degrees of freedom lost due to f.e.	1101	1101	1179	630	1101	656
Green pat marginal effect	0.001	-0.006	-0.029	-0.058	-0.009	-0.003
p-value	0.954	0.826	0.349	0.192	0.713	0.963
Emission intensity marginal effect	0.028	0.045**	-0.001	0.087***	0.037**	0.224***
p-value	0.141	0.018	0.977	0.006	0.036	0.000

Note: *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. Each regression includes the following deal-level controls: (log) tranche amount; tenor or maturity; number of lenders; performance pricing provisions; presence of covenants; dummies at the deal level (seniority, loan type, primary purpose); in addition to the following firm-level controls: (log) total assets; return on assets; debt to asset ratio; general patenting activity, and the following fixed effects: 1) country×year; 3) industry×year; 4) year×origination country. Column 1 and column 2 employ as policy exposure variables (green innovativeness and emission intensity) the average across the period in which the firm is observed; column 3 employs three-way fixed effects (country×industry×year); column 4 uses a different measure of emission intensity (emissions/value added); column 5 includes (log) oil prices interacted with the exposure variables as additional controls; Full table available in Appendix. Standard errors clustered at the firm level in parenthesis.
Source: Authors

The results are robust to an alternative fixed effects structure that controls for time-varying country-sector specific shocks that may impact environmental performance and cost of debt of firms, including for example the rise and subsequent decline of the solar power industry in Spain or Germany in the early 2000s, which was fuelled by generous FITs and declining technology costs (Table B.2, column 3). In addition, the results are robust to an alternative emission intensity metric measuring emissions as a share of value added (Table B.2, column 4). Furthermore, the results are robust to the inclusion of the oil price as an additional control variable, interacting with firm-specific environmental performance variables. Changes in oil prices may have similar effects on firms as environmental policies (in particular CO_2 pricing) as they increase input costs for energy-intensive firms. Indeed, we see that an increase in oil prices is associated with a lower spread for innovative green companies and a higher spread for emission-intensive companies (Table B.2, column 5).

Applying a constant when log-transforming the green innovativeness variable could be problematic, as the constant is arbitrary. Results are however robust to the inclusion of a right-shifting constant, as shown in Table B.3. Three alternative transformations are tested: log(x+0.1), log(x+10) and the inverse hyperbolic sine.

Table B.3. Alternative transformation of the green innovativeness variable

Main coefficients

Dep. Var.: (log) All-in-spread-drawn	Transformation	No policy variable	EPS	CO_2 tax	Tech. support	Tech. support & CO_2 tax
		(1)	(2)	(3)	(4)	(5)
Green innovativeness	Baseline	0.001	0.162***	0.006	0.160***	0.136***
		(0.024)	(0.063)	(0.024)	(0.047)	(0.047)
	Log + 0.1	-0.016	0.122*	-0.014	0.131***	0.116**
		(0.027)	(0.066)	(0.027)	(0.050)	(0.049)
	Log + 10	0.000	0.133**	0.011	0.128***	0.097**
		(0.020)	(0.062)	(0.020)	(0.045)	(0.045)
	IHS	0.002	0.166***	0.006	0.164***	0.142***
		(0.024)	(0.063)	(0.024)	(0.047)	(0.047)
Green innovativeness × EPS	Baseline		-0.067***			
			(0.024)			
	Log + 0.1		-0.060**			
			(0.026)			
	Log + 10		-0.053**			
			(0.022)			
	HIS		-0.069***			
			(0.024)			
Green innovativeness × Tech. support	Baseline				-0.073***	-0.061***
					(0.019)	(0.019)
	Log + 0.1				-0.073***	-0.065***
					(0.021)	(0.021)
	Log + 10				-0.053***	-0.038**
					(0.017)	(0.017)
	HIS				-0.076***	-0.065***
					(0.020)	(0.019)
Green innovativeness × Carbon tax	Baseline			-0.176***		-0.117***
				(0.050)		(0.040)
	Log + 0.1			-0.110***		-0.087***
				(0.035)		(0.029)
	Log + 10			-0.230***		-0.127
				(0.082)		(0.087)
	IHS			-0.160***		-0.109***
				(0.048)		(0.037)

Note: *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. The table shows the estimates for the models contained in Table 3, applying different transformations of the green innovativeness variable. The green innovativeness variable is standardized after the transformation. Only the coefficients for the green innovativeness variable and its interaction are reported. Standard errors clustered at the firm level in parenthesis

Source: Authors

Annex C. Instrumental variable estimates

Table C.1 shows the IV-GMM estimates of the investment elasticity with respect to loan spreads, in increasingly demanding specifications. The analysis relies on two instruments: the interaction of the duration of the firm's syndicated loans with the change in monetary policy interest rates and the interaction of the duration with the level of interest rates. The Hansen J-statistics, reported at the end of the table and used to test for overidentification, support the use of two instruments instead of each independently. The control variables have generally the expected sign: firms with higher debt-to-asset ratios, more assets and less current short-term assets invest more in fixed assets. A somewhat surprising result is the negative coefficient on return on assets, pointing to reverse causality.

Table C.1. The effect of loan spreads on investments

Dependent variable:	Log(Investment)				Log(I/K)			
	OLS	IV-GMM			OLS	IV-GMM		
	(1)	(2)	(3)	(4)	(5)	(5)	(6)	(7)
(log) All-in-spread-drawn	0.071***	-0.988*	-1.381*	-1.274	0.190***	-1.723**	-3.067***	-3.954*
	(0.023)	(0.567)	(0.714)	(0.908)	(0.029)	(0.710)	(1.115)	(2.060)
Total Assets	1.543***	0.809***	0.713***	1.375***	0.223***	-0.423***	-0.697***	0.203
	(0.049)	(0.108)	(0.138)	(0.085)	(0.054)	(0.137)	(0.217)	(0.157)
Return on Assets	0.012	-1.668**	-2.253**	-1.719	0.245	-2.442***	-4.196***	-5.241*
	(0.131)	(0.685)	(0.905)	(1.142)	(0.179)	(0.867)	(1.447)	(2.746)
Debt to Total Assets	0.050	0.176	0.389*	0.568**	-0.152**	0.467**	0.952***	0.942*
	(0.056)	(0.164)	(0.223)	(0.243)	(0.073)	(0.207)	(0.352)	(0.497)
Turnover	-0.092***			-0.056	-0.199***			-0.168**
	(0.021)			(0.037)	(0.026)			(0.069)
Shareholders' funds	0.025			0.012	-0.081*			-0.516**
	(0.036)			(0.104)	(0.041)			(0.256)
Loans	0.009			-0.004	0.004			0.039
	(0.007)			(0.013)	(0.009)			(0.031)
Current assets	-0.513***			-0.600***	0.013			-0.371**
	(0.034)			(0.075)	(0.038)			(0.170)
Capital	-0.009*			-0.052**	-0.018***			-0.127**
	(0.005)			(0.024)	(0.006)			(0.060)
Observations	8445	8989	7731	5991	8431	8961	7712	4892
Number of firms	3847	4508	3800	3230	3836	4488	3785	2604
F statistic		10.9	9.2	4.6		12.3	9.7	4.2
Hansen J		0.139	0.198	0.985		4.043	0.066	0.632
Country×Year f.e.		Yes				Yes		
Industry×Year f.e.		Yes				Yes		
Country×Industry×Year f.e.	Yes		Yes	Yes	Yes		Yes	Yes

Note An observation is a firm-year. *** signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. The analysis considers all the firms that are active in the syndicated loan market and not only those with available environmental performance information. An F statistic larger than 10 passes the rule of thumb cut-off for weak instruments. The Hansen J statistics is used to test that instruments are valid and that the excluded instruments are correctly excluded: a lower statistic supports the use of overidentifying restrictions. Standard errors clustered at the firm level in parenthesis
Source: Authors.

The specification in columns 2 is chosen as baseline as it corresponds to a parsimonious model with a large number of observations and has a larger F-statistic, limiting concerns for weak instruments. Estimated elasticities in column 2 to 4 range between -1 and -1.4. As a robustness check, columns 5 to 7 show a similar analysis for the investment rate, offering an alternative interpretation to the result. The investment rate is elastic to loan spreads: a 10% increase in the loan spread causes a 17-40% increase in investment rates. These results are statistically significant, although confidence intervals are large, possibly due to unobserved heterogeneity.