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# An empirical analysis of climate and environmental policy risk, the cost of debt and financial institutions' risk preferences

Xiao Yan Zhou [a,1,*], Ben Caldecott [a,1], Gireesh Shrimali [a,1], Hanyu Zhang [b,2]

[a] School of Geography and the Environment, Oxford University Centre for the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, United Kingdom
[b] China Economics and Management Academy, School of Innovation and Development, Central University of Finance and Economics, No. 39, Xueyuan Nanlu, Haidian District, Beijing 100081, China

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ABSTRACT

This study examines the impact of regulatory risk on the cost of debt and investment preferences across energy sources. We use the OECD Environmental Policy Stringency Index, loan spreads and investment decisions as measures of climate and environmental (CE) policy risk, cost of debt and risk preferences, respectively. We find that the stringency of CE policy risk influences investors' assessment of investment risks and capital allocation across energy sources. In the energy production sector, we observe that greater stringency in CE policies (such as carbon trading schemes) is associated with lower borrowing costs for renewable energy compared to fossil fuels, leading to increased investment in renewables. Moreover, as CE policies become more stringent in a country, the probability of capital flowing into Oil & Gas or coal diminishes. In the electric utilities sector, we provide evidence that CE policies (solar & wind support policies) effectively attract more capital to renewable electric utilities.

## 1. Introduction

Climate and environmental (CE) policies introduced by governments are intended to affect the scale, pace, and nature of change across the energy sector by directly or indirectly shaping the perceptions and behaviours of market participants. This influence extends across upstream, midstream, and downstream sectors, as well as the financial institutions allocating capital to companies and projects at different stages of development. Accordingly, CE policies can either facilitate or hinder the achievement of critical societal objectives, such as those outlined in the Paris Agreement on climate change and the UN Sustainable Development Goals (SDGs).

Environmental economists have long advocated for using policy instruments such as tax or trade instruments to price carbon emissions and internalise the environmental damages caused by carbon dioxide emissions (Aldy, 2015). In measuring the effectiveness of CE policies, much of the literature has focused on their role in stimulating the growth of renewable energy innovations and renewable energy capacity. For example, a large number of country-level studies have been carried out across different geographies, renewable technologies, and policy instruments (Hirth and Steckel, 2016; Wüstenhagen and Menichetti, 2012a; Masini and Menichetti, 2012; Karneyeva and Wüstenhagen, 2017), examining whether specific policy instruments work better in bringing about new capacity. This is often based on the assumption or perception that CE policies reduce financing costs for renewable energy projects and thus increase investments.[3] However, there is a lack of empirical studies substantiating how CE policies affect the cost of debt and influence investors' risk preferences.

Risk preferences refer to the attitudes financial institutions hold toward risks, which is a critical factor in studies on financial institutions' decision-making behaviour (Wen et al., 2014). In standard financial theory, Markowitz (1952) assumes that financial institutions are rational and tend to be risk-averse when making investment decisions. Financial institutions with higher risk aversion rationally weigh the

* Corresponding author.
*E-mail addresses:* xiao.zhou@smithschool.ox.ac.uk (X.Y. Zhou), ben.caldecott@smithschool.ox.ac.uk (B. Caldecott), gireesh.shrimali@smithschool.ox.ac.uk (G. Shrimali), hanyu.zhang@cufe.edu.cn (H. Zhang).
[1] Xiaoyan Zhou, Ben Caldecott, Gireesh Shrimali are from the Smith School of Enterprise and the Environment, University of Oxford.
[2] Hanyu Zhang is from the School of Innovation and Development, China Economics and Management Academy.
[3] De Jager, D., Rathmann,M., 2008. Policy instrument design to reduce financing costs in renewable energy technology project. Annexes. Netherlands. https://www.osti.gov/etdeweb/biblio/21288256

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level of risk and return of a potential investment opportunity and select an opportunity with a more predictable but possibly lower payoff. Financial institutions with lower risk aversion tend to choose those opportunities that provide better returns for a similar level of risk. More risk aversion corresponds to investing more (less) of one's capital in a safe (risky) asset. However, behaviour finance literature finds that the financial institutions' decision-making behaviour in real life does not always comply with this assumption of rationality. Their behaviours are usually limited by cognitive biases and the external environment, leading to risk preferences varying with different situations. One of the main approaches used to measure risk preferences in experimental economics is an investment task for allocations between safe and risky assets. Following previous studies on risk preference measurements and associated applications (Eckel and Grossman, 2002; Binswanger, 1981), we measure risk preference using investment choices between renewable and conventional energy sources.

How CE policies affect investment choices between renewables and conventional energy technologies, such as Oil & Gas and coal, has become a question of particular interest in the context of climate change mitigation. This study uses longitudinal datasets in the loan market in response to the call for empirically based, data-driven research on climate and energy choices (Stern et al., 2016). Insights into financial institutions' decision-making and the effectiveness of different types of CE policies can help policymakers mitigate climate change risk.

We analyse a sample of 15,189 loan facilities from the DealScan database between 2000 and 2019, involving 4066 borrowers across 40 developed and emerging markets in energy production (renewable energy, Oil & Gas and coal) and electricity (renewable electric utilities, fossil fuel electric utilities and mixed electric utilities) sectors. To examine the relationship between CE policies, risk perception, and the cost of debt and to explore how this link varies across energy sources, we start by regressing loan spreads on the CE policy, energy source and their interaction term (energy source * CE policy). We then run a logit regression to test how changes in CE policies affect financial institutions' risk preferences, as measured by their investment choices between energy sources. Additionally, we use the mediation model to investigate whether changes in the cost of debt play a mediating role in the relationship between CE policies and investment preferences.

We find that the stringency of CE policies is priced by financial institutions,[4] which influences their investment choices between energy sources in the loan market. In the energy production sector, we show that the cost of debt for renewable energy is higher than that of conventional energy sources such as Oil & Gas and coal over the past 20 years. However, the introduction of a higher level of CE policy stringency brings this financing cost down and induces lenders to issue cheaper loans to renewable firms. We also find that the more stringent CE policies in a country, the lower the likelihood of loan capital flowing into Oil & Gas or coal. These findings confirm that lenders are sensitive to the changes in CE policies and attempt to avoid conventional energy borrowers subject to substantial policy risk. In the electricity sector, we find that while the CE policy stringency has a significant positive effect on loan spread in general, the difference in the policy effects between renewable electric utilities and fossil fuel and mixed electric utilities is insignificant. However, CE policies are still shown to attract loan investment to renewable firms. Our findings are in line with the argument that investment choices could be made based on the risk and return analysis (Bolkesjø et al., 2014) or financial institutions' preferences over specific policy instruments or particular environmental concerns/beliefs (Bergek et al., 2013).

[4] We use the term of "financial institutions" to describe the lenders in the syndicated loan, as during the past decade, non-bank institutional investors are increasingly taking larger roles in syndicated loan, especially in the leveraged loans (Lim et al., 2014). In our dataset, approximately 15 % loans that have at least one lenders are non-bank financial institutions.

This research also examines the effectiveness of different types of CE policy instruments, we find that carbon (CO2) trading schemes are effective in increasing the cost of debt for Oil & Gas, reducing the likelihood of fossil fuel investments. In addition, solar & wind support policies can also attract more loan investments in renewable energy and renewable electric utilities.

Our study provides global cross-sectoral evidence by covering the energy production (renewable fuels, Oil & Gas, and coal) and electricity sectors (renewable, fossil fuel and mixed electric utilities) across 40 developed and emerging markets from 2000 to 2019. The study makes two main contributions. First, we contribute to the academic literature identifying how CE policy instruments shape financial institutions' climate change adaptive behaviour. The lack of emphasis on determinants of investor preferences is an important shortcoming in climate change studies (Bergek et al., 2013; Wüstenhagen and Menichetti, 2012b). We intend to contribute to the literature surrounding financial institution behaviour by shedding light on the mechanism through which financial institutions allocate capital among energy sources. Second, our findings contribute to the literature on financial institutions' reactions to a firm's environmental externalities. Chava (2014) find that lenders charge firms with higher environmental externalities a higher cost of debt. We show that the stringency of environmental policy is priced in the loan market, and this relation varies across energy sources. Renewable energy borrowers that are supported by the policies are able to obtain a significantly lower interest rate. In contrast, conventional energy borrowers restricted by CE policies face a higher interest rate and receive fewer loan investments.

The remainder of this study is organised as follows. The literature review and hypotheses development are presented in Subsection 2. Subsection 3 explains the research framework, data sources and variable construction. Section 4 presents the empirical results. Section 5 provides policy implications and discussion.

## 2. Literature review and hypotheses development

### *2.1. Climate and environmental policy risk and the cost of debt*

Climate and environmental policies encompass policies formulated to tackle climate change and environmental pollution and promote technological development and diffusion of renewable energy. Widely adopted CE policies include taxes on emissions, trading schemes, feed-in tariff schemes and government R&D subsidies. CE policies can be classified into restrictive indicators (e.g., taxes and emission standards) and supportive indicators (e.g., subsidies) (Steg et al., 2006). The former aims to increase the prices of products and services associated with higher emissions. The latter seeks to decrease the costs of products and services related to lower emissions. For example, the US regulation employs an estimate of the social cost of carbon (SCC) – the present value of monetised damages related to an incremental increase in carbon emissions in a given year to assess business opportunities subject to climate change risk (*Technical support document: Technical update of the social cost of carbon for regulatory impact analysis under executive order* 12866, 2015).

It is argued that both restrictive and supportive measures can be mutually reinforcing. A policy that rewards low-carbon activities would equate to the opportunity cost borne by emitters (Nordhaus, 2013). From a theoretical standpoint, CE policies can be justified as a way of correcting negative externalities resulting from the use of fossil fuels and achieving dynamic efficiency by stimulating technical change. For example, solar & wind support policies such as feed-in tariff schemes are designed to attract investment in and development of low-carbon electricity projects by offering a guaranteed above-market price per unit of electricity generated at which producers can sell their electricity for a fixed period. Thus, CE policy risk is an essential source of financial risk. It requires firms to adapt their business models to evolving economic and social conditions while also prompting financial institutions to assess the value of equity and debt issuers' assets based on their anticipated future payoffs.

The cost of capital is a function of the market's risk-free rate plus a risk premium for the risks associated with an investment. We use the cost of capital or the required rate of return as a proxy of the perceived overall uncertainty regarding investment opportunities during the energy transition. Financial institutions assess the value of a project depending on the appropriate discount rate for future cash flows determined by the riskiness of a given project, including political and legal uncertainties. In particular, the energy sector is heavily influenced by regulatory factors. CE policies directly or indirectly impact the performance of investments in this area. The perception of CE policy risk is reflected in the cost of capital and varies across energy sources. On the one hand, supportive CE policy indicators help increase the confidence of market actors, reduce uncertainties, and hence reduce the cost of capital for renewable investments. On the other hand, restrictive policy indicators raise the price of business activities associated with high carbon emissions, increasing the cost of capital for fossil fuel investments.

### 2.2. Hypotheses development

While public policies targeted at accelerating the diffusion of renewable energy have been explored in depth (Fischer and Newell, 2008; Rodríguez et al., 2014; Theodor F. Cojoianu et al., 2020; Eichholtz et al., 2019; Blyth et al., 2007; Masini and Menichetti, 2012; Stern et al., 2016; Shwom, 2011), it is less understood how financial institutions price risk related to CE policies and integrate it into decision making in the loan market.

According to institutional theory (Scott, 1995), organisations are engrained in and shaped by the regulatory, social and cultural environments in which they operate. Out of these three pillars of institutional theory identified by Scott, we focus on the regulatory pillar, which originates from the idea that regulations monitor and shape organisational behaviour (Bruton et al., 2010). A case study based on 26 firms' accounting data in Belgium shows that the implementation of energy policies has decreased the cost of capital for renewables (Estache and Steichen, 2015). Hirth and Steckel (2016) assess the role of capital costs in decarbonising the electricity sector and conclude that carbon pricing policies reduce capital costs of low-carbon electricity generation. Hoepner et al. (2016) investigate the effects of country sustainability characteristics on the cost of debt and find that country sustainability, especially relating to the environment, has a statistically negative impact on the cost of debt. Most recently, Cojoianu et al. (2020) investigate how different types of environmental policies affect venture capital financing of low-carbon and fossil fuel technologies and find that countries with stringent environmental policies discourage new fossil fuel ventures.

Syndicated loans are an important source of debt financing, even for large public companies (Houston and James 1996). Lenders can be sensitive to the environmental profile of a firm because of the potential for regulatory, compliance, and litigation risk for the borrower, which can lead to higher credit risk. For example, 113 financial institutions in 37 countries have adopted Equator Principles[5] and agreed to consider social and environmental issues in project finance. Cogan (2008) reports that many large publicly traded banks incorporate climate change in lending decisions. According to a survey conducted by PwC in 2020,[6] five of the UK's largest banks, including Barclays and NatWest, have announced net-zero targets or science-based emissions targets that align with the UK's national climate goals.

As more lenders adopt environmentally sensitive lending policies, this could impact the cost of debt for borrowers, with banks charging higher interest rates on loans issued to firms with poor environmental performance to compensate for higher CE policy risk and potential reputation and litigation risk. According to the Climate Change Litigation Database run by The Sabin Center for Climate Change Law at Columbia University, as of 16 Jan 2021, 1762 climate change litigation cases have been documented worldwide.[7] Financial institutions involved in polluting industries can be exposed to the risk of litigation, incurring different types of costs, including legal and administrative costs, insurance costs, and financing costs (Solana, 2020). Therefore, the relationship between environmental policy stringency and the cost of debt varies between renewable and conventional energies. The above literature discussed leads to our first set of hypotheses:

**H1.1**. The stringency of CE policies is negatively related to the cost of debt for renewable energy.

**H1.2**. The stringency of CE policies is positively related to the cost of debt for Oil & Gas.

**H1.3**. The stringency of CE policies is positively related to the cost of debt for coal mining.

**H1.4**. The stringency of CE policies is negatively related to the cost of debt for renewable electric utilities.

**H1.5**. The stringency of CE policies is positively related to the cost of debt for fossil fuel electric utilities.

The relationship between CE policies and investment flows is not straightforward. The stringency of environmental policy has a direct and indirect influence on financial institutions' risk management (Thompson, 1998; Weber, 2012), leading them to adjust their attitude toward risk across countries and energy sources. Investment choices could be made based on the risk and return analysis (Bolkesjø et al., 2014) or financial institutions' preferences over specific policy instruments or environmental concerns/beliefs (Bergek et al., 2013).

If the adoption of CE policies reduces the cost of capital for low-carbon renewables, policymakers can attract investments from traditionally risk-averse institutional investors (e.g., pension funds and banks) (Wüstenhagen and Menichetti, 2012b). An increasingly relevant body of literature studies the role of environmental regulations by looking at whether and how policies should be adopted to stimulate the growth of renewable energy (Kolk and Pinkse, 2004; Lüthi and Wüstenhagen, 2012; Van Renssen, 2014; Criscuolo and Menon, 2015; Polzin et al., 2015; Polzin et al., 2017; Menanteau et al., 2003). Masini and Menichetti (2012) investigate the decision-making process underlying investments in renewable technologies and find that financial institutions' preferences for policy instruments and attitudes toward technological risk influence the likelihood of investing in renewable projects. Menanteau et al. (2003) examine the efficiency of the different incentive mechanisms and highlight the positive role of feed-in tariff schemes in increasing the renewable energy share by lowering the risk associated with the investment decision. Drawing on the assumption that risk reduction is a key channel for stimulating renewable energy growth, Mitchell et al. (2006) find that the feed-in mechanisms were more effective in increasing the share of renewables in the energy mix than the emission trading schemes mechanism. More recently, Polzin et al. (2015) investigate the impact of policy instruments on renewable energy investments in electricity generating capacity and suggest that the combination of feed-in tariffs and trading schemes is an effective policy mix to spur capacity additions in renewables.

The influence of CE policies on financial institutions' risk preferences for conventional energy remains underexplored. Bauer et al. (2016) analyse the economic impact of climate change mitigation policies on

[5] https://equator-principles.com/members-reporting/

[6] PwC 2020, Rising to the challenge: climate risk in the UK banking sector, https://www.pwc.co.uk/industries/financial-services/insights/rising-to-challenge-climate-risk-in-uk-banking-sector.html

[7] https://climatecasechart.com/

Oil & Gas markets, finding that the introduction of energy-based policies reduce fossil fuel profitability. Using syndicated loans, equity and bond data across 33 countries from 2000 to 2015, Cojoianu et al., 2020 investigate the relationship between fossil fuel divestment and environmental policies. They conclude that there is a significant negative relationship between divestment commitments and the fundraising of Oil & Gas firms.

The literature on coal and climate change suggests that limiting global warming under the 2 °C target requires an early coal phase-out (Gohlke et al., 2011), given its carbon intensity (Spencer et al., 2018; Fankhauser and Jotzo, 2018). Edwards (2019) calls for the adoption of both demand-side and supply-side climate policies globally to phase out coal. IEA (2019) reports that global coal production increased by 1.5 % in 2019, continuing the rebound that began in 2017 after three years of decline.[footnote 8. IEA 2019, Coal 2019, Paris.] China, India and other Asian economies led the expansion, while coal power generation fell in Europe and North America. This decrease in coal production in developed economies largely depends on the stringency of climate policy (Johnson et al., 2015). Hence, we hypothesise that:

**Hypothesis 2.1.** The stringency of CE policies increases financial institutions' preference for renewable energy compared to conventional energy: Oil & Gas and coal production.

**Hypothesis 2.2.** The stringency of CE policies decreases financial institutions' preference for Oil & Gas compared to renewable energy.

**Hypothesis 2.3.** The stringency of CE policies decreases financial institutions' preference for coal production compared to renewable energy.

**Hypothesis 2.4.** The stringency of CE policies increases financial institutions' preference for renewable electric utilities compared to fossil fuel and mixed electric utilities.

**Hypothesis 2.5.** The stringency of CE policies decreases financial institutions' preference for fossil fuel utilities compared to renewable electric utilities.

## 3. Research design and data

This study explores how lenders price the risks associated with CE policies across energy sources and whether this affects financial institutions' risk preferences measured by loan investment allocations between renewable and conventional energy over time. We examine whether the stringency of CE policies effectively reduces (increases) the cost of debt for renewable (conventional) energy and affects capital flows among energy sources. If the regulation risk increases the cost of debt for Oil & Gas and coal, to what extent can this risk leverage the investment funding required for the energy transition?

### 3.1. Data

Our data consists of a combination of project-, firm- and country-level datasets, which include (1) syndicated loan data, (2) information on loan and firm characteristics and (3) environmental policy stringency data.

#### 3.1.1. Data: the measurement of climate and environmental (CE) policies

The existing measurements of environmental policies include single policy change measures (i.e., Kyoto, etc.); composite measures of environmental regulation (i.e., the Organisation for Economic Co-operation and Development (OECD) environmental policy stringency); and surveys on the perceptions of stringency (i.e., the European Bank for Reconstruction and Development (EBRD)'s "Climate Laws, Institutions and Measures Index" (CLIMI) index). We use the energy-sector-based environmental policy indices constructed by the OECD to analyse the effect of environmental policy instruments on the cost of capital and financial institutions' risk preferences over the past 20 years. The OECD Environmental Policy Stringency (EPS) Index is a country-specific and internationally comparable measure of environmental policy stringency with broad time and country coverage. The OECD EPS index covers 34 OECD and 6 non-OECD countries for 1990–2020.

**Table 1**
The OECD environmental policy stringency index.

| EPS policy aggregation | EPS policy types | Individual policy instruments |
|---|---|---|
| Restrictive EPS indicators | Taxes | CO2 |
| | Trading scheme | CO2; renewable energy certificate; energy efficiency certificate |
| | | Solar; Wind |
| Supportive EPS indicators | Technology support policies | Government R&D expenditure on Renewable Energy |

Source (Botta and Koźluk, 2014; Kruse et al., 2022).

The EPS index is constructed through two steps: 1) selecting and scoring individual policy instruments and 2) aggregating this information.[9] First, individual policy instruments primarily related to the climate and environment are selected and scored between 0 and 6 to reflect the relative stringency across countries of a particular policy instrument.[10] Next, the instrument-specific indicators are aggregated into five policy categories: taxes, trading schemes, government R&D subsidies and solar & wind support (Table 1). The aggregated EPS index is the mean of these five categories. OECD distinguishes policy instrument types into technology-support policy indicators and market-based restrictive policy indicators (Kruse et al., 2022). The former includes taxes and trading schemes that internalise environmental externalities, and the latter policies comprise feed-in tariff schemes and government R&D subsidies to support low-carbon activities. At each level of aggregation, equal weights are applied. This method allows us to conduct analysis on the different policy categories as well as overall policy stringency.

#### 3.1.2. Data: cost of debt

Data on bank loans are obtained from DealScan, which is the most widely used by both academics and market practitioners. It provides detailed historical information on syndicated loans worldwide, such as the identity of the lender/borrower and composition/participant of the syndicated loan.[11] The primary sources of loan data are attachments on the U.S. Securities and Exchange Commission (SEC) filings, reports from loan originators, and the financial press.

The basic unit of observation in DealScan is a loan facility or a tranche, which is grouped together into deals or packages. For example, in Jul 2009, Alpha Natural Resources Inc. entered into a $1.051 billion deal consisting of two loan tranches: a 2-year revolving credit facility for $750 million and a 2-year term loan A for $301 million. The initial sample from DealScan comprises loan information on 16,145 loan facilities between 2000 and 2019, involving 5020 borrowers across 118 countries within the energy production and electric utilities sectors.

[8] IEA (International Energy Agency) (2019), Coal 2019. https://www.iea.org/reports/coal-information-2019

[9] The full methodology behind the OECD Environmental Policy Indices construction can be found in the report of Botta and Koźluk (2014) and Kruse et al., 2022.

[10] A higher score of CO2 emission tax and emission standards implies higher stringency. And a higher subsidy is also interpreted as more stringent environmental policy – such subsidies increase the opportunity costs of polluting activities.

[11] The current full DealScan database includes 362,705 loan tranches made between 1981 and t, covering all major industries and over 120 countries.

These sectors are categorised according to the Thomson Reuters Business Classification (TRBC) system, a market-based framework that tracks the primary business of an organisation. In cases where organisations have multiple business segments, the classification is based on the segment contributing the largest share of revenue.[12] Within the energy production sector, we identify three primary energy sources: renewable energy, oil and gas, and coal. For the electric utilities sector, we categorise companies into three groups: renewable, fossil fuel, and other mixed electric utilities.[13] The detailed TRBC classification is presented in Appendix Table 3.

The cost of debt is proxied by loan spread. Following Chava (2014) and Ivashina and Scharfstein (2010), we collect all-in-spread-drawn from the DealScan database. This measures the amount the borrower pays in basis points (bps) over a benchmark interest rate, such as the London Interbank Offered Rate (LIBOR) for each dollar drawn down. It includes both the loan spread and any annual fees (or facility fees) paid to the bank group.

We control for the loan-specific features in the regression, including loan size, maturity, number of lenders, and loan types. We also control borrowers' credit ratings. We do not control for firm size as 1) it is highly correlated with the loan size (Chava, 2014), and 2) our sample will be reduced as many of the borrowers are not publicly listed firms. The regressions also include GDP per capita in a country. Table 2 reports variable definitions and sources. As the evidence shows that firm-level sustainability fails to explain the interest rates charged to borrowing firms by banks (Hoepner et al., 2016), we exclude borrowers' environmental performance in the analysis to keep the sample size.

Combining all data, we document loan information on 15,189 dollar-denominated loan tranches between 2000 and 2019, involving 4066 borrowers across 40 countries in the energy production and electricity sectors identified by the TRBC sector classification.

### 3.2. Research design

We estimate the baseline regression model specified below to test the first set of hypotheses.

$$LoanSpread_{j,i,t} = \alpha_0 + \beta_1 EPS_{i,t} + \beta_2 EnergySource_{i,t} + \beta_3 EPS_{i,t} * EnergySource_{i,t} + \sum_{2}^{k} \beta_i Control_{j,i,t} + \varepsilon_{j,i,t} \quad (1)$$

In this model, $LoanSpread_{j,i,t}$ is the spread of a syndicated loan $j$ received by firm $i$ at year $t$ and measures the default risk. *Control* is a vector of control variables. *EPS* is the OECD Environmental Policy Stringency Index, which is a proxy of the CE policy. We first test the overall EPS index effect on loan spreads across all energy types. *EnergySource* is a set of dummy variables representing five types of energy sources: renewable energy, Oil & Gas, coal, fossil fuel electric utilities, and renewable electric utilities. Each dummy variable is a binary indicator for a specific type of energy source and equals one if the borrower is a particular type of energy firm and zero otherwise, based on the TRBC sector classification. For instance, the dummy variable for renewable energy equals one if the borrower is a renewable energy firm and zero if any other energy sources/utilities. The definitions of each

[12] Companies are assigned to an activity at the lowest level. Each organisation is represented by one primary TRBC Activity and organisations cannot have multiple primary assignments. A 60 % of the total revenue threshold is used to assign an industry to organisations with two business segments. A 51 % of the total revenue threshold is used to assign an industry to organisations with three or more segments.

[13] We have categorised loans within the electric utilities sector where the energy source or type is not identifiable as other mixed electric utilities. It is important to note that no borrower or energy firm is classified under more than one energy type in our sample.

**Table 2**
Variable definitions.

| Variable name | Variable description | Data source |
|---|---|---|
| Loan spreads (bps) | The loan spreads refer to the difference between the interest charged on the loan and a benchmark interest rate, such as the London Interbank Offered Rate (LIBOR) or a government bond yield with a similar maturity. They are measured in basis points (bps). | DealScan |
| Log Loan size | The logarithm of the loan tranche amount in United States Dollars (USD). | DealScan |
| Time to Maturities (month) | It is defined as the number of months remaining until a loan reaches its maturity date. | DealScan |
| No. of Lenders | It indicates the number of lenders who participated in a syndicated loan plus one. | DealScan |
| Guarantor | It is a dummy variable coded as one if the loan has a guarantor and zero otherwise | DealScan |
| Revolver | It is a dummy variable coded as one if this loan facility is a revolver and zero otherwise. | DealScan |
| Term loan | It is a dummy variable coded as one if it is a term loan and zero otherwise. | DealScan |
| Leveraged loan | It is a dummy variable coded as one if this loan facility is leveraged and zero otherwise. | DealScan |
| SP Rating | It is a dummy variable coded as one if this loan issuer is rated above BBB rate and zero otherwise. | DealScan |
| Renewable energy | It is a binary indicator for a specific type of energy source. It equals one if the borrower is a renewable energy producer and zero otherwise, based on the TRBC classification. | TRBC sector classifications |
| Oil & Gas | It is a binary indicator for a specific type of energy source. It equals one if the borrower is an Oil & Gas firm and zero otherwise, based on the TRBC classification. | TRBC sector classifications |
| Coal | It is a binary indicator for a specific type of energy source. It equals one if the borrower is a coal firm and zero otherwise, based on the TRBC classification. | TRBC sector classifications |
| Renewable electric utilities | It is a binary indicator for a specific type of energy source. It equals one if the borrower is a renewable electric utilities firm and zero otherwise, based on the TRBC classification. | TRBC sector classifications |
| Fossil fuel electric utilities | It is a binary indicator for a specific type of energy source. It equals one if the borrower is a fossil fuel electric utilities firm and zero otherwise, based on the TRBC classification. | TRBC sector classifications |
| Investment choices | Investment choices are a set of dummy variables and measure whether a loan is issued to renewable energy, Oil & Gas, or coal within the energy production sector or to renewable electric utilities versus fossil fuel electric utilities within the electric utilities sector. | TRBC sector classifications |

(*continued on next page*)

**Table 2** (*continued*)

| Variable name | Variable description | Data source |
|---|---|---|
| | Within the energy production sector, renewable energy is a binary variable that is equal to one if the borrower is classified as renewable energy according to TRBC sector classification and zero otherwise. Oil & gas is a binary variable that is equal to one if the borrower is an Oil & Gas firm and zero if the borrower is a renewable energy firm. Coal is a binary variable that is equal to one if the borrower is a coal firm and zero if the borrower is a renewable energy. The renewable electric utility is a binary variable that is equal to one if the borrower is classified as a renewable electric utilities firm according to TRBC classification and zero otherwise. Fossil fuel electric utility is a binary variable that is equal to one if the borrower is a fossil fuel electric utility firm and zero if the borrower is a renewable electric utilities firm only. | |
| Environmental policy stringency (EPS) index | The OECD Environmental Policy Stringency Index is a country-specific and internationally comparable measure of the stringency of environmental policy in the energy sector. Stringency is defined as "the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behaviour". The index ranges from 0 (not stringent) to 6 (highest degree of stringency) based on the degree of stringency of 14 environmental policy instruments, primarily related to climate and air pollution. It covers 28 OECD and 6 non-OECD countries from 1990 to 2012. It contains two broad categories: market-based and non-market instruments. | OECD database |
| Carbon taxes | Taxes and charges directly applied to the pollution sources, or taxes and charges applied on input (i.e., tax on emission of CO2). | OECD database |
| Trading schemes | Trading schemes are policy instruments to mitigate the effect of climate policies by limiting the quantity of CO2 emission, either through the allocation or purchase of allowance from a central authority or the purchase of emissions credits from market participants. They include Emission Trading Schemes (price of one CO2 allowance), Renewable Energy Certificate Trading Schemes (% of renewable electricity that has to be procured annually), and Energy Certificate Emission Trading Schemes (% of electricity saving that has to be delivered annually) | OECD database |
| Solar & wind support | It is a policy mechanism designed to accelerate investment in renewable energy technologies by offering subsidies or long-term contracts for environmentally friendly activities | OECD database |
| R&D Subsidies | It indicates government R&D expenditure on Renewable energy | OECD database |
| Log GDP per capita | The logarithm of Gross Domestic Product (GDP) per capita in USD. It is an important indicator to capture economic activity | World bank |

energy type are provided in Table 2. Our interest variable is the interaction term (*EPS*EnergySource*), which is created by multiplying the energy sources with the value of EPS. *Control* is a vector of control variables. We control loan characteristics (logarithm of loan size, time to maturity, number of lenders, and other loan types), borrower's credit rate, and GDP per capita. All variables are defined in Table 2.

We also test the EPS component policy instruments effects on loan spread in subsample analysis for energy production and electric utilities, respectively. The estimates of individual policy effects (taxes, trading schemes, R&D subsidies and solar & wind support) are presented in Table 6 for energy production and Table 7 for electric utilities.

To test the second set of hypotheses, we estimate the logic regression specified below.

$$Investment\ choice_{j,i,t} = \alpha_0 + \beta_1 EPS_{i,t} + + \sum_{2}^{k} \beta_i Control_{j,i,t} + \varepsilon_{j,i,t} \qquad (2)$$

In this model, the dependent variable *Investment choice* is a dummy variable. It measures whether the loan is issued to renewable energy, Oil & Gas, or coal within the energy production sector or to renewable electric utilities versus fossil fuel electric utilities within the electric utilities sector. We estimate whether the level of environmental policy stringency in a country affects investment decisions across energy sources. We analyse the effects of the overall EPS index and its component policy instruments (carbon taxes, carbon trading schemes, solar & wind support schemes, and government R&D subsidies) in order to identify which individual policy instrument is effective in influencing financial institutions' risk preferences. We estimate all regression controlling for year and loan purpose fixed effects.

## 4. Empirical results

### 4.1. Baseline results: CE policies and loan spreads

The purpose of this study is to uncover the influences of regulation risk on loan investment in renewable and conventional energies by financial institutions over time in a longitudinal research design. We first report the summary statistics for all samples by energy source and country. Next, we present the impact of both aggregated environmental policy stringency and individual policy on the cost of debt, followed by the impact on financial institution risk preferences. The analysis is conducted on a subsector basis to allow differentiated policy recommendations. In the following discussion, we highlight policy instruments that prove to be effective in influencing the cost of debt and financial institutions' risk preferences among different energy technologies. We also relate our findings to previous literature.

Table 3 reports summary statistics at the syndicated loan tranche level for all samples and by energy production (renewable energy, Oil & Gas, coal mining) and electric utilities (renewable, fossil fuel and mixed electric utilities). Mean, standard deviation and observations are reported for the whole sample and each energy source. The environmental policy stringency variable shows that, within the energy sector, renewable energy has the highest average EPS value of 2.44, followed by Oil & Gas and coal mining. Among different electric utilities technologies, renewable electric utilities have higher ESP value than fossil fuel

**Table 3**
Descriptive statistics for all samples and by energy sector.

| Variable | All sample | | | Energy Production | | | | | | | | | Electric Utilities | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Renewable energy | | | Oil & Gas | | | Coal mining | | | Renewable electric utilities | | | Fossil fuel electric utilities | | | Other electric utilities | | |
| | Mean | St.d | Obs | Mean | St.d | Obs | Mean | St.d | Obs | Mean | St.d | Obs | Mean | St.d | Obs | Mean | St.d | Obs | Mean | St.d | Obs |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) |
| Environmental policy stringency | 2.13 | 0.79 | 15,189 | 2.44 | 0.75 | 1258 | 2.12 | 0.78 | 8240 | 1.83 | 0.85 | 552 | 2.55 | 0.71 | 174 | 2.05 | 0.77 | 143 | 2.09 | 0.79 | 4822 |
| CO2 Trading Scheme | 0.72 | 0.87 | 15,189 | 1.43 | 1.40 | 1258 | 0.66 | 0.74 | 8240 | 0.43 | 0.63 | 552 | 0.91 | 1.18 | 174 | 0.55 | 0.89 | 143 | 0.66 | 0.81 | 4822 |
| CO2 Tax | 0.16 | 0.79 | 15,189 | 0.19 | 0.66 | 1258 | 0.19 | 0.90 | 8240 | 0.04 | 0.37 | 552 | 0.09 | 0.56 | 174 | 0.01 | 0.12 | 143 | 0.13 | 0.66 | 4822 |
| R&D expenditure | 2.37 | 1.14 | 15,189 | 2.08 | 1.25 | 1258 | 2.47 | 1.12 | 8240 | 2.02 | 1.31 | 552 | 1.98 | 1.24 | 174 | 2.19 | 1.24 | 143 | 2.34 | 1.08 | 4822 |
| Solar support | 1.16 | 1.32 | 15,189 | 1.94 | 1.64 | 1258 | 1.08 | 1.18 | 8240 | 1.08 | 1.41 | 552 | 2.55 | 2.29 | 174 | 0.92 | 1.1 | 143 | 1.06 | 1.31 | 4822 |
| Wind support | 1.14 | 1.22 | 15,189 | 1.8 | 1.44 | 1258 | 1.12 | 1.21 | 8240 | 0.98 | 1.16 | 552 | 1.36 | 1.53 | 174 | 0.96 | 1.09 | 143 | 1.03 | 1.12 | 4822 |
| Loan spread (bps) | 215 | 184 | 15,189 | 237 | 175 | 1258 | 230 | 161 | 8240 | 292 | 235 | 552 | 198 | 153 | 174 | 207 | 151 | 143 | 177 | 211 | 4822 |
| Log(Loan size) | 5.89 | 1.33 | 15,189 | 5.31 | 1.23 | 1258 | 5.84 | 1.35 | 8240 | 5.78 | 1.32 | 552 | 6.16 | 1.65 | 174 | 6.34 | 1.15 | 143 | 6.10 | 1.24 | 4822 |
| Time to maturities | 5.03 | 3.93 | 15,189 | 9.60 | 6.52 | 1258 | 4.17 | 2.36 | 8240 | 4.17 | 1.92 | 552 | 7.33 | 5.83 | 174 | 6.32 | 4.90 | 143 | 5.28 | 4.33 | 4822 |
| No. of lenders | 4.14 | 3.77 | 15,189 | 3.77 | 4.25 | 1258 | 4.02 | 3.75 | 8240 | 3.95 | 3.25 | 552 | 4.76 | 4.74 | 174 | 4.08 | 2.99 | 143 | 4.45 | 3.67 | 4822 |
| Guarantor | 0.04 | 0.20 | 15,189 | 0.02 | 0.13 | 1258 | 0.05 | 0.22 | 8240 | 0.05 | 0.21 | 552 | 0.05 | 0.21 | 174 | 0.05 | 0.22 | 143 | 0.04 | 0.19 | 4822 |
| Revolver | 0.57 | 0.50 | 15,189 | 0.17 | 0.38 | 1258 | 0.65 | 0.48 | 8240 | 0.44 | 0.50 | 552 | 0.29 | 0.46 | 174 | 0.48 | 0.50 | 143 | 0.55 | 0.50 | 4822 |
| Term loan | 0.08 | 0.27 | 15,189 | 0.06 | 0.24 | 1258 | 0.09 | 0.28 | 8240 | 0.13 | 0.34 | 552 | 0.09 | 0.29 | 174 | 0.09 | 0.29 | 143 | 0.07 | 0.25 | 4822 |
| Leveraged loan | 0.51 | 0.50 | 15,189 | 0.49 | 0.50 | 1258 | 0.63 | 0.48 | 8240 | 0.70 | 0.46 | 552 | 0.27 | 0.45 | 174 | 0.47 | 0.50 | 143 | 0.30 | 0.46 | 4822 |
| SP Rating | 0.17 | 0.38 | 15,189 | 0.01 | 0.11 | 1258 | 0.11 | 0.31 | 8240 | 0.04 | 0.19 | 552 | 0.22 | 0.41 | 174 | 0.31 | 0.47 | 143 | 0.33 | 0.47 | 4822 |
| log(GDP per capita) | 10.51 | 0.81 | 15,189 | 10.4 | 0.84 | 1258 | 10.6 | 0.81 | 8240 | 10.2 | 1.15 | 552 | 10.3 | 1 | 174 | 10.2 | 1.26 | 143 | 10.5 | 0.71 | 4822 |

This table reports summary statistics at the syndicated loan tranche level for all samples and by energy source. We use the Thomson Reuters Business Classification (TRBC) economic sector system to classify borrowers into energy production and electric utilities sectors. There are three types of energy sources: renewable energy, Oil & Gas, and coal. The electric utilities include renewable electric utilities, fossil fuel electric utilities and other electric utilities. We document 14,573 loan tranche observations for a total of 4066 firms in the energy (2813) and electric utilities (1253) sectors in 26 OECD countries and 6 non-OECD countries over the period 2000–2019.

and mixed electric utilities. This suggests that renewable investment most occurred in countries with the most stringent environmental regulations. In contrast, conventional energy sources such as Oil & Gas and coal mining borrowers are often from countries with less policy stringency. This feature also applies to five components of the EPS index: taxes, trading schemes, solar & wind supporting schemes, and government R&D subsidies. The mean and standard deviation of loan spread for coal mining are 292 and 235, much higher than those of renewable and Oil & Gas energies, indicating that the capital cost for coal mining is the highest and varies significantly over time and across borrowers. There isn't much variation in loan spreads across electric utilities technologies.

The average loan size for renewable energy is relatively smaller than for conventional energies, and the dispersion for the former is smaller than the latter. It is worth noting that the mean time to maturity for renewable energy is twice longer than for Oil & Gas, and coal. It is also interesting to note that, on average, renewable energy borrowers have lower credit ratings than other energy sources. We also observe that, in the energy sector, Oil & Gas account for 82 % of the total deals for the whole period, whereas renewable energy represents approximately 13 %, with coal being just 5 % of our sample. In the electric utilities sector, 94 % of the loans are issued to mixed electric utilities. The share of renewable and fossil fuel electric utilities is only 3.4 % and 2.6 %, respectively.

Table 4 presents the country distribution of syndicated loans. Columns (1), (2), and (3) report the mean of loan spread, loan size, and overall EPS value by country. Columns (4), (5), and (6) present the country distribution of syndicated loans in renewable energy, Oil & Gas, and coal, respectively. Columns (7) to (9) report the loan distribution in renewable and fossil fuel electric utilities. Column (10) shows the number of loan tranche observations in a country. The average loan spread varies significantly across countries. On average, while Indonesia, South Africa, and Israel have the highest loan spreads above 349 bps, Japan, Finland, Greece, and Hungary have the lowest loan spreads lower than 100 bps. The variation in loan tranche volume is not as significant as the loan spread. Looking at the distribution of the overall environmental policy stringency, environmental policies to reduce greenhouse gas emissions and support renewable energy vary widely across countries and over time. During the sample period, three country groups can be distinguished with regard to their aggregate EPS level: at the lower end of the spectrum, Brazil, New Zealand and Indonesia; above the average, France, Sweden, and Japan; the rest of the countries score close to the average. Looking at the renewable energy share, we observe that the percentage of renewable energy loan investment is over 60 % in Demark and Portugal, the highest among all the sample countries. The highest rate of loan investment in renewable electric utilities is 20 % in Austria. It is worth mentioning that approximately 1/3 of loans are made to US borrowers in the energy sector, followed by Canada and the United Kingdom. We will make sure to conduct a subsample (excluding the US data) robustness test after the main analysis. The country distribution of loan deals in renewable energy is in line with the geographical distribution of venture capital deals in clean energy 40 % of companies receiving funding are in the US, followed by the UK and Canada (Criscuolo and Menon, 2015). The correlation between variables is reported in Appendix Table 2.

### 4.2. Baseline results: environmental policies stringency and the cost of debt

Table 5 presents the effect of overall environmental policy stringency on the cost of debt across energy sources: renewable energy, Oil & Gas, coal, renewable electric utilities, and fossil fuel electric utilities, along with the interaction of each energy type with EPS in the regression. In each regression, the dependent variable is the loan spread. Column (1) reports the estimates of the effect of EPS on loan spreads without controlling for country, firm and loan facility-level factors. Column (2) reports the regression results controlling for loan facility-level

**Table 4**
Country distribution of loan spreads, loan size, EPS and energy sources.

| Country | Loan spreads | Log loan size | EPS | Energy sources | | | Electric utilities | | | Obs |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Renewable energy | Oil & Gas | Coal | Renewable electric utilities | Fossil fuel electric utilities | Other electric utilities | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| United States | 220.29 | 5.28 | 2.06 | 0.04 | 0.59 | 0.03 | 0.00 | 0.01 | 0.33 | 10,099 |
| Canada | 198.95 | 5.38 | 2.68 | 0.04 | 0.66 | 0.03 | 0.03 | 0.00 | 0.24 | 636 |
| United Kingdom | 229.38 | 5.12 | 2.73 | 0.17 | 0.46 | 0.01 | 0.00 | 0.00 | 0.35 | 534 |
| Australia | 191.06 | 4.95 | 2.40 | 0.16 | 0.21 | 0.12 | 0.09 | 0.00 | 0.43 | 448 |
| Spain | 156.69 | 4.34 | 2.36 | 0.50 | 0.09 | 0.00 | 0.00 | 0.00 | 0.40 | 417 |
| India | 280.88 | 5.24 | 1.73 | 0.12 | 0.56 | 0.01 | 0.03 | 0.04 | 0.24 | 338 |
| Italy | 161.42 | 4.75 | 2.82 | 0.32 | 0.10 | 0.00 | 0.07 | 0.00 | 0.51 | 231 |
| Russia | 259.32 | 5.84 | 0.71 | 0.00 | 0.85 | 0.10 | 0.02 | 0.02 | 0.01 | 217 |
| Netherlands | 158.15 | 5.59 | 2.91 | 0.12 | 0.69 | 0.03 | 0.04 | 0.03 | 0.10 | 196 |
| Germany | 176.72 | 5.65 | 2.92 | 0.35 | 0.32 | 0.03 | 0.01 | 0.00 | 0.30 | 187 |
| Indonesia | 351.26 | 5.10 | 0.65 | 0.11 | 0.36 | 0.36 | 0.01 | 0.01 | 0.15 | 179 |
| France | 140.67 | 4.74 | 3.38 | 0.31 | 0.27 | 0.04 | 0.03 | 0.00 | 0.35 | 167 |
| China (Mainland) | 298.61 | 4.88 | 2.28 | 0.04 | 0.51 | 0.13 | 0.02 | 0.02 | 0.29 | 166 |
| Brazil | 269.28 | 5.14 | 0.43 | 0.11 | 0.47 | 0.04 | 0.01 | 0.01 | 0.36 | 161 |
| Mexico | 163.49 | 5.36 | 1.00 | 0.10 | 0.56 | 0.02 | 0.01 | 0.00 | 0.30 | 147 |
| Switzerland | 135.66 | 6.97 | 3.13 | 0.00 | 0.88 | 0.11 | 0.00 | 0.00 | 0.01 | 133 |
| Norway | 205.08 | 5.88 | 3.20 | 0.02 | 0.92 | 0.01 | 0.00 | 0.00 | 0.05 | 125 |
| Portugal | 168.85 | 4.14 | 2.56 | 0.62 | 0.02 | 0.00 | 0.06 | 0.00 | 0.30 | 97 |
| Hong Kong | 169.24 | 5.63 | 1.92 | 0.02 | 0.66 | 0.03 | 0.01 | 0.00 | 0.28 | 90 |
| South Korea | 340.93 | 4.17 | 2.91 | 0.27 | 0.16 | 0.05 | 0.06 | 0.13 | 0.34 | 86 |
| Chile | 147.82 | 4.72 | 0.84 | 0.10 | 0.20 | 0.00 | 0.01 | 0.01 | 0.68 | 84 |
| Turkey | 227.92 | 5.09 | 1.48 | 0.28 | 0.33 | 0.00 | 0.02 | 0.00 | 0.37 | 54 |
| Poland | 120.77 | 4.54 | 2.09 | 0.21 | 0.49 | 0.00 | 0.00 | 0.00 | 0.30 | 53 |
| Czech Republic | 164.92 | 4.53 | 2.62 | 0.25 | 0.39 | 0.00 | 0.00 | 0.00 | 0.36 | 36 |
| Finland | 96.89 | 6.10 | 2.98 | 0.09 | 0.09 | 0.00 | 0.00 | 0.00 | 0.82 | 33 |
| Belgium | 182.73 | 4.71 | 2.69 | 0.28 | 0.34 | 0.00 | 0.00 | 0.16 | 0.22 | 32 |
| Japan | 67.34 | 5.48 | 3.23 | 0.00 | 0.45 | 0.00 | 0.03 | 0.03 | 0.48 | 29 |
| Greece | 97.77 | 5.03 | 1.65 | 0.07 | 0.79 | 0.00 | 0.00 | 0.00 | 0.14 | 28 |
| Sweden | 213.30 | 6.20 | 3.30 | 0.04 | 0.57 | 0.00 | 0.00 | 0.00 | 0.39 | 28 |
| Hungary | 93.81 | 6.02 | 2.61 | 0.00 | 0.78 | 0.00 | 0.00 | 0.04 | 0.19 | 27 |
| Ireland | 149.90 | 4.08 | 2.28 | 0.36 | 0.16 | 0.00 | 0.00 | 0.08 | 0.40 | 25 |
| South Africa | 349.00 | 4.49 | 0.73 | 0.20 | 0.32 | 0.20 | 0.00 | 0.00 | 0.28 | 25 |
| New Zealand | 146.38 | 5.14 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 24 |
| Austria | 101.33 | 6.25 | 2.72 | 0.00 | 0.47 | 0.13 | 0.20 | 0.00 | 0.20 | 15 |
| Denmark | 120.67 | 5.69 | 3.09 | 0.60 | 0.13 | 0.00 | 0.00 | 0.00 | 0.27 | 15 |
| Israel | 403.85 | 5.21 | 0.95 | 0.00 | 0.92 | 0.00 | 0.00 | 0.00 | 0.08 | 13 |
| Slovakia | 137.25 | 5.20 | 1.79 | 0.10 | 0.20 | 0.00 | 0.00 | 0.00 | 0.70 | 10 |

characteristics, and column (3) shows the results after controlling for loan and firm characteristics. Column (4) reports the estimated coefficients of the five energy sources accounting for loan facility-, firm-, and country-level characteristics. All regressions control for year, country, and loan purpose fixed effects to account for unknown factors in the market.

We find that the coefficients of EPS ($\beta_1$) and renewable energy ($\beta_2$) are all positive and significant, which suggests that, in general, the cost of debt for renewable energy production is higher than that of conventional energy[14] and loan spreads have also been higher in countries with higher EPS than countries with lower levels of EPS over the past 20 years. However, the coefficient on the interaction term (*EPS*Renewable energy*) ($\beta_3$) is negative and highly significant, indicating renewable energy borrowers experience lower borrowing costs than fossil fuel firms in countries with higher policy stringency. A one standard deviation increase of the environmental policy stringency index leads to a decrease in loan spread of 17 bps (−21.938*0.79) for the renewable loan investment, compared to a loan issued to fossil fuels and other firms (Column (4)). The results support hypothesis 1.1 and suggest that environmental policies can play a crucial role in reducing the cost of debt for renewable energy.

We then look at the influence of the environmental policy stringency on loan pricing for Oil & Gas firms compared to renewable and other energy types, controlling for country, firm and loan facility-level characteristics in Column (4). Our interest variable, the estimate of the interaction term (*EPS*Oil&Gas*), is positive and statistically significant at the 1 % significant level. The results suggest that the borrowing cost for Oil & Gas is higher in countries with higher levels of policy stringency. An increase of one standard deviation in the fitted value of EPS translates into an increase in the loan spread of 14 bps for Oil & Gas firms compared to other energy types.[15] Similarly, this policy effect applies to coal. An increase of one standard deviation in the value of EPS corresponds to an increase in the loan spread of 27 bps for coal borrowers relative to other borrowers. The relationships are economically and statistically significant. Our results highlight that the climate and environmental policies increase risks associated with fossil fuel investments, which supports hypotheses 1.2 and 1.3.

Turning to the results of the EPS effect on loan spread for renewable

[14] IEA 2015 Energy Technology Perspectives also reports that fossil fuels are still significantly cheaper than low-carbon alternatives under many circumstances. https://iea.blob.core.windows.net/assets/3f901e93-c083-4649-a9e6-c591e28a7b70/ETP2015.pdf

[15] The standard deviation of EPS for all samples is 0.79, and the coefficient of the interaction term *EPS*Oil&Gas* is 17.423 in Column (4). Therefore, when loans issued to Oil &Gas (*Oil&Gas* $= 1$), one standard deviation increase in ESP is associated with 14 bps (17.423*0.79) decrease in loan spreads.

**Table 5**
The results of overall CE policy effect on loan spreads by energy sources.

| | Loan spreads | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| EPS* Renewable energy | −22.774*** | −23.020*** | −22.879*** | −21.938*** |
| | (7.395) | (6.504) | (6.502) | (6.512) |
| EPS *Oil & Gas | 28.604*** | 17.535*** | 17.107*** | 17.423*** |
| | (4.169) | (3.669) | (3.670) | (3.671) |
| EPS *Coal | 36.390*** | 33.029*** | 32.903*** | 33.844*** |
| | (9.684) | (8.472) | (8.469) | (8.476) |
| EPS*Renewable electric utilities | 9.923 | 17.504 | 15.935 | 15.687 |
| | (18.632) | (16.308) | (16.307) | (16.305) |
| EPS *Fossil fuel electric utilities | −0.644 | 3.005 | 2.011 | 2.263 |
| | (19.119) | (16.723) | (16.719) | (16.717) |
| Renewable energy | 103.990*** | 52.199*** | 50.942*** | 49.345*** |
| | (18.286) | (16.060) | (16.058) | (16.068) |
| Oil & Gas | −8.593 | −35.354*** | −36.738*** | −37.448*** |
| | (9.298) | (8.174) | (8.181) | (8.184) |
| Coal | 33.450* | −33.320* | −35.475** | −37.726** |
| | (20.120) | (17.641) | (17.645) | (17.666) |
| Renewable electric utilities | −13.335 | −45.642 | −41.978 | −40.778 |
| | (49.003) | (42.900) | (42.896) | (42.892) |
| Fossil fuel electric utilities | 15.440 | −20.576 | −17.934 | −18.213 |
| | (41.721) | (36.489) | (36.483) | (36.477) |
| EPS | 10.629* | 10.731* | 11.399** | 12.085** |
| | (6.275) | (5.504) | (5.505) | (5.511) |
| Log(loan size) | | −5.414*** | −4.781*** | −4.792*** |
| | | (1.126) | (1.140) | (1.139) |
| Time to Maturities | | 1.969*** | 1.892*** | 1.837*** |
| | | (0.400) | (0.401) | (0.401) |
| No. of Lenders | | −3.906*** | −3.843*** | −3.748*** |
| | | (0.401) | (0.402) | (0.403) |
| Guarantor | | −28.579*** | −29.621*** | −30.191*** |
| | | (6.165) | (6.170) | (6.173) |
| Revolver | | −66.635*** | −65.768*** | −65.579*** |
| | | (3.288) | (3.295) | (3.296) |
| Term loan | | 16.355*** | 16.066*** | 16.262*** |
| | | (5.054) | (5.053) | (5.053) |
| Leveraged loan | | 150.004*** | 145.692*** | 145.451*** |
| | | (2.820) | (3.069) | (3.070) |
| SP Rating | | | −14.355*** | −14.374*** |
| | | | (4.043) | (4.043) |
| Log (GDP per capita) | | | | −17.382** |
| | | | | (7.130) |
| Observations | 15,187 | 15,187 | 15,187 | 15,187 |
| R-squared | 0.147 | 0.348 | 0.349 | 0.349 |
| Year FE | YES | YES | YES | YES |
| Loan purpose FE | YES | YES | YES | YES |
| Country FE | YES | YES | YES | YES |

This table shows the regression results of Eq. (1). Column (1) reports the estimates of the effect of EPS on loan spreads without controlling for loan facility-, firm-, and country-level characteristics. Column (2) reports the regression results controlling for loan facility-level characteristics, and column (3) accounts for loan facility and firm characteristics. Column (4) shows the results accounting for loan facility-, firm-, and country-level characteristics. Five dummy variables of energy sources and utilities (Renewable energy, Oil & Gas, Coal, Renewable Electric Utilities, Fossil Fuel Electric Utilities) are created based on the full sample (the sample size decreases to 15,187 as two singleton observations dropped in the regression). It is a binary indicator for a specific type of energy source and equals one if the borrower is one type of energy and zero if any other energy sources, based on the TRBC sector classification. For instance, it is equal to 1 if the borrower is a renewable energy firm and zero if any other energy sources/utilities. The definition of each type of energy source is reported in Table 2. For instance, it is equal to 1 if the borrower is a renewable energy firm and zero if any other energy sources/utilities. The definition of each type of energy source is reported in Table 2. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. We use robust standard errors in these regressions. The dependent variable is the syndicated loan spread. Controls include loan characteristics, borrowers' credit rating and logged GDP per capita. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

electric utilities relative to fossil fuel and mixed electric utilities in Column (4). It shows that the EPS effect ($\beta_1$) is positive and significant, but the estimate for the interaction term *EPS*Renewable electric utilities* ($\beta_3$) is insignificant. These results suggest that while the EPS has a significant positive effect on loan spread in general, the difference in the policy effects between renewable electric utilities and fossil fuel and mixed electric utilities is negligible. Similarly, the coefficient of the interaction term between EPS and fossil fuel electric utilities is insignificant. Overall, the findings suggest that electric utility firms experience higher borrowing costs in countries with higher EPS levels, and this policy effect does not vary between renewable and fossil fuels electric utilities. One of the explanations might be that, within the electric utilities sector, most companies are classified as "Mixed Electric Utilities," as many companies do not operate in one specific energy type but invest in both fossil fuel and renewable utilities companies. In our sample of the electric utilities sector, 93 % of loan transitions were issued to mixed electric utilities firms.

The coefficients of the control variables in all models are in the expected direction and consistent with the prior literature. Larger firms (loan volume) and higher credit rating firms have lower spreads. Among the loan-specific features, a higher number of lenders and revolver loans are associated with lower loan spreads, whereas leverage loans have a higher loan spread.

We then look at the components of the EPS effects and identify which policy indicators are more effective in affecting the cost of debt for energy production and electric utilities, respectively. It is suggested that different types of policy instruments might not be of an equivalent degree of ambition in achieving environmental objectives, and some policy instruments are better suited to deal with the specific capital market imperfections relevant to renewable projects ((Rodríguez et al., 2014).

The results of individual effects of CE policies (taxes, trading schemes, R&D subsidies, and solar & wind supports) on loan spread within the energy production sector are reported in Table 6. Column (1) reports the estimated coefficients for renewable energy relative to Oil & Gas and coal. We present regression specifications with year, country and loan purpose fixed effects. The coefficient of the interaction term *CO2 taxes* Renewable energy* is negative and significant, suggesting that banks tend to charge a significantly lower spread for renewable energy issuers than conventional energy borrowers in a country with a higher level of emission tax. The relationship is economically and statistically significant. The coefficient of the interaction term *CO2 trading schemes*Renewable energy* indicates that banks also integrate the carbon trading schemes in assessing the risk of an investment opportunity and charge approximately 12 bps lower spread on loans issued to renewable energy borrowers than conventional energy firms when the trading schemes increase one standard deviation (0.74). Banks also incorporate national R&D subsidies into investment analysis and decision-making processes. There is a significant negative relationship between the R&D subsidies level and loan spread for the renewable energy project. Among the four individual CE policy instruments, it seems that solar & wind-supporting policies have no significant effect on the cost of borrowing for both renewable and fossil fuels energy firms.

Column (2) reports the estimated coefficients for Oil & Gas relative to other energy types. Looking at the impact of carbon taxes, an increase of one standard deviation in the fitted value of carbon taxes (0.86) translates into an increase in the loan spread of 18 bps for Oil & Gas firms. The coefficients of interaction terms *Trading schemes*Oil&Gas* and *R&D subsidies *Oil&Gas* are also positive and significant, suggesting that both trading schemes and R&D subsidies increase regulation risks associated with Oil & Gas investments. These results indicate that banks are sensitive to climate change policies in issuing loans to Oil & Gas projects. The impact of policies on loan spread for coal investment compared to renewable energy and Oil & Gas is reported in columns (3). We observe

**Table 6**
The results of different CE policy instruments effects on loan spreads in the energy production sector.

| Variable | Loan spreads | | |
|---|---|---|---|
| | Energy production | | |
| | Renewable Energy | Oil & Gas | Coal |
| | (1) | (2) | (3) |
| CO2 taxes* Renewable energy | −20.530*** | | |
| | (6.600) | | |
| CO2 trading schemes*Renewable energy | −15.570*** | | |
| | (4.281) | | |
| R&D subsidies*Renewable energy | −18.515*** | | |
| | (3.736) | | |
| Solar&Wind*Renewable energy | 1.083 | | |
| | (3.543) | | |
| CO2 taxes* Oil & Gas | | 20.724*** | |
| | | (6.087) | |
| CO2 trading schemes*Oil & Gas | | 10.730*** | |
| | | (4.130) | |
| R&D subsidies*Oil & Gas | | 8.138*** | |
| | | (3.156) | |
| Solar&Wind*Oil & Gas | | 1.372 | |
| | | (3.097) | |
| CO2 taxes* Coal | | | 0.951 |
| | | | (15.181) |
| CO2 trading schemes*Coal | | | 36.995*** |
| | | | (11.585) |
| R&D subsidies*Coal | | | 1.436 |
| | | | (5.452) |
| Solar&Wind*Coal | | | −8.983 |
| | | | (5.844) |
| CO2 taxes | 5.045 | −15.149** | 4.186 |
| | (3.863) | (6.215) | (3.687) |
| CO2 trading schemes | 7.282** | −4.908 | 0.496 |
| | (3.125) | (3.311) | (2.511) |
| R&D subsidies | 10.320*** | 1.285 | 8.085*** |
| | (2.927) | (3.741) | (2.867) |
| Solar&Wind | 1.956 | 1.282 | 2.893 |
| | (2.121) | (3.029) | (2.036) |
| Renewable energy | 51.984** | | |
| | (21.042) | | |
| Oil & gas | | −40.014*** | |
| | | (8.348) | |
| Coal | | | 14.022 |
| | | | (12.748) |
| Observations | 10,049 | 10,049 | 10,049 |
| R-squared | 0.419 | 0.418 | 0.417 |
| Controls | YES | YES | YES |
| Year, country, and loan purpose FE, | YES | YES | YES |

This table shows the regression results of Eq. (1) in the energy production sector. Columns (1) to (3) report the estimated coefficients for renewable fuels, Oil & Gas and coal. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. Our variable of interest is the interaction between different climate and environmental policy instruments and energy sources. Renewable energy is a binary variable that equals one if the borrower is classified as renewable energy according to TRBC classification and zero otherwise. Oil and gas is a binary variable that equals one if the borrower is an Oil & Gas firm and zero otherwise. Coal is a binary variable that equals one if the borrower is a coal firm and zero otherwise. The dependent variable is the syndicated loan spread. Controls include loan characteristics, borrowers' credit rating and logged GDP per capita. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

**Table 7**
The results of different CE policy instruments effect on loan spreads in the electric utilities sector.

| Variables | Loan spreads | |
|---|---|---|
| | Electric utilities | |
| | Renewable electric utilities | Fossil fuel electric utilities |
| | (1) | (2) |
| CO2 taxes* Renewable electric utilities | −12.414 | |
| | (25.968) | |
| CO2 trading schemes*Renewable electric utilities | −0.120 | |
| | (14.472) | |
| R&D subsidies*Renewable electric utilities | 4.420 | |
| | (13.684) | |
| Solar&Wind*Renewable electric utilities | 15.271 | |
| | (10.924) | |
| CO2 taxes* Fossil fuel electric utilities | | −102.850 |
| | | (137.379) |
| CO2 trading schemes*Fossil fuel electric utilities | | 46.819** |
| | | (22.975) |
| R&D subsidies*Fossil fuel electric utilities | | 6.960 |
| | | (15.191) |
| Solar&Wind*Fossil fuel electric utilities | | −19.565 |
| | | (15.954) |
| CO2 taxes | 8.145 | 8.220 |
| | (6.867) | (6.707) |
| CO2 trading schemes | 8.365 | 6.986 |
| | (5.109) | (4.957) |
| R&D subsidies | 5.717 | 6.069 |
| | (6.454) | (6.419) |
| Solar&Wind | −6.203 | −4.099 |
| | (3.947) | (3.839) |
| Renewable electric utilities | −38.569 | |
| | (38.831) | |
| Fossil fuel electric utilities | | −43.869 |
| | | (40.696) |
| Observations | 5136 | 5136 |
| R-squared | 0.258 | 0.259 |
| Controls | YES | YES |
| Year, country, and loan purpose FE, | YES | YES |

This table shows the regression results of Eq. (1) in the electric utilities sector. Column (1) reports the estimated coefficients for renewable electric utilities, and column (2) shows the coefficients for fossil fuel electric utilities. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. Our variable of interest is the interaction between environmental policy instruments and energy sources. The renewable electric utility is a binary variable that is equal to one if the borrower is classified as a renewable electric utilities firm according to TRBC classification and zero if it is fossil fuel and other mixed electric utilities. Fossil fuel electric utility is a binary variable that is equal to one if the borrower is a fossil fuel electric utility firm and zero if it is renewable or other mixed electric utilities. The dependent variable is the syndicated loan spread. Controls include loan characteristics, borrowers' credit rating and logged GDP per capita. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

that trading schemes have a statistically positive effect on loan spread (*CO2 trading schemes*Coal*), whereas the impact of other policy instruments is insignificant.

Table 7 reports the effects of individual CE policy instruments on the cost of debt for electric utilities. The coefficients of our interest variables—the interaction terms for policy instruments and electric utility types—are insignificant for both renewable and fossil fuel electric utilities, except *CO2 trading schemes*Fossil fuel electric utilities*. Compared to the positive overall EPS effect on loan spreads, the impact of individual policy stringency on financial cost is negligible, controlling for year, country, loan purpose fixed effects and other compounding factors.

In sum, the EPS components results show that carbon taxes, carbon trading schemes, and R& D support policies are effective in increasing the cost of debt for Oil & Gas compared to renewable energy in the energy production sector. We provide evidence that the regulation risk is priced by financial institutions, which seem to demand a significantly higher interest rate from conventional energies that are more exposed to the CE policies. For electric utilities, it appears that the effect of individual policy effect on borrowing costs is limited for both renewable and fossil fuel electric utilities.

### 4.3. Endogeneity – difference in difference (DiD) analysis

Endogeneity, which can arise from unobserved heterogeneity or omitted variables in panel data analysis, is a valid concern for our estimates. One approach to address unobserved heterogeneity is to include fixed effects in the model (Imbens and Wooldridge, 2009). In our regression, we control for fixed effects of year, country, and loan type to correct potential bias induced by unobserved country-specific effects and endogeneity of explanatory variables. However, we also employ a difference-in-difference approach to alleviate these concerns further.

The European Union Emission Trading System (EU ETS) was established in 2005 with the aim of reducing carbon emissions and incentivising companies to adopt more sustainable practices. To accomplish this, regulated firms must modify their operations and investments to reduce their emissions when faced with a higher price of emissions compared to their other production costs. This cap-and-trade program grants companies the ability to emit a certain amount of greenhouse gases annually. If a company exceeds its allowance at the end of the year, it must either purchase extra allowances from another company or pay a fine. This market-based emission program grants firms the flexibility to work toward reducing total emissions. The EU ETS is the world's first and largest international trading system, accounting for over 75 % of global carbon trading. Among the 40 countries in our sample, 19 European countries implemented the cap-and-trade program in 2005 and 2 European countries in 2007.

Following (Fard et al., 2020), we employ the EU ETS as a natural experiment and utilise a difference-in-difference model to assess the impacts of the EU ETS on target countries for fossil fuels energy production, including Oil & Gas and coal. The model specifications are detailed/explained in Appendix 7. Out of the 40 countries in our sample, 19 European countries implemented the EU ETS program in 2005 and 2 European countries in 2007. Fig. 1 illustrates the changes in loan spread for the EU ETS countries and non-EU ETS countries over the past two decades. Prior to the launch of the carbon trading scheme in 2005, there was a generally parallel trend between the two groups. The target countries that adopted the EU ETS have a lower loan cost than the control countries that haven't implemented the EU ETS. This trend changed after 2005 when the loan spreads for target countries surged, causing the gap to narrow to less than 50 bps with those of control countries in 2008. Since the financial crisis ended in 2010, the loan spreads between the two groups have hovered around 250 bps, and the gap has almost closed.

The result of DiD analysis is reported in Table 8. In Column (1), the DiD coefficient on Target * Post is 38.840 and statistically significant, suggesting that after the implementation of the EU ETS, Oil & Gas companies in countries that participated in the scheme had a significant increase in their loan spreads compared to their peers in countries that did not adopt the scheme. Column (2) reports the estimates for Oil & Gas and coal mining. The coefficient on the interaction term Target * Post is also positive and highly significant, indicating that the result is consistent for all fossil fuel energy production. This result not only supports our previous findings in the fixed effect models but also alleviates endogeneity concerns, improves the identification of the EC policy effect, and enables a more causal interpretation of our results.

### 4.4. The effect of EPS on financial institutions' risk preferences

This subsection presents the results relating the overall value and components of EPS value with investors' risk preferences. We measure risk preference using investment choices between renewable and conventional energies. Table 9 reports the logit regression results of the aggregated EPS effect on the lender's risk preferences (hypothesis 2). Columns (1) to (3) present the estimations for renewable, Oil & Gas, and coal energy sources. Columns (4) to (5) show the estimations for renewable and fossil fuel electric utilities. The regressions include all loan characteristics, borrowers' credit ratings, and logged GDP per capita controls. The coefficient of the aggregated EPS is 0.722 for renewable energy (column 1) and significant at the 1 % level. This finding supports hypothesis 2.1, that lenders are more likely to issue a loan to renewable firms in a country with a higher level of environmental policy stringency. And a country with a lower level of EPS likely struggles to attract investment in renewable energy. Together with the result that the EPS value decreases the cost of debt, this result shows that

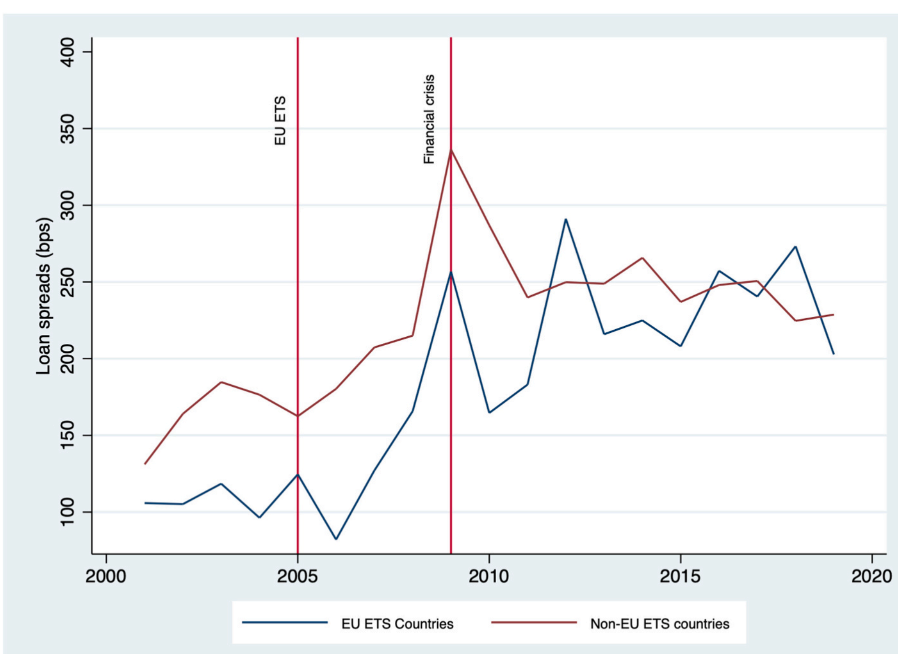


**Fig. 1.** The changes in the loan spreads for fossil fuels energy production.

**Table 8**
The results of difference in difference analysis.

| Variable | Loan spreads | |
|---|---|---|
| | Oil & Gas production | Oil & Gas and Coal mining |
| | (1) | (2) |
| Target*Post | 38.840*** | 35.075*** |
| | (10.881) | (10.878) |
| Target | 53.798 | 59.145* |
| | (33.316) | (33.926) |
| Post | 97.792*** | 108.105*** |
| | (11.171) | (11.397) |
| Log(loan size) | −12.342*** | −11.013*** |
| | (1.276) | (1.291) |
| Time to Maturities | 2.674*** | 2.037*** |
| | (0.669) | (0.677) |
| No. of Lenders | −3.987*** | −4.349*** |
| | (0.464) | (0.472) |
| Guarantor | −24.035*** | −26.300*** |
| | (6.345) | (6.431) |
| Revolver | −103.980*** | −104.862*** |
| | (3.681) | (3.704) |
| Term loan | −6.706 | −6.874 |
| | (5.510) | (5.523) |
| Leveraged loan | 129.399*** | 132.887*** |
| | (3.467) | (3.514) |
| SP Rating | −15.497*** | −15.629*** |
| | (5.043) | (5.189) |
| Log(GDP per capita) | 1.171 | −4.852 |
| | (7.354) | (7.290) |
| Observations | 8240 | 8792 |
| R-squared | 0.446 | 0.435 |
| Year FE | YES | YES |
| Loan purpose FE | YES | YES |
| Country FE | YES | YES |

This table presents the results of the difference-in-difference regressions that test the effect of implementing carbon trading scheme in European countries on the cost of bank loans for Oil & Gas production (Column (1)) and Oil & Gas and coal mining (Column (2)). The dependent variable in all models is loan spreads. The target equals one if it is from countries that adopted the EU ETS scheme and zero otherwise. The Post equals one if firm-year observations after the EU ETS was adopted in 2005 and zero otherwise. Target*Post are the interaction terms showing the impacts of adopting the Emission Trading System on fossil fuels firms' cost of loans in EU ETS countries compared to non-EU ETS countries. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

risk-averse financial institutions tend to invest in renewable energy, which is less risky than conventional energies in a country with a higher level of EPS. This finding aligns with (Rodríguez et al., 2014), who find that environmental policies positively correlate with private financing for renewable energy. Column (2) shows the EPS effect on the probability of issuing a loan to an Oil & Gas firm. The coefficient is −0.708, at a 1 % significance level, suggesting that the EPS effectively decrease investment preference for Oil & Gas investment compared to renewable energy. The estimate of EPS in column (3) is negative and significant, indicating that financial institutions are less likely to invest in coal in a country with more stringent environmental policies. We accept hypotheses 2.2 and 2.3.

Regarding the EPS effect on investment choice between renewable and fossil fuel electric utilities technologies, the coefficient of EPS in column (4) is 0.526 and significant at the 1 % level. This finding suggests that the increase in environmental stringency level has a positive effect on capital flow into renewable electric utilities compared to fossil fuel and mixed electric utilities. This result supports hypothesis 2.4, that banks tend to invest in renewable firms in a country with a higher EPS level. This finding is consistent with (Apergis et al., 2022), who find that corporate environmental performance is associated with a lower cost of debt in the primary bond market. This implies that climate regulation risks influence how investors allocate their capital and exercise their oversight of firms.

Columns (5) report the results of the aggregated EPS effects on risk preference for fossil fuel electric utilities. The coefficient is statistically negative, suggesting that the overall EPS decreases the loan issued to fossil fuel electric utilities compared to renewable electric utilities, which supports hypothesis 2.5.

We then look at which CE policy instruments are more effective in changing lenders' investment decisions between energy sources. The results are reported in Table 10. The logit regression specification is similar to the specification in Table 9, with a dummy variable of an energy source as the dependent variable and using loan facility-firm and country-level controls. Columns (1) to (3) report the influence of carbon taxes, carbon trading schemes, R&D subsidies, and solar & wind support schemes on investment preference among renewable energy, Oil & Gas and coal. The coefficients on trading schemes and solar wind supports are positive and significant at the 1 % level for renewable investments, indicating that the introduction of the carbon trading scheme and solar & wind supporting instruments accelerates the capital flow to renewable energy in the loan market. This finding is consistent with (Cojoianu et al., 2020), who show that solar & wind support policy contributes greatly to the new green venture financing. Evidence from survey analysis also supports those financial institutions perceived solar & wind support as an effective renewable energy policy. And the preference for solar & wind schemes is even more pronounced among financial institutions based in Europe and with higher exposure to clean energy (Bürer and Wüstenhagen, 2009).

The estimates for trading schemes and solar & wind support are negative and significant at the 1 % level for Oil & Gas (Column 2), suggesting that those two schemes significantly reduce the likelihood of investing in Oil & Gas compared to renewable energy. The results of different EPS policy instruments effects on coal investment are reported in columns (3). Compared to renewable energy, we find that the likelihood of investing in coal is significantly lower in a country with higher trading schemes and solar & wind supporting instruments. They contribute significantly to coal phase-out in a country. The change in the level of taxes and government subsidies seems to have a negligible effect on capital flow among energy sources.

Column (4) reports the estimates of investment preference for renewable electric utilities compared to fossil fuel and mixed electric utilities. Column (5) presents the results of investment preference between fossil fuel and renewable electric utilities. Again, we find that solar & wind support, such as feed-in tariff schemes, attracts significantly more loan investment in renewable electric utilities compared to fossil fuel and other electric utilities. The changes in the level of the carbon tax, carbon trading schemes and R&D subsidies hardly influence investment choice for renewables. Regarding risk preference between fossil fuel and renewable electric utilities, solar & wind support is the only policy instrument that proves effective in reducing capital flow to fossil fuel electric utilities. To sum up, we find that environmental policy instruments attract renewable investment. This result is in line with the evidence by (Rodríguez et al., 2014; Polzin et al., 2015), which shows that a higher level of policy stringency attracts private capital flow into renewable energy.

### *4.5. The mediation role of the cost of loan between CE policies and financial institutions' risk preference*

Based on the previous analysis, we understand that environmental policy stringency reduces the cost of debt for renewable energy, and it also directly attracts more loans issued to renewable energy firms. However, it is still unclear whether the decreased cost of loan plays a mediating role in the relationship between CE policies and investment preferences among energy sources. In this section, we use mediational modelling to test whether this effect exists. The three variables of interest are the independent variable (EPS), the mediator or mediation variable (loan spreads), and the dependent variable (investment

**Table 9**
The results of overall CE policy effect on lenders' investment decision between energy sources.

| Variables | Energy Production | | | Electric Utilities | |
|---|---|---|---|---|---|
| | Renewable energy | Oil & Gas | Coal | Renewable electric utilities | Fossil fuel electric utilities |
| | (1) | (2) | (3) | (4) | (5) |
| EPS | 0.722*** | −0.708*** | −1.044*** | 0.526*** | −0.654** |
| | (0.077) | (0.078) | (0.156) | (0.163) | (0.297) |
| Log(loan size) | −0.372*** | 0.396*** | 0.349*** | 0.164** | 0.050 |
| | (0.040) | (0.041) | (0.069) | (0.077) | (0.133) |
| Time to Maturities | 0.116*** | −0.108*** | −0.219*** | −0.001 | 0.094** |
| | (0.011) | (0.011) | (0.028) | (0.017) | (0.038) |
| No. of Lenders | 0.008 | −0.012 | −0.020 | −0.003 | −0.081* |
| | (0.013) | (0.013) | (0.020) | (0.024) | (0.047) |
| Guarantor | −1.026*** | 0.989*** | 0.330 | 0.106 | −0.537 |
| | (0.266) | (0.266) | (0.395) | (0.408) | (0.773) |
| Revolver | −1.063*** | 1.091*** | 0.531*** | −0.292 | 0.435 |
| | (0.105) | (0.107) | (0.169) | (0.230) | (0.432) |
| Term loan | −0.554*** | 0.539*** | 0.439* | 0.234 | −0.361 |
| | (0.159) | (0.160) | (0.251) | (0.312) | (0.583) |
| Leveraged loan | −0.307*** | 0.268*** | 0.669*** | −0.545*** | 0.981** |
| | (0.095) | (0.097) | (0.165) | (0.204) | (0.390) |
| SP Rating | −0.683** | 0.659** | 0.480 | 0.105 | −0.103 |
| | (0.274) | (0.275) | (0.392) | (0.266) | (0.526) |
| Log(GDP) | 0.075 | −0.072 | 0.071 | −0.405*** | 0.017 |
| | (0.056) | (0.057) | −0.102 | (0.102) | (0.165) |
| Observations | 10,050 | 9498 | 1810 | 5139 | 314 |
| Year FE | YES | YES | YES | YES | YES |
| Loan purpose FE | YES | YES | YES | YES | YES |

This table presents the logit regression results of Eq. (2). Columns (1) to (3) show the effect of overall CE policy on the probability of issuing a loan to renewable energy, Oil & Gas, or coal firms, respectively. Columns (4) and (5) report the effect of overall CE policy on the probability of issuing a loan to renewable electric utilities compared to mixed and fossil fuel electric utilities (Column 4) and fossil fuel electric utilities only (Column 5). Within the energy production sector, renewable energy is a binary variable that equals one if the borrower is classified as renewable energy according to TRBC sector classification and zero otherwise. Oil & gas is a binary variable that equals one if the borrower is an Oil & Gas firm and zero if the borrower is a renewable energy firm. Coal is a binary variable that equals one if the borrower is a coal firm and zero if the borrower is a renewable energy. The renewable electric utility is a binary variable that equals one if the borrower is classified as a renewable electric utilities firm according to TRBC classification and zero otherwise. Fossil fuel electric utility is a binary variable that equals one if the borrower is a fossil fuel electric utility firm and zero if the borrower is a renewable electric utilities firm only. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. Controls include loan characteristics, borrowers credit rating and logged GDP per capita. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

**Table 10**
The results of different CE policy instruments effect on lenders' risk preferences between energy sources.

| Variables | Energy production | | | Electric utilities | |
|---|---|---|---|---|---|
| | Renewable energy | Oil & Gas | Coal | Renewable electric utilities | Fossil fuel electric utilities |
| | (1) | (2) | (3) | (4) | (5) |
| CO2 taxes | −0.105 | 0.120 | −0.337 | −0.289 | −1.421 |
| | (0.111) | (0.113) | (0.221) | (0.242) | (1.128) |
| CO2 trading scheme | 0.389*** | −0.382*** | −0.691*** | 0.061 | −0.089 |
| | (0.097) | (0.100) | (0.225) | (0.173) | (0.427) |
| R&D subsidies | −0.049 | 0.018 | 0.041 | −0.174 | 0.199 |
| | (0.092) | (0.094) | (0.165) | (0.154) | (0.366) |
| Solar & wind | 0.173** | −0.155** | −0.290** | 0.382*** | −0.654** |
| | (0.072) | (0.075) | (0.130) | (0.140) | (0.263) |
| Observations | 10,050 | 9498 | 1810 | 5139 | 314 |
| Controls | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES |
| Loan purpose FE | YES | YES | YES | YES | YES |

This table presents the logit regression results of Eq. (2). Column (1) shows the effect of different climate and environmental policy instruments on the probability of issuing a loan to renewable energy compared to fossil fuels. Renewable energy is a binary variable that equals one if the borrower is classified as renewable energy according to TRBC classification and zero otherwise. Column (2) reports the effect of different climate and environmental policy instruments on the probability of issuing a loan to an Oil & Gas firm compared to renewable energy. Oil & Gas is a binary variable that equals one if the borrower is an Oil & Gas firm and zero if the borrower is a renewable energy firm. Column (3) reports the effect of different climate and environmental policy instruments on the probability of issuing a loan to a coal firm. Coal is a binary variable that equals one if the borrower is a coal firm and zero otherwise. Column (4) reports the effect of individual CE policy on the probability of issuing a loan to renewable electric utilities compared to mixed and fossil fuel electric utilities. Column 5 presents the effect of individual CE policy on the likelihood of issuing a loan to fossil fuel electric utilities compared to renewable electric utilities. Controls include loan characteristics, borrowers credit rating and logged GDP per capita. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

decision). We hypothesise that CE policies relate to the cost of debt, which in turn affects investors' risk preferences. The control variables are specified in Table 2. The mediation estimation includes (1) a regression equation predicting investment preferences based on the value of EPS and cost of loan and (2) a regression equation predicting the cost of loan from changes in the EPS level in a country. The model specifications are detailed/explained in Appendix 8.

Fig. 2 depicts the structural regression coefficients between the EPS score, the cost of loan and investment preferences for renewable energy. During the sample period, the direct effect of EPS on investment preference for renewable energy is measured by $\beta_{c'}$ and estimated to be 0.071 at a 1 % significance level, indicating that policy instruments have a direct positive and significant influence on loan investment into renewable energy compared to Oil & Gas and coal. The path coefficient $\beta_a$indicates the effect of EPS on the cost of loan. The coefficient estimate is −13.073 at a 1 % significance level. The direct effect of cost of loan on investment preference for renewable energy is measured by $\beta_b$ which is −0.004 % at a 1 % significance level. The results of $\beta_a$ and $\beta_b$ together suggest that EPS affect loan spreads, which in turn affects financial institutions' investment decisions. This indirect effect of environmental policies on investors' risk preferences equals $\beta_a*\beta_b$, and the result is 0.05 %. It is worth noting that environmental policies, such as trading schemes, can directly attract more loan investments in renewable energy. Moreover, the size of this effect is more pronounced than that achieved through reduced capital costs.

### 4.6. Robustness checks

We performed several robustness checks to verify the stability of our results. Firstly, to address concerns regarding the role played by the United States and measurement errors in the policy variable for this country, we test the EPS effect on renewable energy by excluding the US loan observations from the analysis, as they account for one-third of the total sample. The regressions displayed consistent results. Moreover, we conducted tests to investigate the climate and environmental policy effect on loan spreads for renewable energy before, during and after the 2008 financial crisis. We find that the sign and significance levels of the results for these three time periods are consistent with those reported for the full sample period. The differences observed in the magnitude of the coefficients are mainly due to variations in sample size in the subsample analysis by region and time period. The results of climate and environmental policy effects on the cost of debt remain stable regardless of the countries' GDP level. The results are reported in Appendix Table 4.

Another concern with the results documented so far is that the oil price likely affects the loan spread. To rule out this alternate explanation, we directly examined the link between environmental policy stringency and the loan spread within the oil and gas industry. We found a significant and positive effect of environmental policy instruments on the loan spread. This finding suggests that within the oil and gas industry, lenders charge a higher cost of debt for loans issued to borrowers from countries with higher levels of environmental stringency. The regression estimates are shown in Appendix Table 5.

Another way to test the relationship between environmental policy stringency and capital flow to renewable energy is to examine whether the EPS level affects the number of loans issued to renewable energy. We aggregate the number of deals into year-country cells. We use a Negative Binomial model, which is preferable to log linearising a transformation of the dependent variable, that is, to take the log of one plus the dependent variable when the dependent variable is a non-negative count following (Criscuolo and Menon, 2015). The regression result suggests that the CE policy level is positively associated with the number of loan investments in renewable energy (Appendix Table 6).

## 5. Policy implications and conclusion

The focus of this study is to investigate the relationship between CE policies and lenders' risk preferences measured by asset allocations among energy sources through the lens of capital cost. Our findings provide three main implications for policymakers.

First, financial institutions generally are rational and integrate CE policy risk in investment decision-making. The risk-return consideration can explain observed investment patterns in the energy production and electric utilities sectors.

In the energy sector, we show that the cost of debt for renewable energy has been higher than conventional energy, such as Oil & Gas and coal, for the past 20 years. However, the introduction of environmental policy brings the cost of capital cost down and induces lenders to issue more loans to renewable firms. This finding shows that environmental policies have a vital role in deploying renewable energy. Next, our analysis shows that adopting stringent environmental policies increases the cost of debt for Oil & Gas and reduces investment in Oil & Gas compared to renewable energy. The relationship between CE policies, cost of debt and investment for Oil & Gas also applies to coal mining, with stringent CE policies reducing capital flows into coal mining. This result could be explained by the increasing national commitments to phase out coal. Lenders seem to avoid fossil fuel borrowers who are subject to substantial regulatory risk concerns (Goodin et al., 2009). In the electricity sector, we find that implementing these policy instruments helps attract loan investment to renewable electric utility firms.

Secondly, CE policies directly impact financial institutions' investment decisions. They also shape financial institutions' climate change adaptation behaviour by incentivising the market to value the positive externalities of renewable energy and price negative externalities

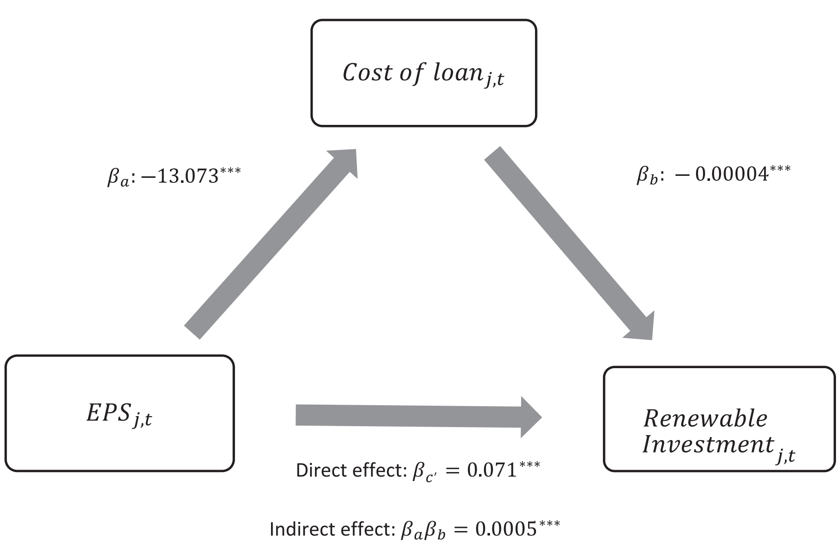


**Fig. 2.** Structural results for the direct and indirect effect of EPS on financial institutions' risk preference.

associated with fossil fuel investments.

This research examines the effectiveness of various environmental policies. Carbon taxes, carbon trading schemes, and R&D subsidies are shown to effectively increase (decrease) the cost of debt for conventional (renewable) energy sources. Additionally, trading schemes are effective in influencing capital flows to renewable energy. This finding is consistent with the findings from previous literature, which are focused on renewable energy generation (Georgallis et al., 2019; Georgallis and Durand, 2017; Theodor F. Cojoianu et al., 2020) and innovation (Calel and Dechezleprêtre, 2016).

Regarding investment preferences between fossil fuel and renewable electric utilities, solar & wind support, such as feed-in tariff schemes, proves effective in increasing capital flow to renewable electric utilities. This is in line with Criscuolo and Menon (2015), who find a positive relationship between feed-in tariffs and venture capital investment. The success of feed-in tariffs in increasing the share of renewables can be explained more by the higher security they provide to financial institutions investing in renewables (Menanteau et al., 2003). Feed-in tariffs are also needed to induce innovation in costly energy technologies at the earlier stage of the development (Johnstone et al., 2010), as "push" policies, such as tradable emissions permits, taxes on CO2, or emissions standards, do not provide sufficient incentives to improve technologies (Fischer and Newell, 2008). Sawin (2012) and Mitchell et al. (2006) conclude that feed-in systems have been responsible for most of the additions in renewable capacity and generation.

Thirdly, as private capital is essential in the energy transition, policymakers who aim to accelerate the low-carbon transition should deploy policy instruments to direct capital flows to low-carbon energy. Considering that different CE policies have varying effects on capital cost and flow, a tailored policy mix is required to support the deployment of low-carbon energy. The summary of our hypotheses and main outcomes are presented in Appendix Table 7.

Our study has some limitations. While we manage to analyse how CE policies explain the cost of debt variations across energy sources at the firm level, we are unable to distinguish the risks that arise from different business activities within a firm. Oil & Gas firms are increasing their share of renewables. Further analysis is required to investigate how exactly the financial institutions correspond to the changing share of transitional revenue/cost for Oil & Gas firms. Seeking to answer questions, such as whether CE policy risk affects the internal capital structure, transparency, and other organisational behaviours, can provide a complementary view of our research angle. It is also important to study whether Environmental, Social, and Governance (ESG) initiatives or civil society strategies have impacted the cost of capital and risk preferences. Moreover, further research could extend the sectors in scope beyond energy (i.e., shipping and heavy industry) and explore how other asset-class investors respond to the CE policies during the energy transition.

## CRediT authorship contribution statement

**Xiao Yan Zhou:** Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ben Caldecott:** Writing – review & editing, Validation, Supervision, Funding acquisition, Conceptualization. **Gireesh Shrimali:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Hanyu Zhang:** Writing – review & editing, Visualization, Methodology, Data curation.

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## Appendix A. An empirical analysis of climate and environmental policy risk, the cost of debt and financial institutions' risk preferences

**Appendix Table 1**
The definition of abbreviation.

| Abbreviation | Definition |
|---|---|
| bps | Basis points |
| CE | Climate and environmental |
| CLIMI | Climate Laws, Institutions and Measures Index |
| CO2 | Carbon Dioxide emission |
| DiD | Difference in Difference |
| ESG | Environmental, social, and corporate governance |
| EBRD | European Bank for Reconstruction and Development |
| EPS | Environmental Policy Stringency (EPS) Index |
| EU ETS | The European Union Emission Trading System |
| EU | European Union |
| GDP | Gross domestic product |
| IPPs | Independent power producers |
| OECD | Organisation for Economic Co-operation and Development |
| PwC | PricewaterhouseCoopers International Limited |
| R&D | Research and Development |
| SCC | The social cost of carbon |
| SDGs | UN Sustainable Development Goals |
| TRBC | The Thomson Reuters Business Classification |

**Appendix Table 2**
Variables correlation t.

| | loan spread | CO2 taxes | CO2 trading schemes | R&D subsidies | solar&wind support | Renewable fuels | Renewable electric utilities | Log (loan size) | Time to maturity | No. of lenders | Guarantor | Revolver | Term loan | Leveraged loan | SP Rating | log (GDP per capita) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| loan spread | 1.00 | | | | | | | | | | | | | | | |
| CO2 taxes | −0.01 | 1.00 | | | | | | | | | | | | | | |
| CO2 trading schemes | 0.07 | 0.26 | 1.00 | | | | | | | | | | | | | |
| R&D subsidies | 0.07 | 0.18 | 0.28 | 1.00 | | | | | | | | | | | | |
| solar&wind support | 0.08 | 0.07 | 0.43 | 0.14 | 1.00 | | | | | | | | | | | |
| Renewable fuels | 0.04 | 0.01 | 0.25 | −0.08 | 0.19 | 1.00 | | | | | | | | | | |
| Renewable electric utilities | −0.01 | −0.01 | 0.02 | −0.04 | 0.08 | −0.03 | 1.00 | | | | | | | | | |
| Log(loan size) | −0.16 | 0.11 | 0.05 | 0.03 | 0.06 | −0.13 | 0.02 | 1.00 | | | | | | | | |
| Time to maturity | 0.08 | 0.06 | 0.25 | −0.16 | 0.20 | 0.35 | 0.06 | 0.01 | 1.00 | | | | | | | |
| No. of lenders | −0.14 | 0.18 | 0.15 | 0.00 | 0.19 | −0.03 | 0.02 | 0.51 | 0.03 | 1.00 | | | | | | |
| Guarantor | −0.02 | −0.02 | −0.07 | −0.10 | −0.01 | −0.04 | 0.00 | 0.03 | 0.01 | 0.02 | 1.00 | | | | | |
| Revolver | −0.24 | −0.06 | −0.10 | 0.23 | −0.16 | −0.24 | −0.06 | 0.05 | −0.35 | 0.03 | −0.03 | 1.00 | | | | |
| Term loan | 0.18 | 0.01 | 0.05 | 0.07 | 0.00 | −0.02 | 0.00 | 0.06 | 0.05 | −0.01 | −0.03 | −0.33 | 1.00 | | | |
| Leveraged loan | 0.48 | −0.02 | 0.01 | 0.13 | −0.05 | −0.01 | −0.05 | −0.19 | −0.01 | −0.17 | 0.03 | −0.06 | 0.19 | 1.00 | | |
| SP Rating | −0.30 | −0.03 | −0.07 | 0.05 | −0.07 | −0.13 | 0.01 | 0.26 | −0.18 | 0.17 | −0.05 | 0.24 | −0.11 | −0.46 | 1.00 | |
| log(GDP per capita) | −0.03 | 0.09 | 0.26 | 0.70 | 0.01 | −0.06 | −0.02 | 0.05 | −0.18 | 0.01 | −0.11 | 0.30 | 0.08 | 0.11 | 0.08 | 1.00 |

**Appendix Table 3**
TRBC sector classifications.

| TRBC economic sector | TRBC business activity | TRBC industry group (adjusted) |
|---|---|---|
| Energy | Coal (NEC) | Coal |
| Energy | Coal Wholesale | Coal |
| Energy | Coal Mining Support | Coal |
| Energy | Integrated Oil & Gas | Oil & Gas |
| Energy | Oil & Gas Exploration and Production (NEC) | Oil & Gas |
| Energy | Unconventional Oil & Gas Production | Oil & Gas |
| Energy | Natural Gas Exploration & Production - Offshore | Oil & Gas |
| Energy | Natural Gas Exploration & Production - Onshore | Oil & Gas |
| Energy | Oil Exploration & Production - Offshore | Oil & Gas |
| Energy | Oil Exploration & Production - Onshore | Oil & Gas |
| Energy | Petroleum Product Wholesale | Oil & Gas |
| Energy | Oil & Gas Refining and Marketing (NEC) | Oil & Gas |
| Energy | Petroleum Refining | Oil & Gas |
| Energy | Gasoline Stations | Oil & Gas |
| Energy | Oil & Gas Drilling (NEC) | Oil & Gas Related Equipment and Services |
| Energy | Oil Drilling - Offshore | Oil & Gas Related Equipment and Services |
| Energy | Oil Drilling - Onshore | Oil & Gas Related Equipment and Services |
| Energy | Unconventional Oil & Gas Drilling | Oil & Gas Related Equipment and Services |
| Energy | Oil & Gas Transportation Services (NEC) | Oil & Gas Related Equipment and Services |
| Energy | LNG Transportation & Storage | Oil & Gas Related Equipment and Services |
| Energy | Oil & Gas Storage | Oil & Gas Related Equipment and Services |
| Energy | Natural Gas Pipeline Transportation | Oil & Gas Related Equipment and Services |
| Energy | Sea-Borne Tankers | Oil & Gas Related Equipment and Services |
| Energy | Oil Pipeline Transportation | Oil & Gas Related Equipment and Services |
| Energy | Oil Related Services and Equipment (NEC) | Oil & Gas Related Equipment and Services |
| Energy | Oil Related Services | Oil & Gas Related Equipment and Services |
| Energy | Oil Related - Surveying & Mapping Services | Oil & Gas Related Equipment and Services |
| Energy | Oil Related Equipment | Oil & Gas Related Equipment and Services |
| Energy | Photovoltaic Solar Systems & Equipment | Renewable Energy |
| Energy | Renewable Energy Equipment & Services (NEC) | Renewable Energy |
| Energy | Waste to Energy Systems & Equipment | Renewable Energy |
| Energy | Wind Systems & Equipment | Renewable Energy |
| Energy | Geothermal Equipment | Renewable Energy |
| Energy | Stationary Fuel Cells | Renewable Energy |
| Energy | Renewable Energy Services | Renewable Energy |
| Energy | Thermal Solar Systems & Equipment | Renewable Energy |

(*continued on next page*)

**Appendix Table 3** (*continued*)

| TRBC economic sector | TRBC business activity | TRBC industry group (adjusted) |
|---|---|---|
| Energy | Hydropower Equipment | Renewable Energy |
| Energy | Wave Power Energy Equipment | Renewable Energy |
| Energy | Biomass Power Energy Equipment | Renewable Energy |
| Energy | Biodiesel | Renewable Energy |
| Energy | Renewable Fuels (NEC) | Renewable Energy |
| Energy | Biomass & Biogas Fuels | Renewable Energy |
| Energy | Ethanol Fuels | Renewable Energy |
| Energy | Hydrogen Fuel | Renewable Energy |
| Energy | Pyrolytic & Synthetic Fuels | Renewable Energy |
| Utilities | Fossil Fuel Electric Utilities | Fossil fuel Electric Utilities & IPPs |
| Utilities | Fossil Fuel Independent Power Producers (IPPs) | Fossil fuel Electric Utilities & IPPs |
| Utilities | Alternative Electric Utilities | Renewable Electric Utilities & IPPs |
| Utilities | Solar Electric Utilities | Renewables |
| Utilities | Biomass & Waste to Energy Electric Utilities | Renewables |
| Utilities | Wind Electric Utilities | Renewables |
| Utilities | Hydroelectric & Tidal Utilities | Renewables |
| Utilities | Renewable IPPs | Renewables |
| Utilities | Electric Utilities (NEC)/Independent Power Producers | Other Electric Utilities & IPPs |

**Appendix Table 4**
The results of overall climate and environmental policy effect on loan spread for renewable energy.

| Variable | Loan spreads | | | | | |
|---|---|---|---|---|---|---|
| | By time period | | | By region | | |
| | 2000–2007 | 2008–2010 | 2011–2019 | Non-US region | Higher GDP countries | Lower GDP countries |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| EPS* Renewable energy | −38.757*** | −48.960*** | −30.879*** | −38.772*** | −21.547** | −43.347*** |
| | (12.568) | (15.794) | (9.890) | (11.772) | (8.718) | (11.047) |
| Renewable energy | 73.871*** | 125.876*** | 75.503*** | 79.130** | 38.184* | 99.022*** |
| | (25.272) | (39.194) | (27.070) | (31.469) | (22.611) | (24.272) |
| EPS | 35.224*** | 16.215 | 24.584*** | 24.152** | 44.614*** | 17.132* |
| | (11.191) | (28.500) | (8.229) | (10.352) | (9.040) | (10.127) |
| Observations | 5761 | 2136 | 7285 | 4164 | 11,921 | 3266 |
| R-squared | 0.275 | 0.398 | 0.347 | 0.264 | 0.351 | 0.363 |
| Controls | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES |
| Loan purpose FE | YES | YES | YES | YES | YES | YES |
| Country FE | YES | YES | YES | YES | YES | YES |

This table reports the effect of climate and environmental policy on loan spreads for renewable energy. Columns (1) to (3) report the estimates before, during, and after the 2008 financial crisis. Columns (4) to (6) report the estimates for non-US countries and higher and lower GDP regions, respectively. Higher GDP countries are those countries with GDP values higher than the mean of GDP in our sample. Renewable energy equals one if the borrower is classified as renewable energy according to TRBC classification and zero otherwise. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. We use robust standard errors in these regressions. The dependent variable is the syndicated loan spread. Controls include loan characteristics, borrowers' credit rating and logged GDP per capita. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

**Appendix Table 5**
The results of overall CE policy effect on loan spreads within the Oil & Gas subsector.

| | Loan spreads | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| EPS | 27.673*** | 11.797** | 12.136** | 12.148** |
| | (6.946) | (5.657) | (5.655) | (5.660) |
| Log(loan size) | | −13.178*** | −12.366*** | −12.367*** |
| | | (1.250) | (1.277) | (1.277) |
| Time to Maturities | | 2.652*** | 2.484*** | 2.480*** |
| | | (0.661) | (0.663) | (0.667) |
| No. of Lenders | | −3.802*** | −3.779*** | −3.775*** |
| | | (0.454) | (0.454) | (0.459) |
| Guarantor | | −23.160*** | −23.857*** | −23.870*** |
| | | (6.344) | (6.345) | (6.349) |
| Revolver | | −103.306*** | −103.442*** | −103.438*** |
| | | (3.684) | (3.682) | (3.683) |
| Term loan | | −5.024 | −5.452 | −5.445 |
| | | (5.510) | (5.509) | (5.510) |
| Leveraged loan | | 133.545*** | 129.362*** | 129.355*** |
| | | (3.188) | (3.470) | (3.472) |
| SP Rating | | | −15.375*** | −15.380*** |

(continued on next page)

**Appendix Table 5** (*continued*)

| | Loan spreads | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | | | (5.045) | (5.046) |
| Log(GDP per capita) | | | | −0.412 |
| | | | | (7.358) |
| Observations | 8239 | 8239 | 8239 | 8239 |
| R-squared | 0.157 | 0.445 | 0.446 | 0.446 |
| Year FE | YES | YES | YES | YES |
| Loan purpose FE | YES | YES | YES | YES |
| Country FE | YES | YES | YES | YES |

This table reports the estimates of the effect of EPS on loan spreads within the Oil & Gas subsector. Column (1) reports the estimates of the effect of EPS on loan spreads without controlling for country, firm and loan facility-level factors. Column (2) reports the regression results controlling for loan facility characteristics, and column (3) accounts for loan facility and firm characteristics. Column (4) shows the results accounting for loan facility-, firm-, and country-level characteristics. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. We use robust standard errors in these regressions. The dependent variable is the syndicated loan spread. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

**Appendix Table 6**
The results of overall CE policy effect on the number of loans issued to renewable energy.

| | Loan deals | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| EPS | 0.430*** | 0.441*** | 0.442*** |
| | (0.054) | (0.054) | (0.054) |
| Log(loan size) | | −0.003 | −0.003 |
| | | (0.013) | (0.013) |
| Time to Maturities | | 0.004 | 0.004 |
| | | (0.002) | (0.002) |
| No. of Lenders | | 0.019*** | 0.018*** |
| | | (0.004) | (0.004) |
| Guarantor | | 0.128 | 0.126 |
| | | (0.107) | (0.107) |
| Revolver | | 0.002 | 0.004 |
| | | (0.038) | (0.038) |
| Term loan | | −0.008 | −0.007 |
| | | (0.054) | (0.054) |
| Leveraged loan | | −0.033 | −0.035 |
| | | (0.029) | (0.029) |
| SP Rating | | | −0.051 |
| | | | (0.117) |
| Log(GDP per capita) | | | −0.027 |
| | | | (0.076) |
| Observations | 1256 | 1256 | 1256 |
| R-squared | 0.798 | 0.804 | 0.804 |
| Year FE | YES | YES | YES |
| Loan purpose FE | YES | YES | YES |
| Country FE | YES | YES | YES |

This table reports the estimates of the effect of EPS on the number of loans issued to renewable energy. Column (1) reports the estimates of the effect of EPS on loan spreads without controlling for country, firm and loan facility-level factors. Column (2) reports the regression results controlling for loan facility-level characteristics, and (3) shows the results accounting for loan facility-, firm-, and country-level characteristics. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. We use robust standard errors in these regressions. The dependent variable is the syndicated loan spread. All variables are defined in Table 2. *, **, and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

**Appendix Table 7**
Hypotheses tested and main outcomes.

| *Hypotheses* | Outcomes |
|---|---|
| *H1.1 The stringency of CE policies is negatively related to the cost of debt for renewable energy.* | A one standard deviation increase of the environmental policy stringency index leads to a decrease in loan spread of 17 bps for renewable loan investment, compared to a loan issued to fossil fuel and other firms. The result supports hypothesis 1.1. |
| An increase of one standard deviation in the fitted value of EPS translates into an increase in the loan spread of 14 basis points for Oil & Gas firms compared to other energy types. | An increase of one standard deviation in the fitted value of EPS translates into an increase in the loan spread of 14 bps for Oil & Gas firms compared to other energy types. The result support hypothesis 1.2 |
| *H1.3 The stringency of CE policies is positively related to the cost of debt for coal mining.* | An increase of one standard deviation in the value of EPS corresponds to an increase in the loan spread of 27 bps for coal borrowers relative to other borrowers. The result support hypothesis 1.3 |

(*continued on next page*)

**Appendix Table 7** (*continued*)

| Hypotheses | Outcomes |
|---|---|
| *H1.4 The stringency of CE policies is negatively related to the cost of debt for renewable electric utilities.* | The effect of the CE policy on loan spreads for renewable electric utilities is not statistically significant compared to fossil fuel and mixed electric utilities. This result does not support Hypothesis 1.4. |
| *H1.5 The stringency of CE policies is positively related to the cost of debt for fossil fuel electric utilities.* | The effect of the CE policy on loan spreads for fossil fuel electric utilities is not statistically significant compared to renewable and mixed electric utilities. This result does not support Hypothesis 1.4. |
| *Hypothesis 2.1 The stringency of CE policies increases financial institutions' preference for renewable energy compared to conventional energy: Oil & Gas and coal production.* | The coefficient of CE policies is positive and significant for renewable energy, indicating that lenders are more likely to issue a loan to renewable firms in a country with a higher level of environmental policy stringency. This finding supports hypothesis 2.1. |
| *Hypothesis 2.2 The stringency of CE policies decreases financial institutions' preference for Oil & Gas compared to renewable energy.* | The coefficient of CE policies is negative and significant for Oil & Gas, indicating that lenders are less likely to invest in Oil & Gas in a country with more stringent environmental policies. This finding supports hypothesis 2.2. |
| *Hypothesis 2.3 The stringency of CE policies decreases financial institutions' preference for coal production compared to renewable energy.* | The coefficient of CE policies is negative and significant for coal, indicating that lenders are less likely to invest in coal in a country with more stringent environmental policies. This finding supports hypothesis 2.3. |
| *Hypothesis 2.4 The stringency of CE policies increases financial institutions' preference for renewable electric utilities compared to fossil fuel and mixed electric utilities.* | The coefficient of CE policies is positive and significant for renewable electric utilities, indicating that lenders are more likely to issue a loan to renewable borrowers in a country with a higher level of environmental policy stringency. This finding supports hypothesis 2.4. |
| *Hypothesis 2.5 The stringency of CE policies decreases financial institutions' preference for fossil fuel utilities compared to renewable electric utilities.* | The coefficient of CE policies is negative and significant for fossil fuel electric utilities, indicating that lenders are less likely to invest in these utilities in a country with more stringent environmental policies. This finding supports hypothesis 2.5. |

### Appendix 7 Difference in Difference (DiD) model

We employ the EU ETS as a natural experiment and utilise a difference-in-difference model to assess the impacts of the EU ETS on target countries for fossil fuel energy production.

The model specification is as follows:

$$LoanSpread_{i,t} = \alpha_0 + \beta_1 Target_i + \beta_2 Post_t + \beta_3 Target_i{*}Post_t + \beta_4 Control_{i,t} + Fixed\ Effects + \varepsilon_i \quad (3)$$

Where, *LoanSpread* represents the cost of debt observed for firm *i* in year *t*. (VaR or LPM). The *Target* equals 1 if the firm is from countries that adopted the EU ETS scheme and 0 if it is from countries that haven't adopted the scheme. The *Post* equals one if firm-year observations after the EU ETS was adopted in 2005 and zero otherwise. Target*Post are the interaction terms showing the impacts of adopting the Emission Trading System on fossil fuels firms' cost of loans in EU ETS countries compared to non-EU ETS countries. The control variables include loan characteristics (logarithm of loan size, time to maturity, loan types), borrower's credit rate, and GDP per capita. All regression control for year, country, and loan purpose fixed effects to account for unknown factors in the market. All variables are defined in Table 2. The results are reported in Table 8.

### Appendix 8. Mediation model

We use the mediation analysis to test the role of the cost of loan between CE policies and financial institutions' risk preferences. The three variables of interest are the independent variable (EPS), the mediator or mediation variable (loan spreads), and the dependent variable (investment choices such as renewable energy). The mediation estimation includes (1) a regression equation predicting investment preferences based on the value of EPS and cost of loan and (2) a regression equation predicting the cost of loan from changes in the EPS level in a country.

$$RenewableInvestment_{j,t} = \beta_{0i} + \beta_b LoanSpreads_{i,t} + \beta_{c'} EPS_{i,t} + \beta_2 Control_{i,t} + \epsilon_{i,t} \quad (4)$$

$$LoanSpreads_{i,t} = \beta_{0i} + \beta_a EPS_{i,t} + \beta_5 Control_{i,t} + \omega_{i,t} \quad (5)$$

In this model, EPS is the OECD Environmental Policy Stringency Index observed for firm *i* in year *t*, which is a proxy of the CE policy. LoanSpread indicates the cost of debt and is the mediator variable observed for firm i in year t. RenewableInvestment proxies the investment choice of renewable energy and is the dependent/outcome variable observed in year *t* for firm *i*. It equals one if it is renewable energy and zero if it is Oil & Gas or coal. Control is a vector of control variables. We control loan characteristics (logarithm of loan size, time to maturity, number of lenders, and other loan types), borrower's credit rate, and GDP per capita. All variables are defined in Table 2.

The slopes in all three regressions $\beta_{c'}$, $\beta_a$, $\beta_b$ are path coefficients. The direct effect of EPS on investment choice of renewables controlling the mediator (loan spread) is designated $\beta_{c'}$, the effect of loan spreads on investment choice is designated $\beta_b$ and the effect of EPS on loan spreads is designated $\beta_a$. The product $\widehat{\beta_a}\widehat{\beta_b}$ is a second point estimate of the mediated effect, which evaluates the extent to which EPS affects loan spreads and the extent to which the loan spread, in turn, affects investment choices. The path coefficient is measured by the standardised regression coefficient. The result graph is presented in Fig. 2.

### Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2025.108323.

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