Drivers of Firm Investment in Low and High-Carbon Energy: Capital Markets and Climate Policy

Abstract

The cost of capital is a key driver of the low-carbon transition, as changes in firm-level financing costs can support or hinder low-carbon energy investment (LCI) and high-carbon energy investment (HCI). Using asset-level data from the S&P World Electric Power Plant database, we track firm-level LCI and HCI for publicly listed electric utilities firms from 2012-2021. Using a fixed-effects Poisson model, we find that a reduction in the firm-level cost of debt directly increases firm-level LCI and HCI, and indirectly increases investment by enabling debt capital raising. We then control for climate policy using the OECD Environmental Policy Stringency Index. We find that market-based policies, such as carbon prices and taxes, directly increase domestic LCI and act as a moderator, strengthening the relationship between debt capital raising and LCI, while doing the opposite for HCI. With regard to pricing policies, such as feed-in tariffs, we find inconclusive results. In summary, these findings demonstrate the importance of capital markets in firm-level transitions and show that governments can channel capital away from HCI and into LCI through policy interventions.

1. Introduction

Meeting the goals of the Paris Agreement requires a rapid scaling up of investment in low-carbon energy. The IEA estimate that limiting global temperature rises to 1.5C requires $4 trillion of investment in low-carbon energy annually by 2030, requiring investment to more than triple from current levels (IEA, 2021a). Yet, while this significant investment gap in low-carbon energy exists, investment in fossil fuel power continues despite the need for sharp curtailments in development. According to NGO Urgewald, 476GW of coal power capacity is in the development pipeline (Carrington, 2022), despite the incompatibility of new coal power assets with the goals of the Paris Agreement (IEA, 2021a). Mobilising private sector capital towards low-carbon energy and away from high-carbon energy is critical for closing the investment gap in low-carbon energy.

The low-carbon transition will see the energy sector move "from an OPEX to a CAPEX world" (Auverlot et al., 2014), as capital-intensive renewables, with minimal operational costs relative to fossil fuel alternatives, take on a larger and larger share in the global energy mix. The cost of capital is a key lever in accelerating this transition. First, the cost of capital affects the ability of firms and countries to finance the upfront investments required to decarbonise the energy system (Advisory Group on Finance for the UK's Climate Change Committee, 2020). And second, capital-intensive renewables are more sensitive to changes in the cost of capital than fossil fuel power (Hirth & Steckel, 2016). As a result, differences in the cost of capital between countries can affect the overall costs of decarbonisation, and drive low-carbon investment away from counties with high capital costs (Ameli et al., 2021; Polzin et al., 2021). This is pertinent, given the recent uptick in inflation and interest rates seen across the world, which could blunt the trend in falling LCOE of renewable energy (Schmidt et al., 2019)

In this context, this study examines the relationship between the firm-level cost of debt and debt capital raising with firm-level energy investment, and the effect of environmental policy on these relationships. To conduct our analysis, we use a global asset-level database of power assets (WEPP) to track the development of new assets by publicly listed electric utilities firms between 2011-2021. From this we construct a panel dataset that we analyse using a utilising a fixed effects Poisson model. We focus on debt given its dominance in the financing of energy firms relative to equity (Wilson & Caldecott, 2021).

For example, for them firms analysed in this study, between 2011 and 2021 net debt issuance is over four times greater than net equity issuance[1].

In the first stage of analysis, we show that globally reductions in the cost of debt increase both low-carbon energy investment (LCI) and high-carbon energy investment (HCI), but with a stronger relationship for LCI than HCI. However, in OECD regions this relationship holds only for LCI, and in non-OECD regions for HCI. With regard to debt capital raising, we find that as expected, capital raised increases both LCI and HCI globally. We also demonstrate through channel analysis that the cost of debt has an indirect effect on investment, as a lower cost of debt increases debt issuance, which in turn increases investment as capital is deployed.

In the second stage of analysis, we control for climate policy in a domestic setting using the OECD Environmental Policy Stringency Index (EPS). We find that stronger market-based policies (e.g. carbon prices, taxes, and portfolio standards) increase firm-level LCI (a negative but insignificant relationship with HCI is found). Through the inclusion of interaction effects, we then examine the role of stronger market-based policies as a moderator of the relationship between the cost of capital and investment, and debt capital raising and investment. While for the cost of debt, no moderating relationship is found, for debt capital raising, we find that stronger market-based policies strengthen the positive relationship with LCI and weaken the positive relationship with HCI. This demonstrates how pricing carbon emissions can channel capital away from HCI and towards LCI. This analysis is then repeated for pricing policies, namely, feed-in tariffs (FITs). In terms of direct effects, we do not find a significant relationship with either LCI or HCI, and globally, find no evidence of a moderating effect on the relationship between the cost of debt and debt capital raising with investment.

These findings have several implications. First, they provide evidence that the cost of capital is a driver of LCI, both directly and through its effect on debt capital raising. However, they also show that a lower cost of capital can drive HCI, especially in non-OECD countries. As a result, our finding that stronger climate policy, such as carbon pricing, can guide capital raised by firms into LCI and away from HCI is particularly important in ensuring that capital markets do not finance carbon lock-in. In addition, these findings provide empirical evidence that a rising interest rate environment could harm low-carbon energy investment, as highlighted in Schmidt et al. (2019), meaning that additional policy interventions may be required to ensure the cost competitiveness of low-carbon energy (Voldsgaard et al., 2022)

These findings are also of relevance to financial institutions, namely those representing over $130 trillion in assets committed to aligning with net zero by 2050 (GFANZ, 2021). In particular, those investing in corporate bonds through primary markets, or banks providing loans. Our results show that debt capital raising increases both LCI and HCI. While unsurprising, this demonstrates the importance for financial institutions of insuring that capital provided to firms in the real economy is invested in accordance with net zero goals, and does not lead to carbon lock-in (Wilson & Caldecott, 2021). These findings are also of relevance to the debate regarding the efficacy of sustainable finance more broadly. While there is literature showing the impact of climate risks and impacts on the cost of debt (Caragnano et al., 2020; Chava, 2014; Jung et al., 2018; Pizzutilo et al., 2020), this pricing is yet to be empirically linked to real economy impact. By showing how changes in the firm-level cost of debt can drive energy investment, we provide evidence of the role of the cost of capital as a transmission mechanism for investor impact in the energy transition (Caldecott et al., 2022; Kölbel et al., 2020). Indeed, there is already divergence occurring in the cost of debt between low- and high-carbon-intensity electric utilities firms in certain regions (X. Zhou et al., 2023). While this could help accelerate the transition of lower

[1] Net debt issuance is defined as the difference between debt issuance and debt retirement, while net equity issuance is defined as the difference between equity issuance and equity retirement (for example, through share buy backs).

carbon firms, this could reduce the ability of higher carbon incumbent firms to finance their transitions (Hickey et al., 2021).

To the best of our knowledge, this is the first study to utilise asset-level data to explore the relationship between firm-level financing conditions and investment, and while many studies have modelled the importance of the cost of capital in the energy transition, this study is the first to demonstrate this empirically at the firm-level. In doing so, while contributing to the sustainable finance literature, we also build on both the corporate finance literature regarding the cost of capital and investment (Frank & Shen, 2016b) and the energy economics literature regarding climate policy and low-carbon energy deployment (Pfeiffer & Mulder, 2013). This is achieved by providing a new perspective on the moderating role of policy on the relationship between capital markets and firm-level energy investment. Furthermore, we provide new insights on the effectiveness of climate policy at driving investment within the past decade, filling an important gap in the literature (Teixidó et al., 2019). In particular, with regard to CO2 Trading & Taxes, our findings add to an ongoing and live debate regarding the efficacy of these policies at changing levels of investment (Lilliestam et al., 2021).

This study is structured as follows. In section 2, we provide a review of the existing literature and derive hypotheses from this. In Section 3 we provide details of the data and methods deployed. In Section 4 we show our results, which are then discussed and concluded in Section 5.

2. Literature Review and Hypothesis Development

2.1 Capital Markets and Investment

Pratt & Grabowski (2014) define the cost of capital as “the expected rate of return that market participants require to attract funds to a particular investment”. On the liability side of the balance sheet, the weighted average cost of capital (WACC) is derived from the views of the providers of equity and debt investors regarding the risks and prospects of a firm (Pratt & Grabowski, 2014). On the asset side of the balance sheet, firms use the cost of capital as an input into capital budgeting methods to guide their investment decisions in the real economy. For example, as a discount rate when calculating the Net Present Value (NPV) of a project, or as a hurdle rate to be compared to the Internal Rate of Return (IRR) of prospective projects (Finnerty, 2013). This is shown as the economic appraisal stage of the investment decision making process in Figure 1. While Donovan & Corbishley (2016) state that firms should alter the cost of capital used to evaluate different investment opportunities, so that capital is allocated efficiently, in many cases, firms default to their estimated WACC when calculating NPVs or evaluating IRRs (Block, 2003; Meier & Tarhan, 2011). Furthermore, even if a project passes economic appraisal, to reach a final investment decision, a firms WACC can affect the affordability of financing needed to fund the capital expenditure to begin construction (Figure 1).

Within the context of the low-carbon transition, Helms et al. (2020) outline how the use of firm-level WACC to evaluate projects could reduce corporate investment in low-carbon energy. Unlike fossil fuel power generation where incumbent utilities dominate, institutional investors and independent power producers control a significant proportion of renewable power generation (Helms et al., 2020; Kelsey & Meckling, 2018). Helms et al. (2020) outline how these new investors can deploy more capital into lower risk and lower return renewables than incumbent firms, whose cost of capital is higher, reflecting their existing fossil fuel asset base. Therefore, if firms with a high cost of capital use their WACC to evaluate potential investments, this could lead to underinvestment in low-carbon energy. Furthermore, at the asset level, the cost of renewable energy is more sensitive to changes in the cost of capital than fossil fuel power assets due to their greater capital intensity, with significant CAPEX required by little OPEX (Hirth & Steckel, 2016; Steffen, 2020). Therefore, a fall in the firm-level cost of capital could increase the propensity of firms to increase LCI.

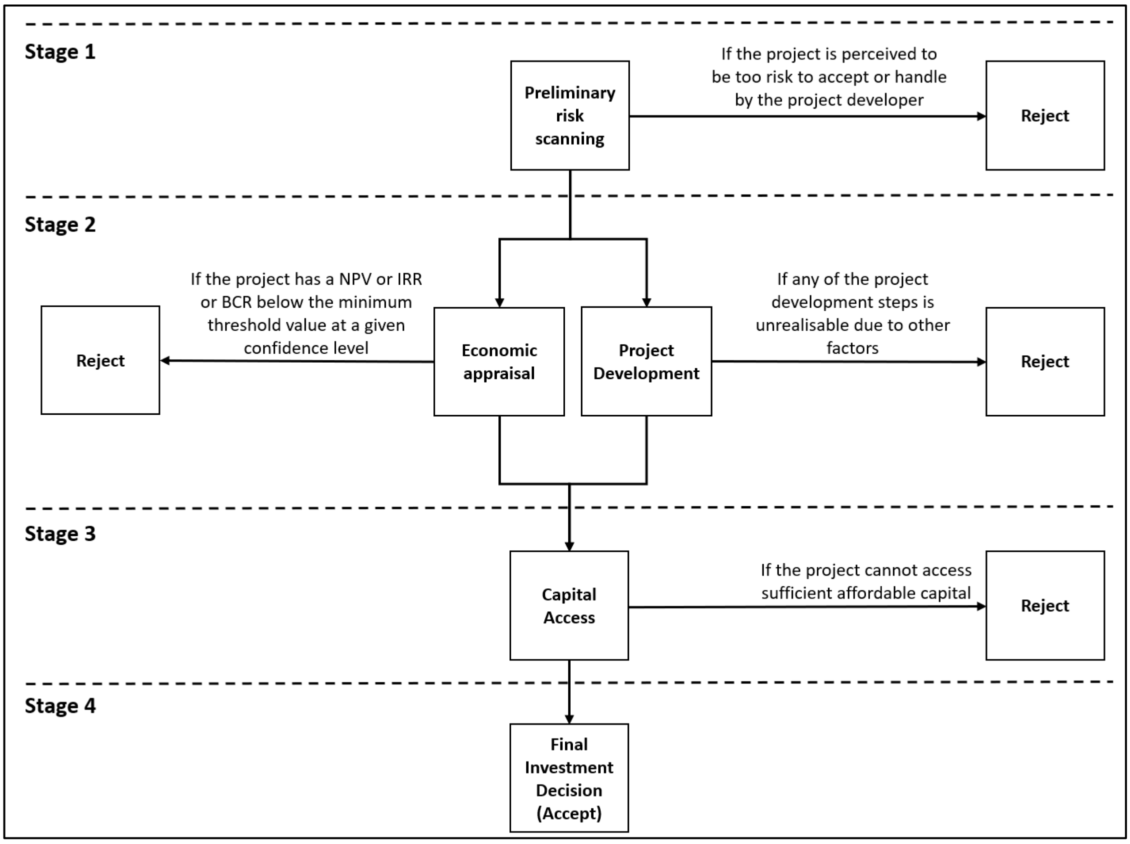

Figure 1: Integrated investment decision making process.
Adapted from Hu et al. (2018).

While research has studied how the cost and stock of financial capital could affect country-level energy transitions (Ameli et al., 2021; Best, 2017; Polzin et al., 2021), there is limited empirical research at the firm-level. This is an important gap in the literature, as corporate financing accounts for the majority of funding for the development of power assets (Ameli et al., 2021). For IPP firms, the cost of capital affects their ability to grow and challenge incumbent electric utilities, with IPPs dominating market share in renewables in the US and Europe (Kelsey & Meckling, 2018). For incumbent electric utilities, which can have a limited financial capacity to invest due to significant debt burdens, the cost of capital is a key input into their ability to transition from high- to low-carbon assets (Hickey et al., 2021). For example, debt investors may no longer view fossil fuel assets as safe collateral (Hickey et al., 2021). The cost of capital for low- and high-carbon electric utilities is already diverging in some regions, namely Europe (X. Zhou et al., 2023). This divergence could limit the ability of firms to invest in low-carbon energy to transition.

In the corporate finance literature, a lower cost of capital is shown to increase corporate investment (Drobetz et al., 2018; Frank & Shen, 2016b; Gilchrist & Zakrajsek, 2007; Gilchrist & Zakrajšek, 2012; X. Lin et al., 2018). We build on these studies by testing the hypothesis that a lower cost of debt increases LCI and HCI. We expect a negative relationship in both instances, but that LCI is more sensitive to changes in the cost of debt, given the aforementioned literature. In addition to examining the direct effect of the cost of debt, we examine the indirect effects on investment through the channel of debt capital raising (see Figure 2). Evidence shows that when faced with lower interest rates firms issue more debt to take advantage of lower financing costs relative to historical or expected future levels (Barry et al., 2008), with lower financing costs facilitating access from external capital markets (stage 3 in Figure 1). Alternatively, as lower interest rates raise project NPVs within internal capital markets (stage 2 in Figure 1), firms raise more debt to finance these investment opportunities (Barry et al., 2008). In either case, a lower cost of capital leads to a final investment decision due to its effect on capital raising. As the cost of capital can affect investment either through its impact on NPVs in Stage 2, or its impact on capital access in Stage 3, we would expect there to be a partial, rather than a full mediation effect. In other words, the cost of capital affects investment both directly, and indirectly through it's impact on capital access. We state our first two hypotheses as follows in H1 and H2.

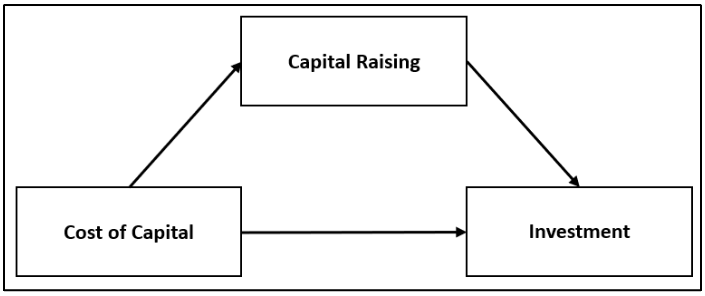

Figure 2: Theoretical channel analysis.

Hypothesis 1 (H1): A lower firm-level cost of debt directly increases firm-level LCI and HCI.

Hypothesis 2 (H1): A lower firm-level cost of debt increases firm-level LCI and HCI through the channel of increased debt issuance.

2.2 Climate Policy and Investment

Alongside financing conditions, the policy environment in which a firm operates is key to accelerating investment in LCI. Policymakers have numerous reasons to stimulate the deployment of low-carbon energy such as minimising harmful pollution, reducing energy dependence, stimulating economic growth, and delivering on climate commitments that require the rapid decarbonisation of energy systems. Indeed, numerous studies at the country-level have demonstrated the ability of policy interventions to accelerate LCI (Fadly, 2019; Liu et al., 2019; Neil & Seri~, 2022; Neil & Seriño, 2018; Pfeiffer & Mulder, 2013; Zhao et al., 2013). Within the context of firm-level investment, policies can alter the economics of specific types of projects and their NPVs. For example, lowering the cost of low-carbon energy through subsidies, or increasing the costs of high-carbon energy through taxes. Therefore, in our second stage of analysis, we test the hypothesis that the implementation of stronger climate policy directly increases firm-level investment in LCI and decreases HCI.

In addition to the direct impact of policy, we examine its moderating role on the relationship between the cost of capital and investment. We hypothesise that with stronger policy, the negative relationship between the cost of capital and LCI increases, while decreasing for HCI. We expect that firms are more likely to take advantage of lower financing costs to increase LCI when operating in a supportive policy environment, with the opposite occurring for HCI. However, arguably more important, is how policy affects the relationship between capital raising and investment. The IEA define Final Investment Decision as the decision to begin construction (IEA, 2021b), which can be financed from the balance sheet of a firm or via project finance (Ameli et al., 2021). In the case of the former, a firm may tap capital markets or bank lending to raise financing. Therefore, by examining the moderating role of policy, we examine how policy affects the deployment of capital from the financial system in the real economy, through its impact on firm-level capital allocation decisions. We hypothesis that with stronger policy, the positive relationship between debt capital raising and LCI increases, while decreasing for HCI. This is expressed in Figure 3 below.

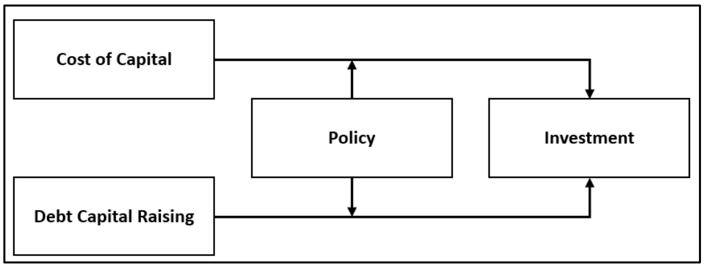

Figure 3: Theoretical moderating role of policy.

To conduct our analysis, we focus on two types of policy that have a real-time impact on firm-level investment decisions, given the direct effect on project economics. First, *market-based policies* that price carbon dioxide, including carbon prices, carbon taxes, and renewable energy trading schemes (portfolio standards) (Kruse et al., 2022). Second, *technology support policies* or *pricing policies* that support the adoption of low-carbon energy types by providing a fixed price, or a premium above market prices for electricity generated (Couture et al., 2010). This includes feed-in tariffs, feed-in premiums, or auctions (Kruse et al., 2022). While other policies such as direct government investments, the provision of information and education, and R&D spending also support the deployment of low-carbon energy, the impact on firm-level decisions is indirect and with a longer lag, as technology diffusion and learning by doing occurs. Indeed, research shows that market-based and pricing policies are among the most effective at driving low-carbon energy deployment (Liu et al., 2019).

For market-based policies, Liu et al. (2019) show their effectiveness in increasing low-carbon deployment at the country level. However, at the firm-level, empirical studies have not found strong evidence that carbon pricing affects investment (Lilliestam et al., 2021). However, these studies exclude the majority of the last decade when carbon prices have risen. For example, in the EU ETS, there is a gap in the literature regarding Phase III from 2013-2020 (Teixidó et al., 2019), during which the time the carbon price increased from below 10 EUR per ton of CO2 to over 30 EUR (Ampudia et al., 2022) and free allocations were removed for the power sector except for low-income countries (Carbon Market Watch, 2022). We build on this literature by considering the effect of market-based policy on firm-level investment within the past decade.

For pricing policies, country-level empirical studies have shown that FITs drive low-carbon energy deployment. For example, studies that capture implementation of FITs as dummy variables, or count the number of policy instruments implemented, find a positive relationship with the deployment of low-carbon energy (Bersalli et al., 2020; Liu et al., 2019; Zhao et al., 2013). However, results differ when using the price level of FIT support as the independent variable. For example, Smith & Urpelainen (2014) find evidence of a positive relationship between the price level and deployment for 1979-2005. Whereas García-Álvarez et al. (2017) find a negative relationship between the price level and deployment in the EU between 2000-2014, during which time the absolute level of FIT price support fell in major EU countries (Maekawa et al., 2022; OECD, 2022). This fall, known as digression, is intentional, with decreases following a pre-determined path, or responding to increased deployment or reductions in costs (Couture et al., 2010). Digression is intended to simulate deployment by incentivising project developers to reduce costs and build assets while high rates of support are still available (Rigter & Vidican, 2010). As discussed in the Data and Methods section, we utilise an OECD measure of FIT price support that is normalised by global electricity prices to account for falls in the LCOE of renewables (Kruse et al., 2022). As a result, we expect that higher levels of FIT support relative to LCOE will increase firm-level LCI and decrease HCI.

H3: Stronger climate policy increases firm-level LCI and decreases HCI.

H4: Stronger climate policy strengthens the relationship between the cost of debt and debt capital raising with LCI, but weakens it for HCI.

3. Data and Methods

3.1 Asset-Level Investment

To estimate firm-level LCI and HCI, the S&P World Electric Power Plant (WEPP) database is used. From 2001, the direct owner of assets is provided, and from 2011, both the direct owner and the parent is provided. As we group subsidiaries into a single owner at the parent level, WEPP data from 2011 to 2021 is used. To identify the corporate owners of assets, we extract a list of publicly listed firms from Eikon in the following The Refinitiv Business Classifications (TRBC) industry groups: electric utilities and IPPs, multiline utilities, and natural gas utilities. Manual matching is then performed between these 923 firms, and the 46,363 unique direct owners and 42,419 unique parent owners in the WEPP 2021 dataset. Overall, 526 firms are successfully matched (57%). For each listed firm matched, we identify an average of 1.9 associated firms, subsidiaries, or joint ventures[2]. The WEPP database does not differentiate between assets owned directly, or those owned via a special purpose vehicle (SPV), and therefore, both are included by default[3]. This applies to both joint ventures and majority owned projects. Using this approach, between 2011 and 2021, the proportion of global capacity accounted for by the publicly listed firms in our sample rises from 33% to 40%.

The WEPP database provides rich information on each asset, including fuel type, development status, and mega-watt (MW) capacity[4]. The WEPP database provides detail on a large number of fuels, which we classify by energy type drawing on (Gotzens et al., 2019; Thesis, 2017) (see Appendix A). These are then grouped into two broad categories. Solar, wind, geothermal, hydro, nuclear, bioenergy, and waste are classified as low-carbon, while oil, gas, and coal are classified as high-carbon. From 2011 to 2021, the proportion of low-carbon energy in global capacity rose steadily from 35% to 41%, while the share of under construction capacity rose faster from 45% to 66% with coal falling by 67% from a peak in 2012.

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[2] When a joint venture is identified, the MW of the asset is split evenly between participants, as the WEPP database does not track ownership shares (S&P Global Market Intelligence, 2017). We include joint ventures, as owners still provide capital, and therefore, financing costs remain relevant to investment activity through this channel.

[3] Assets owned by SPVs are funded via project finance. Project finance transactions enable project sponsors to finance assets by raising debt off-balance sheet often at lower financing costs (Steffen, 2018), and as a result account for a large proportion of low-carbon energy finance (Ameli et al., 2021). A limitation of including these assets is that investment activity may be less affected by the corporate cost of capital. However, in either case project sponsors still provide equity investment, which requires capital from their balance sheets.

[4] The WEPP database does have certain limitations. For example, while WEPP is considered one of the most comprehensive databases (Gotzens et al., 2019), with complete to comprehensive coverage of medium and large power plants (>75-95%), it's coverage of small assets, such as wind assets below 1MV and solar PV below 10MW is adequate (>50%) (S&P Global Market Intelligence, 2017). However, as we are focused on the total investment of larger listed firms, the impact of smaller assets may be limited. In addition to challenges with coverage, the WEPP database may have inconstancies regarding how capacity is recorded Alova, 2020). However, while other asset-level databases exist, WEPP has a unique feature in providing historical releases dating back to 2001(Alova, 2020), enabling panel data analysis.

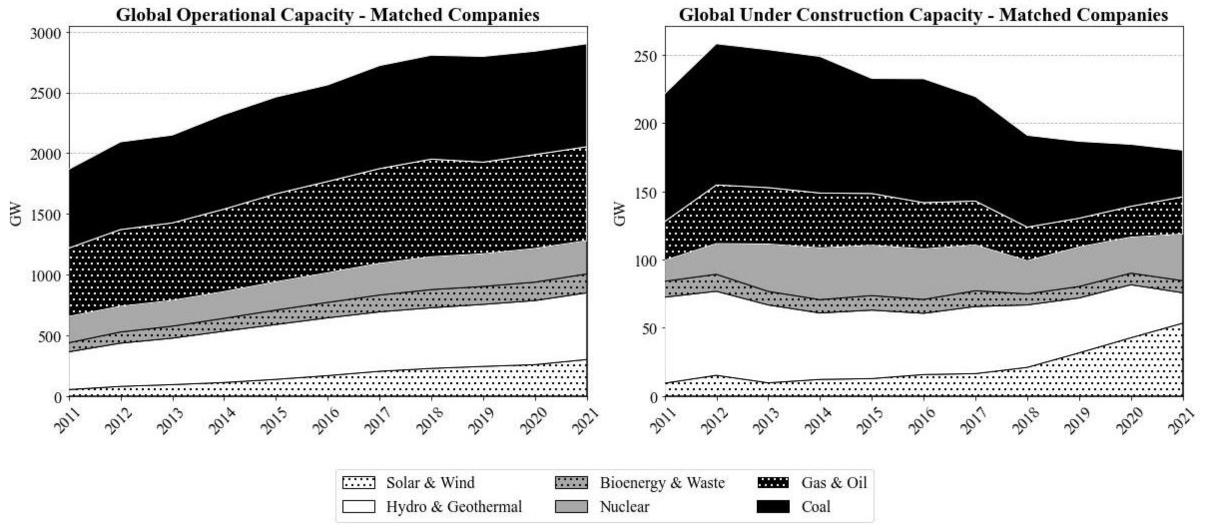

Figure 1: Global Energy Mix
Matched Firms refers to the capacity of publicly listed firms matched to the WEPP database. Fuel Types are classified according to Appendix A.

For each matched firm, LCI is calculated as the under-construction capacity of firm i in year t in low-carbon fuel types scaled by the total operating capacity of all fuel types in the previous year (Eq. 1)[5]. This is then repeated for HCI with high-carbon fuel types (Eq. 2). While the WEPP database also contains assets in the planning stage of development, these are not included, as our focus is on the factors affecting final investment decisions. As noted by (Hu et al., 2018), while there are costs associated the project development phase (Figure 1), these are not comparable to the costs of construction once a final investment decision has been reached. Furthermore, obtaining planning permission or permits can be challenging and take multiple years (Christakou et al., 2022), with a high proportion of assets never reaching the construction stage[6].

$$1)\ LCI_{i,t} = \frac{Low - Carbon\ \&\ Alernative\ Under\ Construction\ Capacity_{i,t}}{Total\ Operating\ Capacity_{i,t-1}}$$

$$2)\ HCI_{i,t} = \frac{High - Carbon\ \ Under\ Construction\ Capacity_{i,t}}{Total\ Operating\ Capacity_{i,t-1}}$$

LCI and HCI are calculated for two different scopes: domestic and international. Domestic refers to the investment of a firm in their nation of headquarters, while international refers to their investment activity globally, with firms in our sample operating in 2.3 countries on average (Appendix B). As the international database captures all investment activity, it is most appropriate for examining the relationship between firm-level financing conditions and firm-level investment. However, the domestic dataset enables us to test how climate policy affects the investment activity of firm in the countries

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[5] Total operating capacity is lagged to isolate the effect of financing conditions and policy on the construction of new assets, rather than the completion of assets already under construction, which would affect total operating capacity. Capacity under construction is scaled by total existing capacity in order to calculate a rate of investment that is comparable across firms, by accounting for the size of a firm's existing operations.

[6] For example, in the U.S. in 2021, 10% of solar capacity was cancelled while still in the permitting stage of development following public opposition (Groom, 2022). Alternatively, firms may not be able to raise sufficient affordable capital to move out of the planning stage of development (Hu et al., 2018). Within the 10 years of WEPP data in this study, for plants of all types that were at some point in the planning stage, approximately 14% were cancelled while 29% began construction.

where policies are implemented. As a result, the domestic sample is limited to firms headquartered in countries within the scope of the OECD Environmental Policy Index[7].

Table 1 shows the average LCI and HCI by year, for domestic and international investment. Domestic LCI falls from a high of 11.8% in 2012 to a low of 3.7% in 2018, before rising to 5.4% in 2021. As shown by Figure 1, this fall occurred as under-construction capacity levelled off in 2012 as operating capacity continued to rise. However, since 2018, under construction capacity for low-carbon energy picked up. In contrast, HCI has fallen consistently, from 7.6% in 2012 to 1.9% in 2021. International investment shows similar trends in LCI and HCI. When looking at investment by region, LCI is higher than HCI on average for both OECD and non-OECD countries (Table 2). Between these two regions, non-OECD countries have higher rates of investment in both LCI and HCI.

Table 1: **Yearly Summary Statistics**

	Percentage	LCI	HCI	CoD	DCR	CO2	RPS
Domestic							
2011	6.34	.	.	4.69	3.40	0.78	2.16
2012	6.85	11.81	7.55	4.73	2.62	0.66	2.51
2013	7.21	9.47	5.98	4.73	1.86	0.68	2.51
2014	8.03	8.06	4.41	4.66	2.63	0.76	2.32
2015	8.85	6.98	3.98	5.11	0.92	0.78	2.32
2016	9.45	4.15	3.18	5.34	0.69	0.78	2.32
2017	9.68	4.39	2.81	5.07	1.21	0.84	2.31
2018	10.31	3.72	2.56	4.93	1.58	0.95	2.19
2019	10.82	4.34	2.43	4.82	1.33	1.04	2.24
2020	11.05	5.17	2.12	4.50	1.68	1.13	2.49
2021	11.41	5.36	1.87	.	.	.	.
Total	100.00	5.98	3.40	4.87	1.69	1.86	2.32
International							
2011	5.73	.	.	5.49	3.16	.	.
2012	6.57	10.56	7.41	5.39	3.08	.	.
2013	7.10	10.11	5.95	5.57	2.14	.	.
2014	8.03	6.67	4.89	5.39	2.89	.	.
2015	8.87	6.57	3.93	5.65	2.06	.	.
2016	9.45	3.73	4.75	5.97	1.57	.	.
2017	10.01	4.74	4.86	5.51	1.31	.	.
2018	10.29	4.22	3.67	5.31	1.48	.	.
2019	10.88	4.81	3.62	5.27	1.49	.	.
2020	11.05	5.95	3.30	5.34	1.34	.	.
2021	12.00	5.69	3.13	.	.	.	.
Total	100.00	5.97	4.32	5.48	1.92	.	.

LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively, CoD stands for Cost of Debt, DCR for Debt Capital Raising, CO2 for CO2 Trading & Taxes, and RPS for Renewable Energy Price Support. Domestic refers to the sample of investment activity in the country of headquarters, while International refers to the global investment activity of firms.

[7] The OECD Environmental Policy Index covers 34 OECD countries, BRICS countries (Brazil, Russia, India, China, and South Africa), and Indonesia. This provides coverage for 30 out of the 65 countries in the full international sample.

Table 2: **Regional Summary Statistics**

	Percent	LCI	HCI	CoD	DCR	CO2	RPS
Domestic							
Australia and New Zealand	3.98	4.79	0.12	5.76	1.84	1.16	1.59
Eastern Asia	25.53	8.22	3.56	3.26	1.40	0.36	3.85
Europe	25.98	2.23	2.69	4.78	1.00	1.00	2.35
Latin America and the Caribbean	9.61	23.93	0.46	6.78	1.60	0.18	0.00
Northern America	22.00	0.99	0.95	4.51	1.72	1.62	1.09
South-Eastern Asia	1.01	0.00	1.99	11.19	-2.55	0.00	3.69
Southern Asia	7.91	4.82	16.12	6.67	4.16	1.10	3.36
Western Asia	3.98	5.16	6.33	7.30	4.08	0.00	3.14
Non-OECD	36.15	9.07	5.84	6.14	2.16	0.36	2.24
OECD	63.85	4.22	2.02	4.15	1.42	1.14	2.37
Total	100.00	5.98	3.40	4.87	1.69	0.86	2.32
International							
Africa	1.40	6.47	0.00	6.87	1.12	.	.
Australia and New Zealand	3.03	4.82	1.85	6.11	3.24	.	.
Eastern Asia	18.60	7.62	4.61	3.41	1.87	.	.
Europe	22.58	3.24	2.59	5.00	1.19	.	.
Latin America and the Caribbean	9.40	16.02	0.32	8.15	1.64	.	.
Northern America	18.85	2.47	1.01	4.56	2.31	.	.
South-eastern Asia	12.48	6.34	9.10	6.11	1.46	.	.
Southern Asia	8.67	4.93	12.95	8.44	2.67	.	.
Western Asia	4.99	7.84	6.51	6.57	3.77	.	.
Non-OECD	50.74	6.54	6.52	6.59	1.86	.	.
OECD	49.26	5.39	2.10	4.36	1.98	.	.
Total	100.00	5.97	4.32	5.48	1.92	.	.

LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively, CoD stands for Cost of Debt, DCR for Debt Capital Raising, CO2 for CO2 Trading & Taxes, and RPS for Renewable Energy Price Support. Domestic refers to the sample of investment activity in the country of headquarters, while International refers to the global investment activity of firms.

3.2 Cost of Debt and Firm-Level Control Variables

Data from Eikon is used to calculate firm-level independent and control variables. Using a definition common in the literature the average cost of debt is calculated as the interest expense for firm i in year t divided by total outstanding debt (Eq. 3) (Frank & Shen, 2016a; Polzin et al., 2021). The advantage of this approach is that it generates a time series for each firm for panel data analysis and provides global coverage. Other approaches, such as secondary market bond spreads, are limited in geographic coverage, while syndicated loans, do not generate a yearly time series unless debt is issued annually. However, the drawback of this approach as highlighted by Frank & Shen (2016a) is that the average cost of debt is partly backwards looking, by incorporating past debt issuances, so does not only reflect current financing conditions. Furthermore, the average cost of debt will only change if old debt matures, or new debt is issued. To control for this dynamic, we include debt issuance as a potential confounding variable, as debt raised is likely to affect both the cost of debt and investment activity. Similar to the cost of debt, we scale debt capital raising by total outstanding debt (Eq. 4). While the average cost of debt has remained stable, average debt capital raising has fallen over time, for example, from 3.16% in 2011 to 1.34% in 2020 in the international sample (Table 1). By region, while non-OECD countries have a higher cost of debt, they have higher debt capital raising than OECD countries, reflecting higher rates of LCI and HCI (Table 2).

$$3)\ Cost\ of\ Debt_{i,t} = \frac{Interest\ Expense_{i,t}}{Outstanding\ Debt_{i,t}}$$

$$4)\ Debt\ Capital\ Raising_{i,t} = \frac{Net\ Issuance\ and\ Retirement\ of\ Debt_{i,t}}{Outstanding\ Debt_{i,t}}$$

We control for additional firm-level variables that could affect investment. This includes firm size measured by total revenue and profitability defined as operating income to total revenue. Firm leverage is controlled for, defined as total debt to total assets, as debt overhang is likely to constrain the potential of electric utilities firms to invest (Hickey et al., 2021). Asset tangibility, defined as fixed assets to total assets, is included as we expect firms with more capital-intensive operations to have higher rates of investment. Similarly, the ratio of cash flow to capital is included, as a common element of investment regressions (Frank & Shen, 2016a). Alongside LCI and HCI, all firm-level variables are winsorized at 1% and 99% levels to mitigate the effect of outliers. Variable definitions and summary statistics are provided in Appendix B.

3.3 Climate Policy and Country-Level Control Variables

This the OECD Environmental Policy Stringency Index, which ranges from 1990 to 2020 and focuses on climate change and air pollution mitigation policies (Kruse et al., 2022), is commonly used in the energy economics and sustainable finance literature (Cojoianu et al., 2020; Fard et al., 2020; C. Lin et al., 2019). The composite index is broken down into three equally weighted sub-indices scored from 0 to 6: “market-based policies” such as carbon prices and taxes, “non-market based policies” that include emission performance standards, and “technology support” which includes government R&D, feed-in tariffs, and renewable energy auctions (Kruse et al., 2022). We extract the elements of relevance to the policies of interest, and define a market-based policies sub-index named CO2 Trading & Taxes and a technology support sub-index named Renewable Energy Price Support (defined in Appendix C). For these two sub-indices, we observe different trends over time. After an initial drop at the start of the sample period, there is an increase in the stringency of CO2 Trading & Taxes across policy types and in both OECD and non-OECD countries (Figure 2). In contrast, there is a decline in the stringency of Renewable Energy Price Support from 2011 to 2017, with a slight increase to 2020. However, the trend in Renewable Energy Price Support differs across regions, with a sharp increase in non-OECD countries from 2013 and a sharp fall in OECD countries from 2011[8].

[8] The OECD scale the level of FIT support in USD/kWh by global LCOE (Kruse et al., 2022). As shown in Appendix D, there is a steady decrease, or digression, in the average unscaled level of price support in both OECD and non-OECD countries, with all countries where FITs are implemented showing digression (except Hungary). However, the fall in unscaled FIT price support is much more significant in OECD countries.

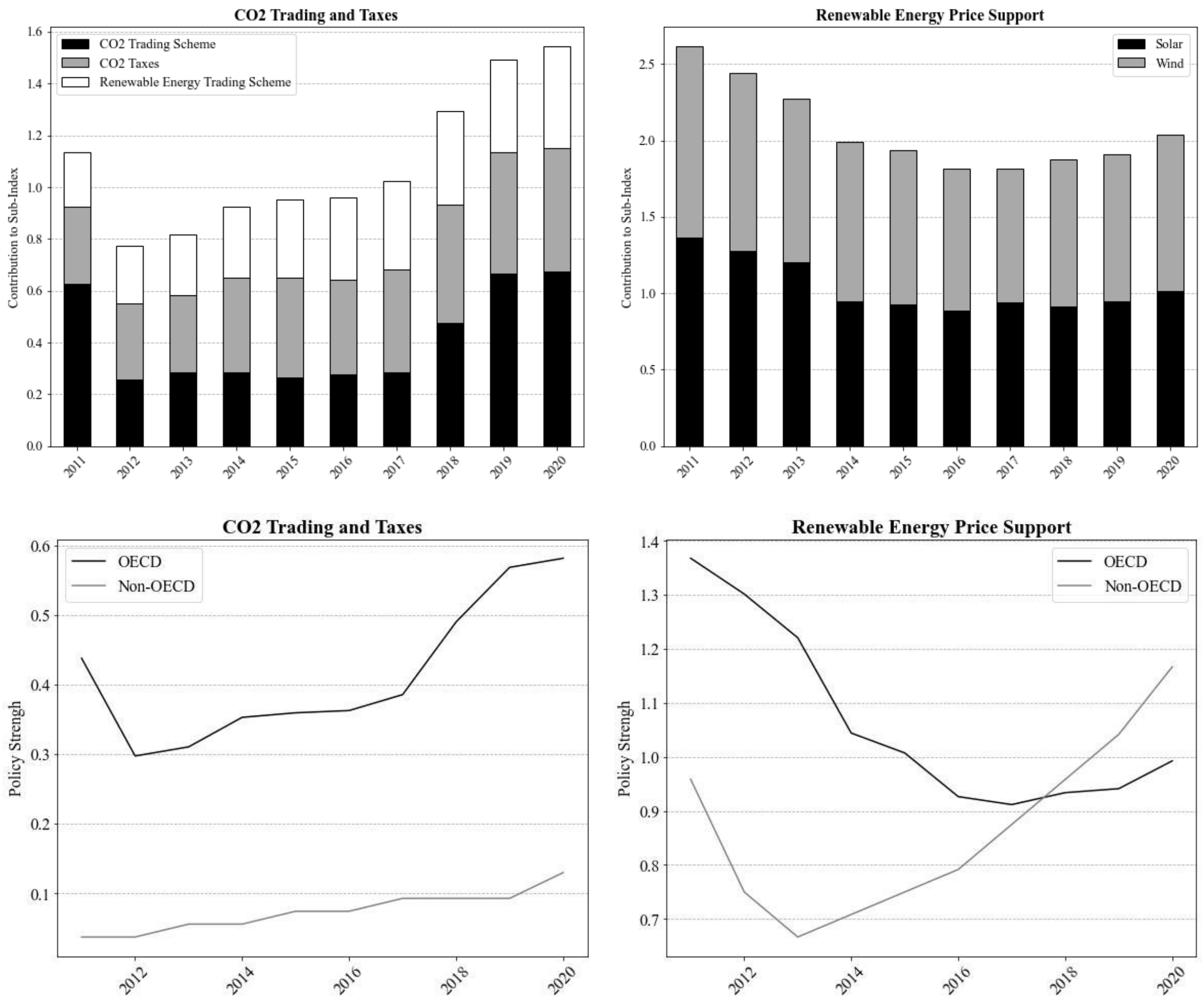


Figure 2: OECD EPS Sub-Indices

The average breakdown of the CO2 Trading & Taxes and Renewable Energy Price Support sub-indices are shown. These are defined in Appendix C.

Alongside climate policy, to control for differences between county-level conditions, we control for economic variables common in the financial (Drobetz et al., 2018; Frank & Shen, 2016a) and the energy economics investment literature (Best, 2017; Cohen et al., 2020; Fadly, 2019; C. Lin et al., 2019; Neil & Seri~, 2022; Neil & Seriño, 2018; Pfeiffer & Mulder, 2013; Zhao et al., 2013). To control for economic growth, we include GDP per capita, GDP growth, and inflation. Then to control for the availability of capital to finance new investment, we include foreign direct investment (FDI) scaled by GDP and the availability of private sector credit from the banking sector scaled by GDP. As shown by (Best, 2017), country-level financial capital facilitates the transition to capital-intensive low-carbon energy. Variable definitions and summary statistics are provided in Appendix B.

3.4 Empirical Analysis

Capital Markets and Investment

In our analysis, we are focused on how changes in firm-level access to finance affects firm-level investment. However, an OLS fixed effects model, which would utilise our panel data structure to exploit within-firm variation, is not suitable as the dependent variables are not normally distributed. Both LCI and HCI are bounded at zero, with a large proportion of values equal to zero (73% of LCI and 81% HCI within the domestic sample). As a result, we utilise a fixed effects (FE) Poisson model that is often used to model energy investment and deployment (Ang et al., 2017; Fabrizio, 2013; Neil & Seri~, 2022; Neil & Seriño, 2018; Zhao et al., 2013). FE Poisson models produce robust estimates, even with a large proportion of zero values, overdispersion, and firm-level unobservable heterogeneity (MartíŔnez-Zarzoso, 2013). In Appendix E, we provide further details on the choice of a FE Poisson model, as well as tests of functional form.

To address H1, we apply the FE Poisson model to the international investment activity of firms, with the baseline specification shown in Eq. 5 and Eq. 6, where $LCI_{i,t}$ represents the rate of low-carbon energy investment by firm i in year t and $HCI_{i,t}$ represents the rate of high-carbon energy investment by firm i in year t. $CoD_{i,t-1}$ and $DCR_{i,t-1}$ represent the lagged cost of debt and debt capital raising of firm i, while $X_{i,t-1}$ represents a vector of firm and country level controls variables. As the dependent variable often consists of investment activity in multiple countries, the country-level control variables are calculated as a weighted average using the weights of a firm's operating capacity in different countries. Finally, δ_i represents firm fixed effects, θ_t represents time fixed effects, and $e_{i,t}$ the error term. All explanatory variables are lagged to avoid any bias from simultaneity, as reserve causality could occur between firm-level investment and control variables in the same period, such as through the cost of debt. We expect CoD to have a negative significant relationship with LCI and HCI. Eq. 5 and 6. is tested on all regions, followed by OECD and non-OECD regions only, given significant differences in the investment activity of these regions (Table 2). Further heterogeneity analysis is conducted by splitting the data first by firm size, using the median MW operational capacity of matched firms. Second, by firm leverage, as defined in Appendix B. Third, by type of energy mix, using the proportion of operational assets that are high-carbon to separate firms into low- and high-carbon. Lastly, we split the sample by period, evaluating 2012-2016 and 2017-2021.

$$5)\ LCI_{i,t} = \beta_0 + \beta_1 CoD_{i,t-1} + \beta_2 DCR_{i,t-1} + \beta_3 X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

$$6)\ HCI_{i,t} = \beta_0 + \beta_1 CoD_{i,t-1} + \beta_2 DCR_{i,t-1} + \beta_3 X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

In Eq. 5 and Eq. 6 we control for debt capital raising as a potential confounding variable that affects both cost of debt and firm-level investment. However, the cost of debt can also facilitate firm-level investment indirectly, by inducing firms to raise additional debt when financing costs are lower, which in turn is used to fund investment. We, therefore, conduct a simple channel analysis, using the structure used by Zhou et al. (2022) and Tang et al. (2021) with a series of recursive equations Eq. 7-9. For a partial mediation effect, β_1, β_2, β_3, and β_4 needs to be statistically significant, with each directional relationship shown in Figure 2 important in driving investment. For a complete mediation effect, β_1, β_2, β_4 need to be significant but not and β_3, as it is only through its effect on debt capital raising that the cost of debt affects investment. These specifications are repeated for HCI. Unlike Zhou et al. (2022) we use lagged explanatory variables for all equations to avoid simultaneity between the cost of debt and capital raising, and with firm-level investment. In addition, as debt raising is normally distributed, an OLS fixed effects model is used for Eq. 8, while a FE Poisson model is used for Eq. 7 and Eq. 9. This prevents us from conducting advanced analysis of mediation effects, for example, through Structural Equation Models. In line with H2, we could expect a partial mediation effect to occur for LCI and HCI specifications, with the cost of debt affecting investment directly and also indirectly through its effect on capital raising.

$$7)\ LCI_{i,t} = \beta_0 + \beta_1 CoD_{i,t-1} + \lambda X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

$$8)\ DCR_{i,t} = \beta_0 + \beta_2 CoD_{i,t-1} + \lambda X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

$$9)\ LCI_{i,t} = \beta_0 + \beta_3 CoD_{i,t-1} + \beta_4 DCR_{i,t-1} + \lambda X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

Climate Policy and Investment

In the next stage of analysis, we control for the effect of country-level climate policy on domestic LCI and HCI. First, we add our measure of climate policy to the baseline specification. This is done for the two policy sub-indices of interest, CO2 Trading & Taxes and Renewable Energy Price Support defined in Appendix C, represented by EPS in Eq. 10 and 11. This enables us to check the robustness of H1 in a domestic setting, and when controlling for policy. In relation to H3, we would expect EPS to have a positive significant relationship with LCI and a negative significant relationship with HCI. For each measure of policy, additional heterogeneity analysis is conducted following the method used for international investment.

$$10)\ LCI_{i,t} = \beta_0 + \beta_1 CoD_{i,t-1} + \beta_2 DCR_{i,t-1} + \beta_3 EPS_{i,t-1} + \beta_4 X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

$$11)\ HCI_{i,t} = \beta_0 + \beta_1 CoD_{i,t-1} + \beta_2 DCR_{i,t-1} + \beta_3 EPS_{i,t-1} + \beta_4 X_{i,t-1} + \delta_i + \theta_t + e_{i,t}$$

Next, we evaluate the moderating effect of climate policy on the relationship between the cost of debt and investment, and debt capital raising and investment. This is achieved by including interaction terms of CO2 Trading & Taxes and then Renewable Energy Price Support with CoD and DCR, shown in Eq. 12 and 13. This is performed for all regions, followed by OECD and non-OECD. Given H4, we expect the interaction term of $CoD * EPS$ to have a negative statistically significant relationship for LCI specifications and a positive significant relationship for HCI specifications, as firms more readily take advantage of lower financing costs to increase LCI when policy is supportive, and are more likely to reduce HCI. We expect the $CoD * EPS$ interaction term to have a positive significant relationship for LCI and negative for HCI, with stronger climate policy guiding capital away from HCI and towards LCI. To aid the interpretation of results, policy variables, cost of debt, and debt capital raising are standardised around the mean.

$$\begin{aligned} 12)\ LCI_{i,t} = {} & \beta_0 + \beta_1 CoD_{i,t-1} + \beta_2 DCR_{i,t-1} \\ & + \beta_3 EPS_{i,t-1} + \beta_4 CoD_{i,t-1} * EPS_{i,t-1} + \beta_5 DCR_{i,t-1} * EPS_{i,t-1} + \beta_6 X_{i,t-1} + \delta_i \\ & + \theta_t + e_{i,t} \end{aligned}$$

$$\begin{aligned} 13)\ HCI_{i,t} = {} & \beta_0 + \beta_1 CoD_{i,t-1} + \beta_2 DCR_{i,t-1} \\ & + \beta_3 EPS_{i,t-1} + \beta_4 CoD_{i,t-1} * EPS_{i,t-1} + \beta_5 DCR_{i,t-1} * EPS_{i,t-1} + \beta_6 X_{i,t-1} + \delta_i \\ & + \theta_t + e_{i,t} \end{aligned}$$

As the OECD measure used excludes 40% of firms in the full international sample, to check the robustness of this approach, we control for potential selection bias in climate policy data. Countries where OECD data is available may have certain characteristics, such as better-functioning capital markets or lower corruption, that affects investment. To address this, a two-stage Heckman model is used that controls for selection bias (J.Heckman, 1979). Further details on the methods used are provided alongside results in Appendix I. Furthermore, while we limit potential simultaneity by lagging all explanatory variables, as an additional robustness test, we test for endogeneity in climate policy. As noted by Smith & Urpelainen (2014), endogeneity in climate policy could result in a downward bias in the estimation of its impacts, as governments in countries with minimal low-carbon energy capacity use stronger policies to increase deployment. Alternatively, upward bias could occur as countries with high low-carbon energy deployment develop vested interests that push for the maintenance or strengthening of climate policy (Smith & Urpelainen, 2014). To test for the presence of endogeneity of policy, a control function procedure is used suitable for a non-linear setting with an FE Poisson model (W. Lin & Wooldridge, 2019; Wooldridge, 2002). Further details on the methods used presented alongside results in Appendix I.

4. Results

Capital Markets and Investment

Results for the baseline regressions Eq. 4 and 5 are tabulated in Table 3[9]. In line with H1, we see that the cost of debt has a negative relationship with LCI and HCI, with both significant at the 5% level. The coefficients from the FE Poisson model can be interpreted as elasticities, indicating that a 1% drop in COD leads to an 0.1% increase in LCI holding all other factors constant. A stronger relationship between the cost of debt and LCI relative to HCI is expected, given the higher sensitivity of low-carbon energy types to financing costs, however, this difference at the global level is not large. For debt capital raising, we also observe a positive significant relationship with both LCI and HCI, significant at the 1% and 5% level respectively. Together, this indicates that if a firm raises capital at a lower cost of debt, then investment will increase more than if is capital raised with a higher cost of debt.

When limited to OECD countries, the cost of debt still has a negative relationship with LCI, now significant at the 1% level. The coefficient is also higher in magnitude at 0.19 vs 0.1 in the global sample. However, while the relationship between the cost of debt and LCI is stronger in OECD countries, for HCI, the coefficient is no longer significant and is smaller in magnitude. The results for non-OECD countries show the opposite, with the coefficient between the cost of debt and LCI no longer significant and smaller in magnitude. Whereas for HCI, the relationship is significant at the 1% level and greater in magnitude. In summary, these results suggest that OECD countries drive the relationship between financing costs and LCI, and non-OECD countries drive the relationship with HCI. Additional heterogeneity analysis is provided in Appendix F.

Table 3: **International Investment**

	All Regions		OECD		Non-OECD	
	LCI	HCI	LCI	HCI	LCI	HCI
	1	2	3	4	5	6
Cost of Debt	-0.100**	-0.0826**	-0.194***	-0.0569	-0.0798	-0.108***
	(0.0441)	(0.0347)	(0.0590)	(0.0682)	(0.0671)	(0.0414)
Debt Capital Raising	0.0212***	0.0321**	0.0255***	0.0900***	0.0183	0.0177
	(0.00710)	(0.0149)	(0.00845)	(0.0344)	(0.0122)	(0.0122)
Cash Flow	-0.0365	-0.0399	-0.000739	0.0419**	-0.0573	-0.0912**
	(0.0292)	(0.0342)	(0.0295)	(0.0183)	(0.0490)	(0.0414)
Tangibility	0.0136	-0.0146	0.00756	-0.000578	0.0138	-0.0140
	(0.0121)	(0.0106)	(0.0148)	(0.0187)	(0.0160)	(0.0125)
Revenue	-0.0809	-0.0317	-0.0676	-0.00190	-0.0658	-0.146*
	(0.0616)	(0.0381)	(0.0425)	(0.0271)	(0.182)	(0.0786)
Leverage	-0.00859	-0.0148*	-0.0320**	-0.0152	0.00131	-0.0185*
	(0.0119)	(0.00853)	(0.0128)	(0.0148)	(0.0176)	(0.0107)
Profitability	0.00365	0.0140*	-0.00143	0.000243	0.0110	0.0212**
	(0.00442)	(0.00765)	(0.00445)	(0.00505)	(0.00945)	(0.00893)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Country Level Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	1624	1219	1028	686	596	533

[9] To deploy the FE Poisson mode, the Stata function "xtpoisson" is used. In this, firms with all zero outcomes are dropped for convenience as they do not contribute to the estimation of parameters via the likelihood function. As a result, the sample size appears smaller that if all firm observations were counted, and the sample size for LCI and HCI specifications differ. In our sample, we have 429 unique firms after retaining those with data for all control variables. Within this sample, 227 have all zero observations of LCI, 280 have all zero observations for HCI, and 78 have all zero observations for both LCI and HCI.

*p < 0.10, ** p < 0.05, *** p < 0.01 denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively.

In H1, controlling for capital raising is important as a potential confounding variable. However, in H2, we explore the potential indirect impact of the cost of debt on investment through its effect on capital raising, with channel analysis results tabulated in Table 4. In Panel A, we see globally that there is a significant negative relationship at the 1% level between the lagged cost of debt and capital raising (specification 2), indicating that a reduction in financing costs does indeed induce capital raising, in line with (Barry et al., 2008). We then see that the cost of debt and debt capital raising have a significant relationship with LCI and HCI when modelled separately, and when both are controlled for. This shows a partial mediation effect, with the cost of debt affecting investment both directly and indirectly by inducing debt capital raising. By region, we find evidence of a partial mediation effect in OECD countries for LCI but not HCI, while in the smaller sample of non-OECD countries, there is no statistically significant evidence of mediation effects (Appendix G).

Table 4: **International Investment – Channel Analysis**

	LCI	DCR	LCI	LCI
Panel A – Low-Carbon	1	2	3	4
Cost of Debt	-0.130**	-0.395***		-0.100**
	(0.0569)	(0.111)		(0.0441)
Debt Capital Raising			0.0283***	0.0213***
			(0.00994)	(0.00712)
N	1624	1658	1624	1624
	HCI	DCR	HCI	HCI
Panel B – High-Carbon	5	6	7	8
Cost of Debt	-0.129***	-0.355***		-0.0828**
	(0.0371)	(0.125)		(0.0347)
Debt Capital Raising			0.0460***	0.0320**
			(0.0140)	(0.0149)
N	1219	1258	1219	1219

*p < 0.10, ** p < 0.05, *** p < 0.01 denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. DCR stands for Debt Capital Raising. All specifications include firm and year fixed effects and firm and country-level controls. Across all panels, in specifications with DCR as the dependent variable an OLS fixed effects model is used, while for LCI and HCI a FE Poisson model is used.

Climate Policy and Investment

Next, to consider the role of domestic climate policy in H3, the measurement of LCI and HCI is limited to investment activity within a firm's country of headquarters. In Table 5, we tabulate results for Eq. 10 and 11. Whether controlling for climate policy using CO2 Trading & Taxes or Renewable Energy Price Support, the cost of debt is statistically significant at the 10% to 5% level for LCI but not HCI. This reinforces the robustness of our findings for H1, by showing that in both international and domestic contexts that the cost of debt stimulates LCI and that LCI is more sensitive to changes in the cost of capital than HCI. However, this differs from the baseline regression results in Table 3, where the cost of debt had a significant relationship for both LCI and HCI.

With regard to climate policy controls, CO2 Trading & Taxes has a strong positive significant relationship with LCI at the 1% level and a negative but insignificant relationship with HCI. In both instances, debt capital raising has a positive relationship with investment at the 5% level. With regard to Renewable Energy Price Support, there is a positive relationship shown with LCI and a negative relationship shown with HCI, but in both cases, the relationship is not significant. We observe that debt capital raising has an insignificant positive relationship with LCI and a positive significant relationship with HCI at the 5% level. In summary, stronger CO2 Trading & Tax policies drive LCI as hypothesised in H3. However, we do not find evidence that Renewable Energy Price Support drives LCI, and for both policy types, while a negative relationship with HCI is found in line with H3, this is not significant.

Further analysis is shown in Appendix H, with results from the heterogeneity analysis described and tabulated.

Table 5: **Domestic Investment with Policy Controls**

	LCI	HCI	LCI	HCI
	3	4	5	6
CO2 Trading & Taxes	0.790***	-0.0720		
	(0.286)	(0.358)		
Renewable Energy Price Support			0.214	-0.0234
			(0.144)	(0.127)
Cost of Debt	-0.102*	-0.0573	-0.0989**	-0.0578
	(0.0545)	(0.0421)	(0.0500)	(0.0408)
Debt Capital Raising	0.0209**	0.0432**	0.0184	0.0430**
	(0.00986)	(0.0175)	(0.0114)	(0.0177)
Cash Flow	-0.0800*	0.00157	-0.0635	0.000385
	(0.0480)	(0.0370)	(0.0450)	(0.0381)
Tangibility	0.0143	0.00417	0.0168	0.00419
	(0.0129)	(0.0131)	(0.0136)	(0.0130)
Revenue	-0.167*	-0.0728	-0.114	-0.0758
	(0.0932)	(0.0772)	(0.0737)	(0.0807)
Leverage	0.01000	-0.0138	0.0161	-0.0137
	(0.0168)	(0.0131)	(0.0156)	(0.0129)
Profitability	0.0108	0.00983	0.00838	0.00992
	(0.00856)	(0.00988)	(0.00803)	(0.00992)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Country Level Controls	Yes	Yes	Yes	Yes
N	1109	832	1109	832

$*p < 0.10$, $** p < 0.05$, $*** p < 0.01$ denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively.

To further examine the effect of climate policy, we show results testing its moderating role on the relationship between the cost of debt and debt capital raising with investment (Table 6). For CO2 Trading & Taxes, there is a positive interaction effect with debt capital raising for LCI and a negative interaction effect for HCI, as expected in H4. This indicates that as CO2 Trading & Taxes strengthen, the relationship between debt capital raising and LCI also strengthens, with more capital deployed into LCI. The opposite occurs for HCI, with the relationship between debt capital raising and HCI weakening, with less capital deployed into HCI. The sign of the coefficients of these interactions is consistent across both OECD and non-OECD regions (Appendix J). However, for OECD regions, the interaction effect is significant only for LCI, while for non-OECD regions, it is only significant for HCI. This consistency makes sense, given the similar trajectory of CO2 Trading & Taxes in the two regions over time (Figure 2). However, for the cost of debt, none of the interaction effects is significant, indicating that the relationship with investment is not affected by policy[10].

In contrast to CO2 Trading & Taxes, for Renewable Energy Price Support, there is no apparent moderation effect seen globally, for both the cost of debt and debt capital raising. When split out by region, the cost of debt interaction effects remains insignificant. However, as shown in Appendix Y, in OECD countries, we observe a negative significant interaction effect with Debt Capital Raising for LCI and a negative significant interaction effect with HCI. This can be interpreted as showing that as FIT

[10] This lack of significance could be due to the fact that even if the cost of debt falls, firms may not take the opportunity to increase investment. For example, due to issues identified during the economic appraisal and project development phase, such as rising input costs or obtaining planning permission (Stage 2 Figure 1). Whereas the decision to raise capital is more likely to be associated with a final investment decision to develop a new asset (Stage 3 Figure 1). As a result, a moderating effect of policy on investment is more likely to be present with regard to debt capital raising than the cost of debt.

support digression occurs, which is intended to drive down costs, increase learning rates, and incentivise deployment, debt capital raising is more likely to be channelled into LCI than HCI. The opposite occurs for non-OECD countries, with a positive significant interaction effect for LCI and a negative but insignificant interaction effect for HCI, indicating that higher levels of FIT price support helped to channel debt capital raising into LCI. The difference between regions can be explained by the difference in trajectories of these policies over time according to the OECD's measure of policy strength (Figure 2), whereby OECD countries have experienced digression whereas non-OECD countries have increased the level of support in relative terms.

To check the robustness of our findings regarding climate policy, we conduct additional robustness checks, with results described and shown in Appendix I. First, by applying a Heckman model, we show that results are consistent when controlling for selection bias in the availability of policy data (Table I.1). Second, by using a control function test for endogeneity in climate policy variables, we demonstrate the exogeneity of our measures of climate policy (Table I.2). These additional tests are conducted with regard to direct effect of policy (Table 5) and the moderating role of policy (Table 6).

Table 6: **Moderating Role of Policy**

	LCI	HCI	LCI	HCI
	1	2	3	4
CO2 Trading & Taxes	0.685∗∗	-0.177		
	(0.267)	(0.366)		
Cost of Debt × CO2 Trading & Taxes	0.0656	-0.0352		
	(0.0602)	(0.0482)		
Debt Capital Raising × CO2 Trading & Taxes	0.0196∗∗	-0.0568∗∗		
	(0.00968)	(0.0284)		
Renewable Energy Price Support			0.185	-0.0646
			(0.133)	(0.132)
Cost of Debt × Renewable Energy Price Support			-0.0135	0.0112
			(0.0247)	(0.0246)
Debt Capital Raising × Renewable Energy Price Support			0.0000404	0.0223
			(0.00619)	(0.0175)
Cost of Debt	-0.0681	-0.0639	-0.118∗	-0.0653
	(0.0570)	(0.0441)	(0.0710)	(0.0445)
Debt Capital Raising	0.0271∗∗	0.0287∗	0.0165	0.0301∗
	(0.0107)	(0.0172)	(0.0136)	(0.0179)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Firm Level Controls	Yes	Yes	Yes	Yes
Country Level Controls	Yes	Yes	Yes	Yes
N	1109	832	1109	832

∗p < 0.10, ∗∗ p < 0.05, ∗∗∗ p < 0.01 denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. All specifications include firm and year fixed effects and country-level controls.

5. Discussion and Conclusion

In this study, we find that a lower firm-level cost of debt increases LCI, both in an international setting and a domestic setting with climate policy controls. While we also find that the cost of debt affects HCI, this is only significant in an international setting, and to a lesser degree than LCI. These findings show how changes in financing conditions can help or hinder firm-level transitions, providing empirical evidence to support arguments foregrounded in the modelling and theoretical energy economics literature. For example, Hickey et al. (2021) highlight how a high firm-level cost of capital, due to high existing indebtedness or the pricing of stranded asset risk, can limit the ability of incumbent firms to invest in low-carbon energy at the speed required to align with climate targets. While Helms et al. (2020) argue that if incumbent fossil fuel electric utilities have a high cost of capital, this could limit their ability to invest in lower-return low-carbon energy relative to firms with a lower cost of capital. Similarly, our finding that globally, LCI is more sensitive to the cost of debt than HCI is consistent with studies showing that at the asset level, renewable power is more sensitive to changes in the cost of capital than fossil fuel assets (Hirth & Steckel, 2016).

Together, these findings provide evidence that the cost of capital can act as a transmission mechanism through which the financial system can affect the real economy in the context of the low-carbon transition. Therefore, if sustainable finance can affect the cost of capital, it can deliver impact (Caldecott et al., 2022; Kölbel et al., 2020). While asset pricing is not addressed in this paper, numerous studies have shown how climate risks are priced in equity and debt markets (Caragnano et al., 2020; Chava, 2014; Jung et al., 2018; Pizzutilo et al., 2020). There is, however, an open debate on whether investors with "impact" or "sustainable" preferences are driving this pricing, and if so, whether the changes they cause in the cost of capital are large enough to affect real economy outcomes (Berk & van Binsbergen, 2021; Kölbel et al., 2020). Nevertheless, while the drivers are hard to disentangle, divergence in the cost of capital between the high and low carbon-intensity electric utilities is occurring, for example, in Europe (X. Zhou et al., 2023).

In addition to the direct effect of the cost of debt on investment, we find that a reduction in the cost of debt can drive investment indirectly through the channel of debt capital raising, with higher debt capital raising increasing both LCI and HCI at a global level. This underscores the importance of primary market transactions for impact-aware investors, as capital provided can be used to develop low-carbon energy or contribute to carbon lock-in through the development of fossil fuel assets (Wilson & Caldecott, 2021). These investors should seek to influence how this capital is allocated, for example, through engagement or use of proceeds instruments such as green bonds. Alternatively, they can analyse the CAPEX plans of corporates to assess how the capital provided will be utilised[11].

Our findings also have several implications for policymakers. In the current global economic climate, interest rates have risen to tackle inflation caused by the Russian invasion of Ukraine and the economic recovery from Covid-19 (Adrian & Natalucci, 2022). Such an increase could have negative consequences for investment in low-carbon energy, given the greater sensitivity of capital-intensive renewables to the cost of capital (Schmidt et al., 2019) and the impact of corporate financing costs on investment activity, as shown in this study. To offset the negative impact of such a rise, Voldsgaard et al. (2022) highlight solutions that include lowering central bank borrowing rates for green lending, making debt tax deductible for low-carbon energy, or altering subsidies in response to interest rates.

Rising interest rates may also require a higher long-term carbon price to ensure the cost competitiveness of low-carbon energy (Pahle et al., 2022). While empirical evidence to date shows inconclusive evidence for the effect of carbon prices on firm-level investment (Lilliestam et al., 2021), we find that stronger policy increases LCI at the firm level within the past decade – a period of analysis lacking within the existing literature (Teixidó et al., 2019). In addition, our analysis examines the moderating role of climate policy on the relationship between the cost of debt and debt capital raising with investment. While we find no evidence of a moderating role for the cost of debt, we show that a more stringent CO2 Trading & Tax policy strengthens the relationship between debt capital raising and LCI and weakens the relationship between debt capital raising and HCI. This demonstrates that policy interventions that can accelerate the energy transition by altering how firms deploy capital raised from financial markets and financial institutions. This finding contributes to the literature on market-based policies by analysing moderating effects in addition to direct effects. Furthermore, existing work has

[11] For example, investors or banks could analyse corporate transition plans that detail forward looking CAPEX plans to assess how capital provided will be deployed. Transition plans detail how a corporate will decarbonise (TPT, 2022).

shown how access to financial capital (Best, 2017) and policy implementation (Liu et al., 2019) can accelerate the energy transition at the country-level. Our findings build on this, by showing how the two interact to accelerate LCI at the firm-level.

This study does, however, have several limitations that could be addressed in future research. First, our sample period of 2011-2021 captures the digression of FITs in nearly every country in our sample, rather than the initial implementation of these policies. Second, our measure of climate policy did not provide coverage for all countries in our sample, with a focus on OECD countries. While we did capture key BRICS countries, a lower coverage of developing countries is a significant limitation given that they are set to account for the majority of growth in emissions in the coming decades (IEA, 2021c). Third, we do not evaluate the cost of equity, but instead, focus on the cost of debt. We justify our decision due to the outsized role of debt within capital flows to electric utilities and the easy availability of accounting data required to calculate the cost of debt. However, equity markets still play an important role, enabling new entrants to grow and challenge incumbents.

Finally, we identify two avenues for future research. First, this study looks at the link between the cost of debt on the liability side of the balance sheet with investment activity on the asset side of the balance sheet. However, we do not analyse the internal capital markets within firms that link the two and the role of the cost of capital within them. Namely, whether firms adjust the cost of capital for project risk, and if not, what effect that has on choices between high and low-carbon projects. Second, our analysis is limited to publicly listed electric utilities firms. However, oil & gas firms are increasingly diversifying into low-carbon power as an avenue to decarbonise and diversify away from fossil fuels. Given the high IRRs of oil & gas projects historically, moving towards lower return power assets could cause considerable challenges for oil & gas firms, and is worthy of future study.

6. Appendix

Appendix A: Classification of WEPP Energy Types

Table A.1

Fuel Group	WEPP Code	Description
Bioenergy	BAG	Bagasse
	BGAS	Biogas from digestion of agricultural waste or food waste or other organic material
	BIOCOAL	Biocoal
	BIOMASS	Biomass excluding wood chips but including agricultural waste and energy crops
	BL	Bioderived liquid fuels such as palm oil or vegetable oils or biodiesel or bio-oil or other bioliquids
	DGAS	Sewage digester gas
	ETHANOL	Ethanol
	LIGNIN	Lignin bio-oil
	LIQ	Pulping liquor (black liquor)
	MANURE	Manure fuel
	MBM	Meat and bonemeal
	PWST	Paper mill waste or sludges
	WOOD	Wood or wood-waste fuel
	WOODGAS	Syngas from gasified wood or biomass
	WSTWSL	Wastewater sludge
Coal	BFG	Blast-furnace gas also converter gas or LDG or Finex gas (approx 10% of the heat content of pipeline gas)
	CGAS	Coal syngas - fuel for IGCC plants (from gasified coal)
	COAL	Coal
	COG	Coke oven gas (approximately 50% of the heat content of pipeline natural gas)
	COKE	Coke fuel
	CSGAS	Coal seam gas (aka coal bed gas or coal bed methane or CBM)
	CWM	Coal-water mixture also knon as coal-water slurry
	CXGAS	Corex process offgas
	PEAT	Peat
	TGAS	Top gas
	WSTCOAL	Waste coal from mining or washing operations (also gangue)
Gas	FGAS	Flare gas or wellhead gas, also used for associated gas consumed at the gas fields
	GAS	Natural gas
	H2	Hydrogen gas
	MGAS	Mine gas (methane from active or abandoned coal mines)
Geothermal	GEO	Geothermal
Hydroelectric	WAT	Hydroelectric
Nuclear	UR	Uranium
Oil	BITUMEN	Bitumen or asphalt or asphaltite
	CKGAS	Synthetic gas from petroleum coke
	GASOIL	Gasoil (intermediate refining product also called diesel or No 2 fuel oil)
	GASOLINE	Gasoline
	JET	Jet fuel
	KERO	Kerosene
	LNG	Liquified natural gas
	LPG	Liquified petroleum gas (usually butane or propane)
	NAP	Naphtha
	OGAS	Gasified crude oil or refinery bottoms or bitumen
	OIL	Fuel oil
	RGAS	Refinery off-gas
	SHALE	Oil shale
	VOCGAS	VOC gas & vapor
	WSTGAS	Waste gas from refinery or other industrial processes
Solar	SUN	Solar power
Unknown	UNK	Unknown operational status typically assigned to old plant
Waste	AGAS	Syngas from gasified agricultural waste or poultry litter Hazardous waste
	HZDWST	Global freshwater thermal emissions from steam-electric power plants with once-through cooling systems
	INDWST	Industrial waste or refinery waste
	LGAS	Landfill gas
	MEDWST	Medical waste
	REF	Refuse (unprocessed municipal solid waste)
	REFGAS	Syngas from gasified refuse
	RPF	Waste paper and/or waste plastic
	TIRES	Scrap tires
	WSTH	Waste heat
	WSTGAS	Waste gas
Wind	WIND	Wind power

Adapted from Raptis (2017) and Hoersch et al. (2017). Ethanol is classified as a biofuel, given that the majority is produced from crops, while Methanol is classified as oil, given the majority if produced from fossil fuels.

Appendix B: Variable Definitions and Summary Statistics

Table B.1: Variable Definitions

Variable	Definition	Source
Firm-Level Variables		
Low-Carbon Investment (LCI)	Under construction capacity of low-carbon and alternative energy, as defined by Appendix 1, scaled by total existing capacity of all energy types.	WEPP
High-Carbon Investment (HCI)	Under construction capacity of high-carbon energy, as defined by Appendix 1, scaled by total existing capacity of all energy types.	WEPP
Cost of Debt (CoD)	Interest expense divided by total debt. Winsorized at 1% and 99%.	Eikon
Debt Capital Raising (DCR)	Net issuance and retirement of debt capital divided by total debt. Winsorized at 1% and 99%.	Eikon
Cash Flow	Cash flow divided by total assets. Winsorized at 1% and 99%	Eikon
Tangibility	Fixed assets divided by total assets. Winsorized at 1% and 99%	Eikon
Revenue	Total revenue. Winsorized at 1% and 99%	Eikon
Profitability	Operating income divided by total revenue. Winsorized at 1% and 99%	Eikon
Country-Level Variables		
Foreign Direct Investment (FDI)	Foreign direct investment divided by GDP.	World Bank
GDP per Capita	GDP divided by population	World Bank
GDP Growth	Percentage growth in GDP.	World Bank
Access to Credit		World Bank
Inflation	Percentage inflation, as measured by X.	World Bank
Renewable Energy Price Support	Level of support from feed-in tariffs and auctions for wind and solar (Appendix 4)	OECD
CO2 Trading & Taxes	Strength of CO2 trading schemes, CO2 Taxes, and renewable energy trading schemes (Appendix 4)	OECD

Table B.2: Variable Summary Statistics

	Mean	SD	p25	p75
Domestic				
Low-Carbon Investment (LCI) (%)	5.98	28.15	0.00	0.08
High-Carbon Investment (HCI) (%)	3.40	13.16	0.00	0.00
Cost of Debt (%)	4.87	3.00	3.14	5.87
Debt Capital Raising (%)	1.69	6.07	-1.41	3.87
Cash Flow (%)	5.74	4.79	4.20	7.80
Tangibility (%)	77.06	15.18	70.65	87.84
Revenue	7.31	13.29	0.59	7.91
Leverage (%)	54.40	20.88	41.82	69.10
Profitability (%)	13.40	18.14	5.51	21.61
FDI (%)	2.14	5.27	1.22	2.61
GDP per Capita	29.21	21.69	9.25	53.39
GDP Growth (%)	2.22	3.47	0.96	3.92
Access to Credit (%)	123.46	53.53	66.48	174.47
Inflation (%)	2.71	3.05	1.00	3.50

Renewable Energy Price Support	1.43	1.90	0.00	3.00
CO2 Trading & Taxes	0.86	0.81	0.33	1.67
Emission Performance Standards	4.32	1.68	4.00	5.33
Observations	2191			
International				
Low-Carbon Investment (LCI) (%)	5.97	25.95	0.00	0.12
High-Carbon Investment (HCI) (%)	4.32	17.26	0.00	0.00
Cost of Debt (%)	5.48	4.29	3.26	6.39
Debt Capital Raising (%)	1.92	7.24	-1.72	4.19
Cash Flow (%)	6.46	5.90	4.35	8.79
Tangibility (%)	75.41	16.16	68.52	87.14
Revenue	5.20	10.70	0.20	5.15
Leverage (%)	51.63	23.26	37.84	67.26
Profitability (%)	15.56	24.50	6.63	25.12
FDI (%)	2.36	4.73	1.31	2.93
GDP per Capita	23.96	21.24	6.57	41.71
GDP Growth (%)	2.53	3.51	1.37	4.97
Access to Credit (%)	110.17	55.37	57.94	159.92
Inflation (%)	3.16	4.40	1.21	3.88
No. Regions Operating	2.28	3.84	1.00	2.00
Observations	3575			

SD stands for standard deviation, p25 for the 25th percentile, and p75 for 75th percentile. Domestic refers to the sample of investment activity in the country of headquarters, while International refers to the global investment activity of firms.

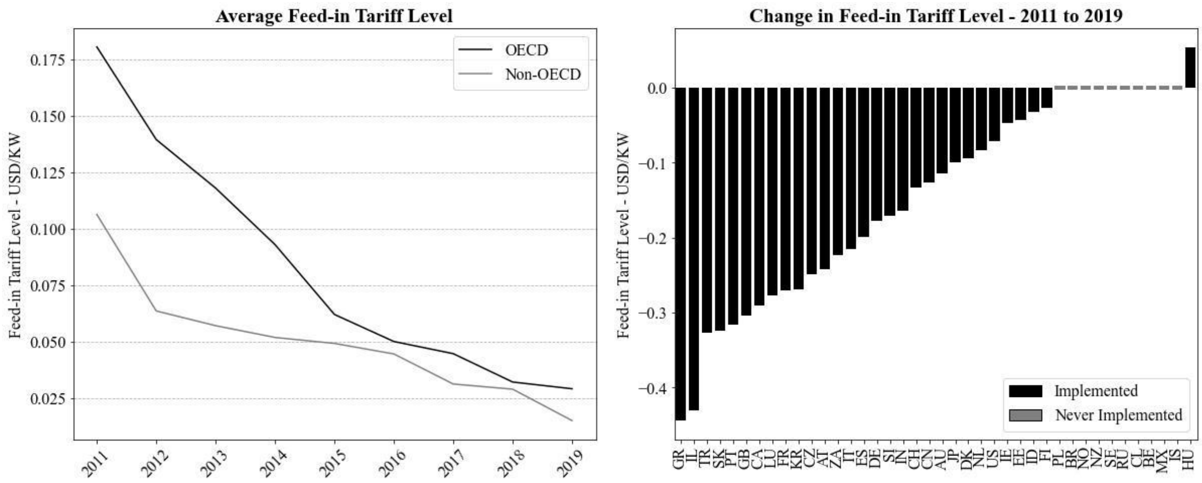
Appendix C: Environmental Policy Index Weightings

Table C.1

EPS Sub-Index	EPS Sub-Index Policy Components	OECD Weight	New Weight	Renamed Sub-Index
Market-Based Instruments	CO2 Trading Schemes	1/6	1/3	CO2 Trading and Taxes
	Renewable Energy Trading Schemes	1/6	1/3	
	CO2 Taxes	1/6	1/3	
	Nitrogen Oxides Tax	1/6	.	
	Sulphur Oxides Tax	1/6	.	
	Diesel Tax	1/6	.	
Non-Market Based Instruments	Nitrogen Oxides Emission Limit Value (ELV)	1/4	.	.
	Sulphur Oxide ELV	1/4	.	
	Particulate Matter ELV	1/4	.	
	Sulphur Content Limit	1/4	.	
Technology Support Policies	Public R&D in renewable energy, efficiency, CCS,	1/2	.	Renewable Energy Price Support
	Solar Price Support from Feed-in Tariffs and Auctions	1/4	1/2	
	Wind Price Support from Feed-in Tariffs and Auctions	1/4	1/2	

Appendix D: Change in Feed-in Tariff Support Price

Fig. D.1



Appendix E: Model Selection

In addition to producing robust estimates with a large proportion of zero values and overdispersion, FE Poisson models avoid the incidental parameters problem that can occur in non-linear models with fixed effects (Greene, 2011). Furthermore, by using robust standard errors, the maximum-likelihood estimator assumption that the outcome variable mean is equal to its variance does not have to hold, meaning that data does not have to follow a Poisson distribution for its application to be valid (Gould, 2011). The FE Poisson model is, therefore, robust and valid under very mild conditions, namely that the conditional mean of the variable of interest is correctly specified (Wooldridge, 1999).

This gives the FE Poisson model an advantage over alternatives such as zero-inflated models and negative-binomial fixed effects models (NB FE), which have more restrictive assumptions (Guimarães, 2008; Wooldridge, 1999). While FE Poisson models do not require data to follow a Poisson distribution, NB FE models require that data fits an NB distribution, making its application to non-count data challenging. Whereas Poisson models can also be used for continuous data with a lower bound at zero (MartíŔnez-Zarzoso, 2013; Westerlund & Wilhelmsson, 2011), and is therefore appropriate for our purposes. While goodness-of-fit is not appropriate for assessing the appropriateness of a FE Poisson model, given that adherence to a Poisson distribution is not required, we check the validity of a FE Poisson model using the Ramsey RESET functional form test (J. B. Ramsey, 1969). This tests that the conditional mean expectation is correctly specified by including squared fitted values as an additional explanatory variable. If the null hypothesis that the coefficient of this variable is zero is rejected, this indicates that the specification used is inappropriate (MartíŔnez-Zarzoso, 2013). After performing the RESET test, none of the tests statistics are significant at the 10% level indicating that the model is correctly specified (Table D.1).

Table E.1: Functional Form Test - Ramsey RESET Test

	International		Domestic	
	LCI	HCI	LCI	HCI
	1	2	3	4
RESET Test *p*-values	0.5624	0.784	0.185	0.125
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Firm Level Controls	Yes	Yes	Yes	Yes
Country Level Controls	Yes	Yes	Yes	Yes
N	1109	832	1109	832

∗p < 0.10, ∗∗ p < 0.05, ∗∗∗ p < 0.01 denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the fixed effects Poisson model are shown in parentheses. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. RESET test is performed by including the squared fitted values as an additional regressor, with the null hypothesis that the coefficient is equal to zero rejected when misspecification is present.

Appendix F: International Investment - Heterogeneity Analysis

Heterogeneity analysis is detailed in Table F.1, splitting the global sample first by firm size, with results showing a negative but insignificant relationship between the cost of debt and investment for large firms, but a significant one for smaller firms. This could be because smaller firms rely more on external financing relative to incumbent firms in less need of growth capital. Next, the sample is split by leverage. For LCI, both firms with high and low leverage have a statistically significant relationship with the cost of debt. However, only high-leverage firms have a significant relationship between the cost of debt and HCI. As one would expect, the coefficient is higher in magnitude for firms with high leverage in both instances, given the greater role of debt in the capital structure. Next, the sample is split into low- and high-carbon firms. For LCI, there is a significant negative relationship at the 5% level for low and high-carbon firms. This is important, as it suggests that financing costs are relevant not only for firms already highly exposed to low-carbon energy but also for those transitioning from a high-carbon asset base. For HCI, the cost of capital is significant for high-carbon but not low-carbon firms. This suggests that lower financing costs do not induce low-carbon firms to increase HCI. Finally, the sample is split by time, showing a negative significant relationship between the cost of debt and LCI at the 5% level in both periods. For HCI, it has a negative relationship between 2012-2016, but between 2017-2021 has a positive significant relationship. A possible explanation for this change is that firms are no longer capitalising on lower financing costs to increase HCI, given changes in the policy environment and economics of high-carbon energy. In the next stage of analysis, when changes in environmental policy are controlled for, there is no longer a significant positive relationship for 2017-2021.

Table F.1

	Size				Leverage			
	Large		Small		High		Low	
	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
Panel A	1	2	3	4	5	6	7	8
Cost of Debt	-0.0549	-0.0380	-0.140**	-0.0816*	-0.304***	-0.246***	-0.126**	-0.0221
	(0.0468)	(0.0448)	(0.0608)	(0.0450)	(0.0773)	(0.0760)	(0.0502)	(0.0376)
Debt Capital Raising	0.0218*	0.0441***	0.0228***	0.0246	0.0168	0.0451***	0.0290**	-0.0178
	(0.0119)	(0.0155)	(0.00708)	(0.0188)	(0.0141)	(0.0165)	(0.0130)	(0.0203)
Cash Flow	0.0238	-0.0324	-0.0107	-0.0245	-0.0331	0.0227	-0.00164	-0.0588
	(0.0206)	(0.0373)	(0.0334)	(0.0393)	(0.0359)	(0.0203)	(0.0262)	(0.0512)
Tangibility	0.0141	0.0296***	0.0143	-0.00939	-0.00727	-0.0177	0.00297	0.00518
	(0.0150)	(0.0105)	(0.0145)	(0.0141)	(0.0194)	(0.0203)	(0.0165)	(0.0123)
Revenue	-0.0178**	0.00876	-0.439***	-0.129	-0.0601	-0.00694	-0.00426	0.0603
	(0.00856)	(0.0193)	(0.169)	(0.0885)	(0.0435)	(0.0263)	(0.102)	(0.0704)
Leverage	-0.00976	0.0148	-0.0143	-0.0144	-0.0279**	0.00973	-0.0119	-0.0190
	(0.00917)	(0.0155)	(0.0134)	(0.0109)	(0.0137)	(0.0240)	(0.0216)	(0.0151)
Profitability	-0.0217***	0.0113*	-0.00122	0.0105	0.00526	-0.000317	-0.00439	0.0249**
	(0.00649)	(0.00614)	(0.00485)	(0.00896)	(0.00553)	(0.00517)	(0.00361)	(0.0118)
N	746	556	691	517	669	501	631	496

	Asset Base				Time Period			
	Low-Carbon		High-Carbon		2012-2016		2017-2021	
	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
Panel B	1	2	3	4	5	6	7	8
Cost of Debt	-0.135**	-0.112	-0.105**	-0.0799**	-0.198**	-0.0765*	-0.0956**	0.0838**
	(0.0613)	(0.113)	(0.0490)	(0.0339)	(0.0873)	(0.0409)	(0.0439)	(0.0407)
Debt Capital Raising	0.0223***	0.0688***	0.0196	0.0120	0.0126	0.0152	0.0183	0.0400**
	(0.00680)	(0.0263)	(0.0143)	(0.0140)	(0.0124)	(0.0154)	(0.0156)	(0.0162)

Cash Flow	-0.0464	-0.0591	-0.0287	-0.0955**	-0.0132	-0.141***	-0.000165	0.00644
	(0.0359)	(0.0398)	(0.0391)	(0.0434)	(0.0309)	(0.0483)	(0.0354)	(0.0266)
Tangibility	0.0242*	0.0152	-0.0350***	0.000633	0.0321**	0.00817	-0.000463	-0.00119
	(0.0132)	(0.0322)	(0.00971)	(0.0101)	(0.0158)	(0.0103)	(0.0245)	(0.0119)
Revenue	-0.115	-0.0443	0.0353	-0.0201	-0.105*	-0.0689***	-0.0184	-0.0119
	(0.130)	(0.0333)	(0.0221)	(0.0292)	(0.0567)	(0.0229)	(0.0272)	(0.0143)
Leverage	-0.00824	-0.0262	-0.0289**	-0.0207*	0.00546	-0.0425***	-0.0301	0.000761
	(0.0148)	(0.0187)	(0.0119)	(0.0108)	(0.0171)	(0.0115)	(0.0213)	(0.0121)
Profitability	0.00177	0.0133	-0.00467	0.0223***	0.00683	0.0288***	-0.00205	0.0119
	(0.00502)	(0.0173)	(0.0120)	(0.00806)	(0.00496)	(0.00892)	(0.00619)	(0.00952)
N	677	550	708	529	507	445	698	429

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$ denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. All specifications include firm and year fixed effects and country-level controls.

Appendix G: International Investment - Regional Channel Analysis

Table G.1

	Low-Carbon				High-Carbon			
	LCI	DCR	LCI	LCI	HCI	DCR	HCI	HCI
Panel A - OECD	1	2	3	4	5	6	7	8
Cost of Debt	-0.232***	-0.288*		-0.194***	-0.112	0.0535		-0.0570
	(0.0739)	(0.170)		(0.0590)	(0.0700)	(0.165)		(0.0682)
Debt Capital Raising			0.0374***	0.0255***			0.0974***	0.0899***
			(0.0116)	(0.00848)			(0.0321)	(0.0344)
N	1028	1037	1028	1028	686	707	686	686
	LCI	DCR	LCI	LCI	HCI	DCR	HCI	HCI
Panel B - Non-OECD	1	2	3	4	5	6	7	8
Cost of Debt	-0.109	-0.390***		-0.0796	-0.138***	-0.432***		-0.108***
	(0.0727)	(0.138)		(0.0671)	(0.0491)	(0.148)		(0.0414)
Debt Capital Raising			0.0273*	0.0184			0.0357**	0.0176
			(0.0144)	(0.0122)			(0.0140)	(0.0122)
N	596	621	596	596	533	551	533	533

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$ denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. DCR stands for Debt Capital Raising. All specifications include firm and year fixed effects and firm and country-level controls. Across all panels, in specifications with DCR as the dependent variable an OLS fixed effects model is used, while for LCI and HCI a FE Poisson model is used.

Appendix H: Domestic Investment - Heterogeneity Analysis

Table H.1 shows that for CO2 Trading & Taxes, the positive relationship between the cost of debt and LCI is driven by smaller firms and those with high leverage. When splitting the sample by energy mix, is it low-carbon firms that have a statistically significant positive relationship between CO2 Trading & Taxes and LCI at the 1% level rather than high-carbon firms, indicating that firms already invested in low-carbon energy that respond to carbon pricing. With regard to HCI, high-carbon firms reduce investment as the strength of CO2 Trading & Taxes increases, and for low-carbon firms there is no significant relationship. Finally, we do not observe any statistically significant relationships when splitting the simple by time period. Unlike CO2 Trading & Taxes, which shows a consistent relationship direction between policy strength and LCI, in many cases, we observe a negative relationship between the level of Renewable Energy Price Support and LCI (Table H.2). For example, we observe a statistically significant negative relationship between Renewable Energy Price Support and LCI for large firms and firms with higher leverage. Similarly, there is no consistency in the direction of the relationship with HCI. This inconsistency is likely driven by the divergence in support between countries. For example, a sharp digression in the level FIT price support in OECD countries relative to non-OECD countries (Figure 2 and Appendix 5).

Table H.1: CO2 Trading & Taxes

	Size				Leverage			
	Large		Small		High		Low	
	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
Panel A	1	2	3	4	5	6	7	8
CO2 Trading & Taxes	0.407	-0.263	1.028***	-0.0752	1.589***	0.200	0.271	-0.0545
	(0.257)	(0.328)	(0.359)	(0.555)	(0.581)	(0.782)	(0.571)	(0.446)
Cost of Debt	-0.0962**	-0.0597	-0.144*	-0.0740	-0.215**	-0.263***	-0.0726	-0.0284
	(0.0457)	(0.0530)	(0.0860)	(0.0558)	(0.0988)	(0.0947)	(0.0700)	(0.0496)
Debt Capital Raising	0.0349	0.0438	0.105	1.055***	0.0645	0.0216	0.228	0.194*
	(0.0391)	(0.0374)	(0.212)	(0.253)	(0.0959)	(0.0819)	(0.220)	(0.111)
N	540	392	518	380	492	370	473	361
	Asset Base				Time Period			
	Low-Carbon		High-Carbon		2012-2016		2017-2021	
	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
Panel B	1	2	3	4	5	6	7	8
CO2 Trading & Taxes	1.042***	0.993	0.195	-0.725*	0.491	-0.493	0.0453	0.277
	(0.249)	(0.729)	(0.394)	(0.412)	(0.852)	(0.533)	(0.447)	(0.599)
Cost of Debt	-0.107	-0.371***	0.0489	-0.0427	-0.138	-0.0582	0.0388	-0.0509
	(0.0655)	(0.0948)	(0.0795)	(0.0380)	(0.0847)	(0.0422)	(0.0797)	(0.0808)
Debt Capital Raising	0.0887	0.254***	0.0615	0.440***	0.170	0.170**	0.0674	0.0242
	(0.137)	(0.0743)	(0.0864)	(0.118)	(0.117)	(0.0840)	(0.0884)	(0.162)
N	510	358	533	400	392	348	484	271

$*p < 0.10$, $** p < 0.05$, $*** p < 0.01$ denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the fixed effects Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. All specifications include firm and year fixed effects and country-level controls.

Table H.2: Renewable Energy Price Support

	Size				Leverage			
	Large		Small		High		Low	
	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
Panel A	1	2	3	4	5	6	7	8
Renewable Energy Price Support	-0.253***	-0.0986	0.181	-0.129	-0.450***	0.0137	0.427**	0.123
	(0.0887)	(0.0906)	(0.213)	(0.243)	(0.173)	(0.187)	(0.214)	(0.117)
Cost of Debt	-0.0917*	-0.0664	-0.142*	-0.0691	-0.167	-0.258***	-0.0466	-0.0323
	(0.0530)	(0.0560)	(0.0796)	(0.0550)	(0.114)	(0.0883)	(0.0675)	(0.0502)
Debt Capital Raising	0.0453	0.0449	0.0812	1.042***	0.0967	0.0233	0.0830	0.185*
	(0.0418)	(0.0376)	(0.207)	(0.248)	(0.0921)	(0.0783)	(0.189)	(0.104)
N	540	392	518	380	492	370	473	361
	Asset Base				Time Period			
	Low-Carbon		High-Carbon		2012-2016		2017-2021	
	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
Panel B	1	2	3	4	5	6	7	8
Renewable Energy Price Support	0.238	0.132	-0.0479	-0.642**	0.244*	0.177	0.182	-0.256
	(0.171)	(0.125)	(0.219)	(0.262)	(0.129)	(0.133)	(0.139)	(0.194)
Cost of Debt	-0.105*	-0.369***	0.0571	-0.0267	-0.135	-0.0691	0.0509	-0.00845
	(0.0608)	(0.0892)	(0.0847)	(0.0307)	(0.0856)	(0.0469)	(0.0724)	(0.0774)
Debt Capital Raising	0.122	0.241***	0.0702	0.438***	0.145	0.160**	0.0571	0.0400
	(0.153)	(0.0815)	(0.0875)	(0.105)	(0.107)	(0.0774)	(0.0920)	(0.153)
N	510	358	533	400	392	348	484	271

$*p < 0.10$, $** p < 0.05$, $*** p < 0.01$ denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the fixed effects poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. All specifications include firm and year fixed effects and country-level controls.

Appendix I: Domestic Investment – Sample Selection Bias and Endogeneity

<u>I.1: Sample Selection Bias</u>

In the first stage "selection equation", a probit regression estimates the probability that climate policy data is available based on the country-level control variables used in the baseline regression. The Heckman Correction Factor, or Inverse Mills Ratio (IMR), is then calculated as the probability of selection. Following Li & Wang (2022), in the second stage "outcome equation", the IMR is included in the original FE Poisson model in Eq. 10 and 11 as an additional explanatory variable. The IMR captures information from the full sample, including firms without climate policy data, and therefore controls the likelihood of inclusion. As shown in Table J.1, when including the mills ratio as an additional regressor, results are consistent with Table 5 which tests the direct impact of policy and Table 6 which tests the moderating role of policy. This indicates that our findings are robust to selection bias. The mills ratio is significant in HCI specifications, indicating the sample selection bias is present, but not LCI specifications.

<u>I.2: Control Function Test for Endogeneity</u>

The control function test for endogeneity follows a two-step procedure, where in the first stage, exogenous country-level variables are regressed on policy variables to obtain the residuals. In the second stage, residuals are included as an additional explanatory variable in Eq. 10 and 11. Endogeneity is then tested by conducting a t-test on the coefficient of the residuals, with the null hypothesis that the coefficient is zero. In the first-stage regression, we follow Smith & Urpelainen (2014) by using the 4-year lagged measure of policy as an exogenous instrument variable for current policy strength. To show that this instrument meets the requirement of relevance we regress $EPS_{i,t-4}$ on $EPS_{i,t}$ along with country-level control variables and year fixed effects. This shows a significant relationship at the 1% level for CO2 Trading & Taxes and Renewable Energy Price Support, with F-Statistics greater than 10 (Table J.2). With regard to the exclusion restriction, there is no statistically significant relationship between $EPS_{i,t-4}$ and either $LCI_{i},_{t}$ or $HCI_{i},_{t}$ when conditioning for country-level control variables with year fixed effects, or with year and firm fixed effects. When the residuals from the first stage are included as an additional explanatory variable, they show no significance, indicating that endogeneity is not present. This holds both when testing the direct effect of policy and the moderating role of policy.

Table I.1: Heckman Adjustment

	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
	1	2	3	4	5	6	7	8
CO2 Trading and Taxes	0.840***	-0.0533	0.775***	-0.212				
	(0.262)	(0.377)	(0.263)	(0.392)				
Cost of Debt × CO2 Trading and Taxes			0.0547	-0.0651				
			(0.0554)	(0.0470)				
Debt Capital Raising × CO2 Trading and Taxes			0.0168*	-0.0670**				
			(0.00925)	(0.0321)				
Renewable Price Support					0.146	-0.00808	0.108	-0.0324
					(0.153)	0.141)	(0.161)	(0.141)
Cost of Debt × Renewable Price Support							-0.0117	0.0221
							(0.0235)	(0.0242)
Debt Capital Raising × Renewable Price Support							0.000550	0.0276
							(0.00596)	(0.0186)
Cost of Debt	-0.0849*	-0.0546	-0.0568	-0.0620	-0.0876*	-0.0551	-0.103	-0.0650
	(0.0482)	(0.0407)	(0.0528)	(0.0426)	(0.0465)	(0.0392)	(0.0653)	(0.0433)
Debt Capital Raising	0.0177*	0.0446**	0.0225**	0.0249	0.0153	0.0446**	0.0140	0.0284
	(0.00937)	(0.0186)	(0.00985)	(0.0168)	(0.0107)	(0.0189)	(0.0128)	(0.0175)

Mills Ratio	-7.873	9.764*	-7.383	10.97**	-4.759	9.761*	-4.824	11.09**
	(6.100)	(5.379)	(6.195)	(4.855)	(6.283)	(5.094)	(6.314)	(5.002)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1109	832	1109	832	1109	832	1109	832

∗p < 0.10, ∗∗ p < 0.05, ∗∗∗ p < 0.01 denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively.

Table I.2: Control Function Test for Endogeneity

	First Stage		Second Stage							
	CO2	RPS	LCI	HCI	LCI	HCI	LCI	HCI	LCI	HCI
	1	2	3	4	5	6	7	8	9	10
L4.CO2 Trading and Taxes	0.899***									
	(0.0199)									
L4.Renewable Price Support		0.726***								
		(0.0225)								
CO2 Trading and Taxes			0.767**	-0.00183	0.355	0.00421				
			(0.303)	(0.397)	(0.404)	(0.473)				
Cost of Debt × CO2 Trading and Taxes					0.0587	-0.0208				
					(0.0602)	(0.0448)				
Debt Capital Raising × CO2 Trading and Taxes					0.0188**	-0.0532**				
					(0.00911)	(0.0271)				
Renewable Price Support							0.229*	-0.00950	0.244*	-0.0444
							(0.137)	(0.124)	(0.128)	(0.128)
Cost of Debt × Renewable Price Support									-0.00878	0.0152
									(0.0242)	(0.0254)
Debt Capital Raising × Renewable Price Support									0.000820	0.0200
									(0.00664)	(0.0161)
Cost of Debt			-0.0911*	-0.0614	-0.111	-0.0550	-0.0894*	-0.0612	-0.0796*	-0.0661
			(0.0541)	(0.0442)	(0.0726)	(0.0618)	(0.0504)	(0.0425)	(0.0469)	(0.0468)
Debt Capital Raising			0.0238**	0.0430**	0.0132	0.0738***	0.0213*	0.0429**	0.0189	0.0350**
			(0.0103)	(0.0179)	(0.0134)	(0.0269)	(0.0120)	(0.0180)	(0.0115)	(0.0172)
Fitted values			-0.425	-0.160	-0.287	-0.201	0.0720	-0.153	0.0783	-0.130
			(0.689)	(0.447)	(0.682)	(0.459)	(0.160)	(0.421)	(0.166)	(0.452)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Level Controls	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1232	1232	1128	836	1128	836	1128	836	1128	836

∗p < 0.10, ∗∗ p < 0.05, ∗∗∗ p < 0.01 denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively.

Appendix J: Domestic Investment - Regional Moderation Analysis

Table J.1:

	OECD		Non-OECD	
	LCI	HCI	LCI	HCI
Panel A - CO2 Trading & Taxes	3	4	5	6
CO2 Trading & Taxes	-0.0624	-0.378	-0.123	0.0370
	(0.300)	(0.469)	(2.514)	(1.108)
Cost of Debt	-0.0237	-0.0713	-0.132*	-0.0116
	(0.0708)	(0.0782)	(0.0783)	(0.0732)
Debt Capital Raising	-0.00279	0.0504	0.0722**	0.0412**
	(0.00897)	(0.0464)	(0.0286)	(0.0207)
Cost of Debt × CO2 Trading & Taxes	0.0556	0.0600	-0.0876	-0.179
	(0.0613)	(0.0739)	(0.218)	(0.120)

Debt Capital Raising × CO2 Trading & Taxes	0.0342**	-0.0759	0.157	-0.0713*
	(0.0165)	(0.0512)	(0.108)	(0.0371)
N	783	550	326	282
	LCI	HCI	LCI	HCI
Panel B - Renewable Energy Price Support	3	4	5	6
Renewable Energy Price Support	0.282**	-0.00701	0.627	0.0430
	(0.140)	(0.105)	(0.655)	(0.407)
Cost of Debt	-0.0979	-0.0317	-0.176*	-0.0662
	(0.0811)	(0.0754)	(0.0981)	(0.0557)
Debt Capital Raising	-0.00582	0.0676	0.0407**	0.0489*
	(0.0108)	(0.0418)	(0.0191)	(0.0283)
Cost of Debt × Renewable Energy Price Support	0.0327	0.0175	-0.0358	-0.0527
	(0.0323)	(0.0223)	(0.0475)	(0.0485)
Debt Capital Raising × Renewable Energy Price Support	-0.00708*	0.0462**	0.0276**	-0.0334
	(0.00410)	(0.0205)	(0.0124)	(0.0345)
N	783	550	326	282

$*p < 0.10$, $** p < 0.05$, $*** p < 0.01$ denote statistical significance at the 10%, 5% and 1% level, respectively. Robust standard errors from the FE Poisson model are shown in parentheses. All explanatory variables are lagged by one year. LCI and HCI stand for Low-Carbon Investment and High-Carbon Investment respectively. All specifications include firm and year fixed effects and country-level controls.

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