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The role of financing constraints and environmental policy on green investment☆

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ABSTRACT

Despite ambitious carbon reduction targets set by policymakers worldwide, current investments fall well short of the net-zero emissions scenario. This paper investigates the impact of financing constraints (FCs) on green investment among large, publicly listed firms across diverse sectors and countries. We find that FCs significantly reduce the propensity to undertake green investments by 2.5 percentage points. This result is even more pronounced in a difference-in-differences framework when focusing on the exogenous increase in financing costs resulting from the Great Financial Crisis of 2007/08. The study reveals further that the negative impact of FCs can be reduced by market-based environmental policies.

1. Introduction

Most OECD countries have set ambitious targets to become carbon neutral by 2050. This will require significant investment to reduce greenhouse gas emissions over the next few decades from the private sector (IEA, 2021). However, investments to date fall far short despite a wide range of policies that have been adopted. Understanding why this is the case is essential to ensure that the investments needed for the green transition are mobilized.

This paper analyzes the impact of financing constraints (FCs) on large, publicly listed firms from a wide range of industries and countries. Due to their specific characteristics (e.g., high fixed costs and risks, information asymmetries), investments in such technologies may be more difficult to finance than investments in other, more established, technologies (see for example De Haas et al., 2023; Nelson and Shrimali, 2014). Moreover, while a range of environmental policies have been introduced to stimulate investment, it is not clear how effective they are in mitigating firm-level barriers. We explore these issues by studying the interplay between FCs and environmental policy, leading to two main findings.

First, we show that being financially constrained reduces the propensity to invest by about 2.5 percentage points. This result is confirmed when using the exogenous shock to financing costs resulting from the *Great Financial Crisis* (GFC) in 2007/08. Second, our results show that the negative effect of FCs on green investment can be mediated by market-based environmental policies.

Our analysis makes two main contributions. First, while previous studies have highlighted that FCs are relevant for green investment in small and medium-sized firms (SMEs) (Accetturo et al., 2022) or in emerging markets (De Haas et al., 2023), we provide evidence that FCs are important for a wide range of countries and sectors, including large, listed firms.[1] Second, we contribute to the ongoing policy discussion on the green transition by highlighting the interplay between policy stringency and FCs. We find that the effect of FCs on green investment and carbon emissions is less pronounced in countries that enforce strict environmental policies (Ng et al., 2023). Environmental regulation may thus substitute for other policies, including an easing of FCs.

2. Data and empirical methodology

Our analysis is based on firm-level data on green investments and emissions from *Refinitiv* and balance sheet information from *Orbis*, merged with country-level indices measuring environmental policy stringency (EPS) from the OECD (Kruse et al., 2022) and sector-country specific energy prices (extending the database in Sato et al., 2019). The final dataset contains annual information on nearly 7000 firms in 33

☆ The views and opinions expressed in the paper are those of the authors only, and not necessarily those of the OECD.

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[1] One notable exemption is Guérin and Suntheim (2021) that show that tighter FCs are associated with weaker environmental performance of listed firms.

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countries between 2004 and 2020. Descriptive statistics and further data details are provided in the Appendix (Table A.1, Fig. A.1, and Appendix B).

Our main dependent variable is a binary indicator for whether a firm has made environmental investments. Alternatively, we have information on emission intensity and environmental expenditures. The main explanatory variable are FCs, which we proxy with balance sheet information. We use *interest coverage* and *financial leverage*, as well as two *indices*, SAFE and FCP, that combine several variables to define the financial position of each firm (Ferrando and Ruggieri, 2018; Schauer et al., 2019).[2] We create indicator variables for the firms that fall within the 25th percentile of the most constrained firms within their economic sub-sector and year. To limit endogeneity concerns, we lag the FCs by one year. Our main regression specification is

$$\mathbb{1}(\text{green investment}_{icst}) = \beta_0 + \beta_1 \text{FC}_{ics,t-1} + \gamma X_{ics,t-1} + \theta_{sct} + \varepsilon_{icst}, \quad (1)$$

where $\mathbb{1}(\text{green investment}_{icst})$ in an indicator equal to one if firm i in country c and sector s has made green investments in year t. The main coefficient of interest is β_1, which captures the effect of a firm being financially constrained in the previous year. We control for country-by-sector-by-year fixed-effects (FEs) (θ_{sct}) which capture factors that can impact country-industry pairs heterogeneously over time. We include lagged controls at the firm level, $X_{ics,t-1}$ accounting for differences in firm size, age, sales growth, and return on assets. Standard errors are clustered at the firm level.

Finally, we extend Eq. (1) in two ways. First, we use the GFC as exogenous shock to firms' financing needs in a difference-in-differences (DiD) framework. We hypothesize that the GFC had a stronger impact on firms with a high short-term to long-term debt ratio as debt roll-over became more expensive during this period (see also Campello et al., 2010). We thus interact the *shock exposure* (binary variable based on the debt ratio in the pre-crisis period 2005/06) with annual dummies and include firm FEs in the regression. Second, we include a measure of lagged environmental policy (EPS index, EPS sub-components, or energy price index) interacted with the FCs.

3. Results and discussion

3.1. FCs and green investment

Table 1 shows that FCs are associated with a reduction of approximately 2.5 percentage points in the green investment propensity, which represents a decrease of about 8% of the average investment propensity. This impact is robust to the choice of FC measure. In Appendix A.2, we present further robustness checks using alternative FC definitions (Table A.2), performing sample splits by years (Fig. A.3) and sector (Table A.3), and employing a logit model (Tables A.4 and A.5) that confirm our main findings.

Next, we employ the GFC as an exogenous shock to firms' financing needs. Fig. 1 shows the coefficients of the DiD regression. The main model (green dots) includes the same set of controls as specification (1). A second specification (red diamonds) adds firm FEs. All results are relative to the base period 2005 (see also Table A.6). We find a large drop in green investment propensity of approximately 8.6 percentage points in 2009. This effect is slightly reduced and loses statistical significance (p-value 0.15) when including firm FEs. Yet, the findings remain consistent across specifications. To provide reassurance regarding the parallel-trends assumption, Fig. A.2 plots the average green investment share for firms with low and high shock exposure defined according to the debt ratio in 2005/06. While the debt ratio was strongly related to green investment in 2009/10, the two groups otherwise followed similar paths.

[2] We elaborate on the FC measures in Appendix B.2.

Table 1
FCs and green investment.

DV: $\mathbb{1}$(green investment)	(1)	(2)	(3)	(4)
FC_{t-1}: Interest coverage	−0.026**			
	(0.012)			
FC_{t-1}: Financial leverage		−0.023*		
		(0.012)		
FC_{t-1}: SAFE index			−0.028**	
			(0.012)	
FC_{t-1}: FCP index				−0.024**
				(0.011)
N	23,111	26,215	22,931	23,064
Adjusted R2	0.356	0.352	0.356	0.356
Mean DV	0.317	0.301	0.318	0.317
Constant	Yes			
Controls	Yes			
Sector-Country-Year FE	Yes			

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.2. Additional results

We run specification (1) with an alternative set of dependent variables, firms' emission intensity and green investment in US-dollars. We report these findings in Table A.7, focusing on the SAFE index as main FC measure. The results indicate that FCs are related to an increase in emission intensity and a decrease in the level of green investment by approximately 20%. This response is larger than the 15% impact of FCs on total investment (Table A.8), indicating that green investment is more elastic than total investment in response to FCs.[3]

3.3. Interaction of FCs with environmental policy

Finally, we investigate the mediating effect of environmental policies by interacting the SAFE index with EPS indicators and energy prices. The results are presented in Table 2. Column (1) uses the overall EPS index, while Columns (2) to (4) employ sub-indices (measuring the stringency of market-based, non market-based, and technology support instruments). Finally, Column (5) uses the energy price index as an alternative proxy for market-based policies. Our results show that the negative impact of FCs is counteracted by stringent market-based environmental policy, but not other initiatives. The result is qualitatively similar when using the energy prices proxy, but the coefficients are less precisely estimated as the sample is limited to manufacturing and construction sectors in OECD countries. Table A.9 provides robustness using alternative FC measures with results qualitatively unchanged.

4. Conclusions

This paper shows that financially constrained firms have a lower probability to conduct green investment. Our findings are relevant for the debate on the transition towards a carbon-neutral economy, by isolating firms' financing capacity as a major drag on private-sector investment. The question of which policies affect private-sector green investment and how they interact with existing constraints is vital to promote the behaviour necessary to achieve environmental goals. We further show that stringent market-based policies can counteract the negative impact of FCs, suggesting that regulation may substitute other policies, including those aiming to ease FCs.

These results hold for our sample of large, publicly-listed firms. Yet, given the data, we cannot directly compare our findings to SMEs that

[3] In a working paper version of this article (Costa et al., 2024), a case study based on Portuguese firms with more detailed data confirms that green investment is significantly more elastic to financing constraints than total investment.

Fig. 1. GFC and green investment. *Notes:* Annual coefficients and 90% confidence interval for firms with high exposure to the financing shock (debt ratio in pre-crisis period).

Table 2
FCs and environmental policy.

	EPS	EPS			Energy price
	overall	Market	Non-market	Technology	index
	(1)	(2)	(3)	(4)	(5)
FC_{t-1}: SAFE index	−0.046	−0.072***	−0.029	−0.015	−0.284
	(0.044)	(0.024)	(0.044)	(0.025)	(0.187)
FC_{t-1} × env. $policy_{t-1}$	0.007	0.037**	0.000	−0.006	0.044
	(0.016)	(0.016)	(0.009)	(0.011)	(0.030)
N	22,882	22,882	22,882	22,882	14,247
Adjusted R2	0.354	0.355	0.354	0.354	0.338
Constant	Yes				
Controls	Yes				
Sector-Country-Year FE	Yes				

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

are usually considered most affected by FCs. Finally, while our findings indicate that green investment is more responsive to FCs than total investment, the data does not allow us to investigate the underlying mechanisms. These caveats provide important opportunities for future research.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Stefan Lamp reports financial support was provided by OECD. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

Appendix A. Additional tables and figures

A.1. Summary statistics and descriptives

See Table A.1 and Figs. A.1 and A.2.

A.2. Robustness checks

See Fig. A.3 and Tables A.2–A.9.

Appendix B. Data

B.1. Data sources and data cleaning

The financial covariates are based on Bureau van Dijk's *Orbis* database. We clean the data through the procedure described in Gal (2013) with the aim to ensure comparability across countries and sectors. We only keep harmonized and consolidated accounts that refer to the entire calendar year, and drop observations with missing information on key variables, as well as outliers identified as implausible changes or ratios in these variables or violations of accounting

Table A.1
Summary statistics.

	Mean (1)	Std. dev. (2)	p10 (3)	p50 (4)	p90 (5)	Obs. (6)	Firms (7)
Orbis data:							
Age (1 if age > 10 years)	0.88	0.32	0	1	1	40,175	6307
Lag ln(total assets)	22.06	1.65	19.93	22.1	24.18	42,211	6610
Total employment [thousands]	25.29	68.01	0.47	7.52	58.8	43,205	6776
Gross output [million PPP, real]	10,978	33,408	263	2906	22,547	43,591	6766
Financial debt [million PPP, real]	4058	11,313	1.25	874	9515	43,391	6790
Lag fin. leverage ratio	0.25	0.2	0	0.23	0.5	41,747	6595
Lag interest cov. ratio	47.55	173.14	2.05	9.72	88.87	36,366	5836
Lag SAFE index	−16.5	48.58	−28.32	−5.75	−3.42	35,645	5766
Lag FCP index	−4.32	4.37	−5.81	−3.48	−2.78	35,973	5814
Lag short-long term debt ratio	1.67	14.12	0	0.1	1.1	36,885	5994
Refinitiv data:							
ESG score combined [0–100]	41.5	19.17	17.29	39.9	68.7	43,836	6810
Tot. emissions [million t, CO2 equ.]	3.18	22.88	0	0.12	4.18	43,776	6812
Env. investment [million USD]	224.17	1237.38	1.16	26.57	376	8143	5168
1(env. investment)	0.31	0.46	0	0	1	34,870	5168
1(emission trading)	0.1	0.3	0	0	1	43,180	6802
Env. policy stringency (EPS):							
Lag ln(energy prices) [2005 weights]	6.26	0.55	5.51	6.22	7	21,190	2958
Lag EPS (overall)	2.78	0.73	1.78	2.92	3.75	43,653	6765
Lag EPS (market based)	1.39	0.74	0.67	1.17	2.33	43,653	6765
Lag EPS (non-market based)	4.83	1.07	3	5.25	5.75	43,653	6765
Lag EPS (technol. support)	2.38	1.14	1	2	4	43,653	6765

Notes: Main estimation sample based on Refinitiv ESG data merged to Orbis. 2004–2020 period, annual frequency. Environmental policy measures are either country-year specific (EPS) or country-sector-year specific (energy prices).

Table A.2
Impact of FCs on green investment (tercile definition).

DV: 𝟙(green investment)	(1)	(2)	(3)	(4)
FC_{t-1}: Interest coverage	−0.021*			
	(0.011)			
FC_{t-1}: Financial leverage		−0.013		
		(0.011)		
FC_{t-1}: SAFE index			−0.020*	
			(0.011)	
FC_{t-1}: FCP index				−0.027**
				(0.011)
N	23,111	26,215	22,931	23,064
Adjusted R2	0.355	0.352	0.356	0.356
Mean DV	0.317	0.301	0.318	0.317
Constant	Yes			
Controls	Yes			
Sector-Country-Year FE	Yes			

Notes: Indicator variable for financially constrained firms, defined at sector-year terciles. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3
Impact of FCs on green investment (industrial sectors).

DV: 𝟙(green investment)	(1)	(2)	(3)	(4)
FC_{t-1}: Interest coverage	−0.026*			
	(0.015)			
FC_{t-1}: Financial leverage		−0.017		
		(0.015)		
FC_{t-1}: SAFE index			−0.028*	
			(0.015)	
FC_{t-1}: FCP index				−0.021
				(0.014)
N	16,562	18,834	16,460	16,536
Adjusted R2	0.351	0.351	0.351	0.351
Mean DV	0.383	0.363	0.383	0.383
Constant	Yes			
Controls	Yes			
Sector-Country-Year FE	Yes			

Notes: Sample includes only industrial sectors in line with NACE Rev. 2 definitions B, C, D, E, and F. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4
Impact of FCs on green investment (logit model).

DV: 𝟙(green investment)	(1)	(2)	(3)	(4)
FC_{t-1}: Interest coverage	0.893			
	(0.072)			
FC_{t-1}: Financial leverage		0.776***		
		(0.063)		
FC_{t-1}: SAFE index			0.872*	
			(0.072)	
FC_{t-1}: FCP index				1.005
				(0.081)
N	24,788	27,929	24,609	24,737
Pseudo R2	0.294	0.298	0.296	0.294
Mean DV	0.344	0.327	0.344	0.344
Controls	Yes			
Sector-Year FE	Yes			
Country-Year FE	Yes			

Notes: Coefficients in exponential format for ease of interpretation. Predictive margins presented in Table A.5. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5
Predictive margins (logit model).

Financing constraint (FC) :	Interest coverage (1)	Financial Leverage (2)	SAFE index (3)	FCP index (4)
$FC_{t-1} = 0$	0.348***	0.336***	0.348***	0.344***
	(0.007)	(0.007)	(0.007)	(0.007)
$FC_{t-1} = 1$	0.331***	0.300***	0.328***	0.345***
	(0.011)	(0.010)	(0.011)	(0.011)
$\Delta(FC_1 - FC_0)$	−0.017	−0.036	−0.020	0.001

Notes: Predictive margins for each level of the FC and its difference based on the logit model estimation in Table A.4. Robust standard errors obtained with the delta-method in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

norms. Moreover, all firm level nominal variables are deflated by using two digits industry country specific deflators — when these deflators are missing, we fill in missing values using higher order inflation (e.g. grouped 2 digits, 1 digit, macro-sectors); then, we apply country-industry level purchase power parities (PPPs), using as a reference 2005

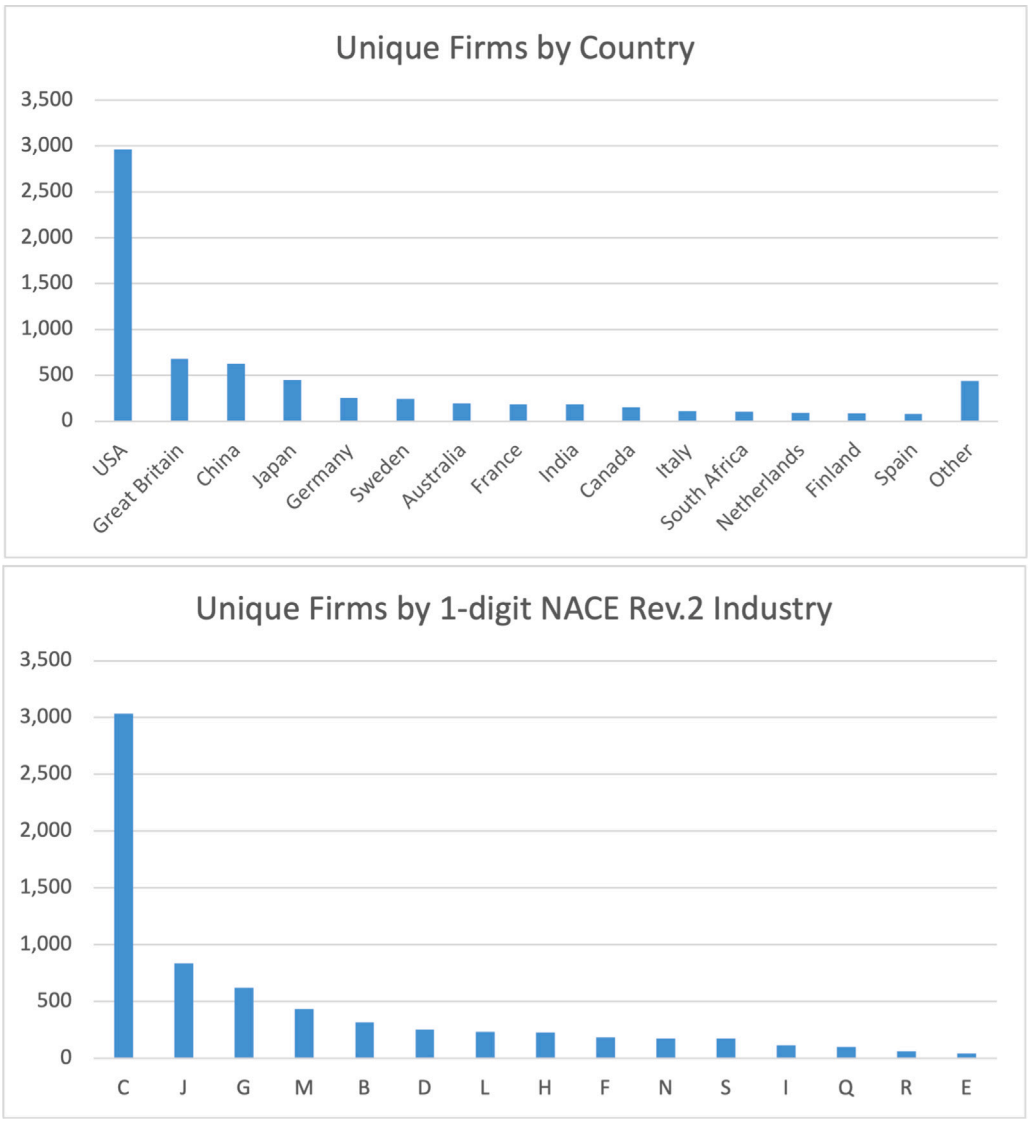

Fig. A.1. Sample coverage by country and sector. *Notes:* Number of unique firms in estimation sample 2004–2020 as reported in Table A.1, by country (upper panel) and economic sub-sector (lower panel). Sector code definition according to NACE Rev.2. C: Manufacturing, J: Information and communication, G: Wholesale and retail trade; repair of motor vehicles, M: Professional, scientific and technical activities, B: Mining and quarrying, D: Electricity, gas, steam and AC supply, L: Real estate, H: Transportation and storage, F: Construction, N: Administrative and support services, S: Other services, I: Accommodation and food services, Q: Human health and social work activities, R: Arts, entertainment, and recreation, and E: Water supply; sewerage, waste and remediation.

US-dollars. Finally, we winsorize all variables included in the regression analysis at the 1st and 99th percentile separately for each sector.

The environmental variables related to green investment are based on the *Refinitiv* database (Thomson Reuters Group) for which we employ a similar data cleaning procedure, winsorizing the variables environmental expenditure share and emission intensity share at the 99th percentile.

We match the two data sets using common firm identifiers. For the regression analysis, we furthermore exclude some countries with poor data coverage (less than 100 observations for the entire sample period 2004 to 2020) to improve precision of our estimates. The main results are fully robust to the inclusion of these observations.

Construction of dependent variables:

The main dependent variable in our empirical analysis is a binary indicator for whether a firm i has made environmental investments and expenditures in year t. It is based on the survey question "Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities?". In addition we employ the following alternative dependent variables in Table A.7:

- **Emissions intensity:** based on Refinitiv. We divide total CO2-equivalent emissions at the firm level by revenues in US-dollars, winsorized at the 99th percentile and re-scaled (x 1000) for readability. Revenues are recovered from variables in Refinitiv that are reported in both levels and revenue shares (such as different measures of emissions and energy use). To convert local currencies in US-dollars, we rely on official exchange rates obtained from St. Louis Fed (https://fred.stlouisfed.org/categories/15)
- **Env. expenditure share:** We construct this variable by dividing the total environmental expenditure by revenues (both reported in local currencies in Refinitv) winsorized at the 99th percentile and re-scaled (x 1000) for readability.
- **Log total env. expenditure:** based on Refinitiv data. Natural log of environmental expenditure + 1. The final estimation sample is limited to strictly positive green investment amounts.

Table A.8 further incorporates data on total investment. This information is based on Orbis (real investment using fixed assets, perpetual inventory method). We convert the PPP data back to USD to make the data source comparable to the green investment variable. We employ

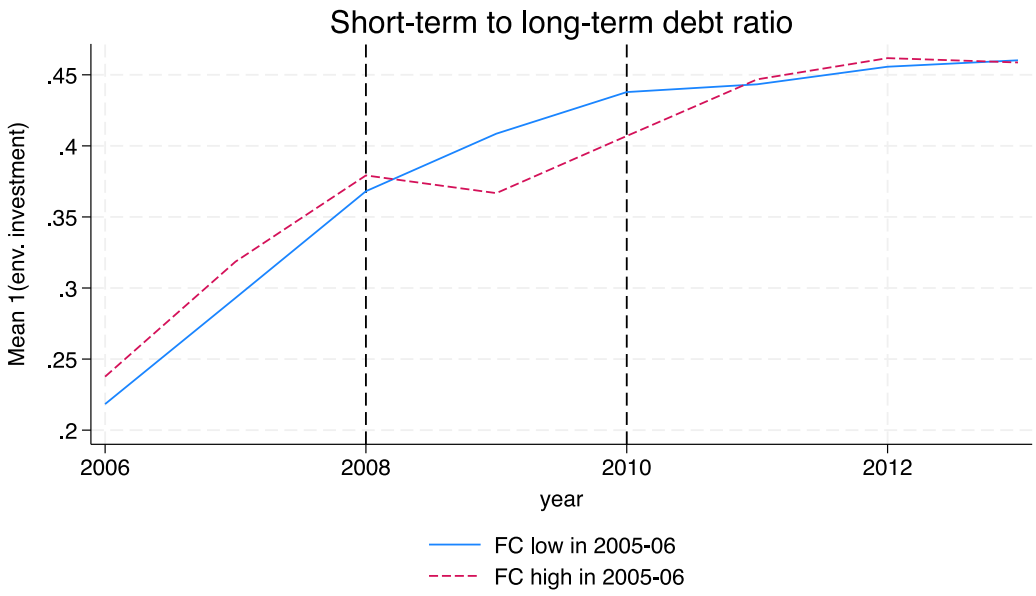

Fig. A.2. DiD analysis: parallel trends. *Notes:* Mean of environmental investment variable (binary) for group of firms with high exposure to the financing shock (FC high) and group of low exposure to the financing shock (FC low), defined according to the average short-term to long-term debt ratio in the pre-crisis period 2005/06 (25th percentile definition at the two-digit NACE Rev.2 sub-sector in line with the other FC measures).

Table A.6
DiD regression, GFC.

Exposure to financing shock	Debt ratio	
FC_{t-1}	−0.022	
	(0.031)	
FC_{t-1} × year = 2006	−0.022	−0.012
	(0.029)	(0.028)
FC_{t-1} × year = 2007	−0.035	−0.015
	(0.040)	(0.041)
FC_{t-1} × year = 2008	−0.032	−0.015
	(0.041)	(0.042)
FC_{t-1} × year = 2009	−0.086**	−0.059
	(0.041)	(0.041)
FC_{t-1} × year = 2010	−0.051	−0.025
	(0.043)	(0.044)
FC_{t-1} × year = 2011	−0.014	0.010
	(0.046)	(0.047)
FC_{t-1} × year = 2012	−0.021	0.012
	(0.046)	(0.047)
FC_{t-1} × year = 2013	−0.001	0.021
	(0.046)	(0.048)
N	7355	7342
Adjusted R2	0.377	0.712
Mean DV	0.365	0.366
Constant	Yes	
Controls	Yes	
Sector-Country-Year FE	Yes	
Firm FE	No	Yes

Notes: Dependent variable: dummy for green investment. Exposure to financing shock (FC) defined as the short-term to long-term debt ratio in the 25th percentile in the base-period 2005/06 (2005 as omitted category). Column 1 follows specification (1) with annual interactions, while Column 2 includes firm FEs. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

either the natural log of total investment or construct a dummy for positive investment in year t.

B.2. Main FC measures

Our main FC measures are **interest coverage ratio** and **financial leverage**. Interest coverage is defined as the ratio of firm earnings (before interest and taxes) to interest expenses. Financial leverage is defined as the debt-to-asset ratio.

Table A.7
Impact of FCs (alternative dependent variables).

Dependent variable:	Emission intensity (1)	Env. expenditure share (2)	Log total env. expenditure (3)
FC_{t-1}: SAFE index	0.106**	−0.788*	−0.227*
	(0.043)	(0.435)	(0.130)
N	27,378	11,345	4702
Adjusted R2	0.339	0.195	0.568
Mean DV	0.500	4.315	17.238
$\%\Delta y = 100 \times (exp^{\beta} - 1)$	–	–	−20.31
Constant	Yes		
Controls	Yes		
Sector-Country-Year FE	Yes		

Notes: Dependent variables. Emissions intensity: total CO2-equivalent emissions/revenues (USD) [x1000] in Column 1, environmental expenditure share: total env. expenditure/revenues (local currency) [x1000] in Column 2, and log of total env. expenditure (USD) (positive green investment amounts) in Column 3. Lagged FC: indicator variable for financially constrained firms according to SAFE index. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8
Impact of FCs (total investment).

Dependent variable:	Log total investment		𝟙(inv.)
	(1)	(2)	(3)
$FC_{(t-1)}$: SAFE index	−0.156***	−0.172***	−0.073***
	(0.027)	(0.060)	(0.007)
N	22,552	3799	22,719
Adjusted R2	0.704	0.743	0.215
Mean DV	19.537	20.434	0.871
Semi-elasticity	–	–	−0.084
$\%\Delta y = 100 \times (exp^{\beta} - 1)$	−14.44	−15.80	–
Sector-Country-Year FE	Yes		

Notes: Dependent variables. Log of total investment (USD) for positive investment amounts, based on fixed assets in Columns 1 and 2 (Column 2, limited to observations with positive green investment amounts as Table A.7) and a dummy for green investment in Column 3, respectively. Lagged FC: indicator variable for financially constrained firms according to SAFE index. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In addition to these individual variables, we combine information from several financial variables to replicate some composite indices

Table A.9
Interaction of FCs and EPS.

Environmental policy:	EPS	EPS			Energy price
	overall	Market	Non-market	Technology	index
	(1)	(2)	(3)	(4)	(5)
Panel (A): FC, Financial leverage ratio					
FC_{t-1}	−0.105**	−0.071***	−0.084**	−0.042	−0.395**
	(0.045)	(0.023)	(0.041)	(0.027)	(0.183)
FC_{t-1} × env. $policy_{t-1}$	0.030*	0.040**	0.013	0.008	0.060**
	(0.017)	(0.016)	(0.008)	(0.012)	(0.030)
N	26,166	26,166	26,166	26,166	16,141
Adjusted R2	0.351	0.351	0.351	0.351	0.343
Mean DV	0.300	0.300	0.300	0.300	0.338
Panel (B): FC, Interest coverage ratio					
FC_{t-1}	−0.054	−0.078***	−0.035	−0.014	−0.351*
	(0.043)	(0.024)	(0.042)	(0.024)	(0.187)
FC_{t-1} × env. $policy_{t-1}$	0.011	0.042**	0.002	−0.006	0.056*
	(0.016)	(0.016)	(0.008)	(0.011)	(0.030)
N	23,062	23,062	23,062	23,062	14,326
Adjusted R2	0.354	0.354	0.354	0.354	0.337
Mean DV	0.316	0.316	0.316	0.316	0.358
Constant	Yes				
Control	Yes				
Sector-Country-Year FE	Yes				

Notes: Dependent variable. Dummy for green investment. FC: Financial leverage ratio (Panel A) and interest coverage ratio (Panel B).* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

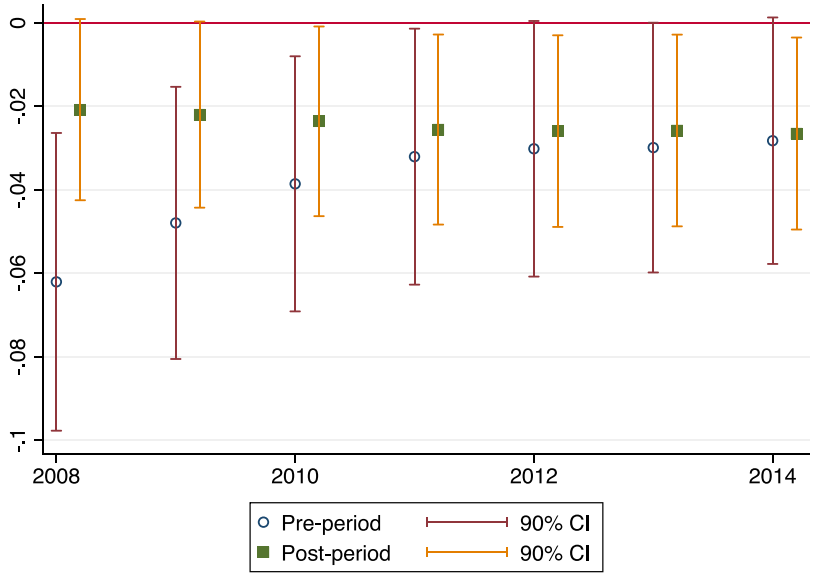

Fig. A.3. Main results, sample splits (SAFE index). *Notes:* Main coefficient for regression model (1) and the SAFE index as reported in Column 3 of Table 1 when splitting the sample in pre- and post-periods according to different thresholds ∈ (2008, 2014), indicated by the horizontal axis.

proposed in the literature. In particular, we compute the index proposed by Ferrando et al. (2015) based on the SAFE survey, extrapolating coefficients out of sample as in Ferrando and Ruggieri (2018), labelled SAFE index. We calculate the *SAFE index* for firm i in year t as:

$$\begin{aligned} SAFE_{it} = &-1.88 + (0.71 * FinLevRatio_{it}) + (-0.51 * ROA_{it}) \\ &+ (-0.28 * InterestCovRatio_{it}) \\ &+ (-1.20 * CashHoldings_{it}) + (-0.21 * AssetsTangibility_{it}) \\ &+ (-0.05 * LogTotAssets_{it}) \end{aligned} \quad (2)$$

where *CashHoldings* stands for the ratio of cash reserves over total assets, *ROA* measures firms profitability as the ratio between profits and total assets, *AssetsTangibility* stands for the ratio between tangible fixed assets and total assets and *LogTotAssets* proxies for firms size using the logarithm of total assets. The financial leverage and interest coverage ratios (*FinLEvRatio* and *InterestCovRatio*, respectively) are defined in the main text. Variables entering the equation with a negative sign are expected to lessen financial constraints the higher their value, while the opposite holds for those with a positive loading. To limit endogeneity concerns, we employ lagged index values at time $t-1$ in our analysis.

Alternatively, we also consider the *FCP index* as developed in Schauer et al. (2019) that focuses on a smaller set of variables and uses different weighting coefficients:

$$\begin{aligned} FCP_{it} = &(-4.04 * ROA_{it}) + (-0.024 * InterestCoverageRatio_{it}) \\ &+ (-1.716 * CashHoldings_{it}) + (-0.123 * LogTotAssets_{it}) \end{aligned} \quad (3)$$

B.3. Data on energy prices

Industrial sector energy prices are obtained from Sato et al. (2019) from 1995–2015 and have been updated to cover also the 2016–2020

period. The price indices cover four fuel types: oil, coal, gas, and electricity, and are constructed as averages of country- and fuel-specific prices weighted by country- and sector-level fuel consumption. To limit endogeneity concerns, as firms may change their fuel mix as a response to changes in fuel prices, we used a fixed share of fuels at the beginning of our sample period (2005). We also experiment with other base years without a change in results. The energy price data only cover the manufacturing and construction sectors in OECD countries, leading to a smaller sample size.

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