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Making the grass greener: The role of firm's financial and managerial capacity in paving the way for the green transition

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ABSTRACT/RÉSUMÉ

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The role of firm's financial and managerial capacity in paving the way for the green transition

Despite the ambitious carbon reduction targets set by policy makers worldwide, current investments fall well short of the net-zero emissions scenario. This paper analyses the factors holding back corporate green investment, with a particular focus on the role of firm capacity – specifically financing constraints and weak green management practices – and its interaction with environmental policy. Combining a variety of econometric techniques, including panel data models, difference-in-differences settings and instrumental variable approaches, our cross-country analysis on large listed companies shows that: i) both financing constraints and a lack of green managerial capacity reduce firms' probability of investing in green technologies, leading to higher emission intensity; ii) well-designed environmental policies can mitigate these impacts. A case study using more granular data on Portuguese firms further shows that: iii) green investment is more elastic to financing conditions than other types of investment; iv) investment in integrated technologies is more sensitive to financing conditions and to managerial capacity compared to end-of-pipe solutions. Lastly, the paper discusses a wide range of policy options that may be considered to foster the green transition through upgrading firms' capacity.

JEL classification codes: D22, G32, Q52, Q58

Keywords: Green investment, Financing constraints, Green management, Environmental policy.

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Rendre l'herbe plus verte:
Le rôle de la capacité financière et managériale des entreprises dans la transition verte

Malgré les objectifs ambitieux de réduction des émissions de carbone fixés par les responsables politiques du monde entier, les investissements actuels sont bien en deçà du scénario de zéro émission nette. Cet article analyse les facteurs qui freinent l'investissement vert des entreprises, en se concentrant particulièrement sur le rôle de la capacité des entreprises – en particulier les contraintes de financement et la déficience des pratiques de gestion de l'environnement – et son interaction avec la politique environnementale. En combinant diverses techniques économétriques, notamment des modèles de données de panel, des méthodes de doubles différences et des approches de variables instrumentales, notre analyse portant sur des grandes sociétés cotées de plusieurs pays montre que: i) les contraintes de financement et la déficience des pratiques de gestion environnementale réduisent la probabilité d'investissement dans les technologies vertes, conduisant à une intensité d'émission plus élevée; ii) des politiques environnementales bien conçues peuvent atténuer ces impacts. Une étude de cas utilisant des données plus granulaires sur les entreprises portugaises montre en outre que: iii) l'investissement vert est plus élastique aux conditions de financement que les autres types d'investissement; iv) l'investissement dans les technologies intégrées est plus sensible aux conditions de financement et à la capacité de gestion que les solutions en bout de chaîne. Enfin, l'article examine un large éventail de politiques publiques qui pourraient être envisagées pour favoriser la transition verte en améliorant les capacités des entreprises.

Classification JEL: D22, G32, Q52, Q58.

Mots-clés: Investissement vert, Contraintes de financement, Gestion environnementale, Politique environnementale.

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Making the grass greener: the role of firm financial and managerial capacity in paving the green transition

By Hélia Costa, Lilas Demmou, Guido Franco and Stefan Lamp[1]

1. Introduction

1. Most OECD countries have set ambitious targets to become carbon neutral by 2050. This will require substantial investment to reduce greenhouse gas emission over the next decade. According to the International Energy Agency (IEA), global energy investment will need to almost double to 4.5% of global GDP by 2030 and remain at this level until 2050 (IEA, 2021[1]; IEA, 2021[2]). A large part of this investment will need to come from the private sector,[2] with action needed across all industries.[3]

2. However, investment efforts so far fall well short of the zero-emission scenario. Understanding why this is the case is vital to ensure that the investment necessary for the green transition can be mobilised. Amidst several market imperfections that could be holding back environmentally friendly investment, this paper examines the role of organisational and financial factors in shaping firms' investment in low-carbon technologies. Due to its specific characteristics (e.g., high fixed costs and risks, information asymmetries), investment in such technologies may be more difficult to finance compared to investment in other, more established, technologies. In the same way, investment in green technologies that are newer and riskier may be delayed because firms lack sufficient knowledge of this type of investment and how to manage it.

3. The paper analyses the interplay between financing constraints and green management practices with macroeconomic and institutional settings, with a particular focus on the role of environmental policy,

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[2] For example, the IEA estimates that around 70% of clean energy investment will have to be carried out by private developers, consumers and financiers responding to market signals and policies set by governments (IEA, 2021[1]).

[3] For instance, in the European Union, the bulk of greenhouse gases is emitted in five sectors: transportation, industry, power, buildings and agriculture. https://www.mckinsey.com/business-functions/sustainability/our-insights/how-the-european-union-could-achieve-net-zero-emissions-at-net-zero-cost.

in determining firms' green investment. While a range of environmental policies has been put in place to stimulate investment that generates positive externalities, it is not yet clear how effective they are in mitigating firm-level barriers. We explore these issues through two parallel and complementary avenues, combining a rich set of data sources and econometric techniques, including panel data models, difference-in-differences settings and instrumental variable approaches.

4. First, we analyse green investment and emissions of large companies which are more strictly affected by environmental policy and for which cross-country data on green investment and economic performance are available. Our findings suggest that being financially constrained or lacking green managerial capacity reduces firms' probability of investing in green technologies substantially. Specifically, becoming financially constrained reduces the propensity to make green investments by 2.5 percentage points, which amounts to around 8% of the average propensity. In turn, implementing one green management practice increases the propensity to invest in green technologies by 9.5 percentage points, or around 30% of the average propensity to invest. Next, exploring the mediating impact of environmental policies, results show that the negative effect of financing constraints on green investment is reduced when stringent market-based environmental policies are in place (that is, they are substitutes), while the positive effect of green management practices is larger the more generous are public subsidies (that is, they are complementary). Specifically, in settings of low environmental policy stringency, the effect of being financially constrained on the probability of making green investment is estimated between 3.5 and 4 percentage points. Moreover, the analysis confirms that financially constrained firms are more emission intensive than their non-constrained counterparts and that environmental management training is instead related to lower emission intensity. Both these points suggest that policy intervention improving firms' organisational and financial capacity could make a substantial contribution to the green transition. Finally, we show that easy credit conditions could magnify the aggregate impact of firm-level green investments by allowing green-investing firms to grow more than their non-green-investing competitors; when financing conditions are tight, instead, investing in green technologies is neither growth-enhancing nor growth-damaging, plausibly because it becomes harder to make the additional investments in other areas that may be needed to prevail in the market.

5. Second, we conduct a case study of green investment in Portugal where access to granular data allows us to analyse further different types of investment and the impact of firm size, in particular SMEs' carbon footprint for which cross-country data are not easily available. Results show that large firms account for the bulk of green investment. This possibly occurs because green investment requires large upfront investment and hence internal resources that are more likely to be mobilized by large firms.[4] At the same time, as they are typically less financially constrained as compared to SMEs, large firms tend to be more sensitive to changes in financing conditions. Examining investment types, green investment appears more elastic to financing constraints than other types of investments, providing indirect evidence that specific characteristics (e.g., substantial initial fixed costs, higher risks, or information asymmetry) makes the financing of green investment more difficult. Furthermore, this sensitivity to financing conditions is higher in the case of investment in integrated technologies compared to end-of-pipe solutions. Looking at the role of green management, results are qualitatively similar but point also to the importance of having upper management staff with green functions in addition to technical staff with green functions for investment in integrated technologies. Overall, these findings point to heterogeneous effects across types of investments and suggest that specific attention should be paid to investment in integrated technologies, which are expected to provide larger co-benefits, particularly in terms of efficiency (Hammar and Löfgren, 2010[3]) and productivity (Porter and van der Linde, 1995[4]).

6. Finally, while our empirical analysis delivers insights on the broad policy response needed to foster the green transition (i.e., upgrading firm financing and managerial capacity), we rely on the latest literature

[4] Conversely, SMEs are typically more financially constrained than large firms, but their decision to invest in green is relatively less sensitive to financial constraints.

to propose a menu of more granular policy options. Specifically, in order to ease firms' financing constraints and strengthen their managerial capacity, policy makers could consider the following areas for policy action:

- There is room to harness the potential of banks and capital markets as catalyst for green finance. For example, green equity markets could be deepened by a combination of stringent environmental policies and measures to develop capital markets (such as removing the tax advantage of debt over equity, simplifying IPOs, progressing on the EU capital market union). Meanwhile, there is room to further support banks to adjust their business model to the needs of the green transition (e.g., via implementing secondary markets for green and brown assets, improving insolvency regimes). In addition, the development of reliable monitoring tools, such as (improved) ESG standards, could help mobilise more capital from financial institutions and equity investors, as it provides a more precise assessment of firms' exposure to climate risks and stranded assets. Similarly, de-risking instruments deployed by the public sector (e.g., private-public partnerships or state-loan guarantees) could help raise private investment and channel it towards green technologies hitherto considered riskier. Integrating climate and environmental risks into central banks' supervisory frameworks and asset purchase strategies, currently in its early stages, could possibly also help alleviate financing constraints of firms going green.
- Finding an appropriate balance among environmental policy tools requires understanding their interactions with firm capacity. In particular, carbon pricing is one of the most efficient means to influence investment behaviours and also mitigate the negative effects of financing constraints on green investment.
- Environmental education and training are key to successful environmental management. Training programmes can be promoted by governments for example through subsidies and tax incentives financed by the recycling of revenue from environmental taxation. Standards for management practices can also play a role in promoting best practices and providing incentives for taking energy efficiency measures.

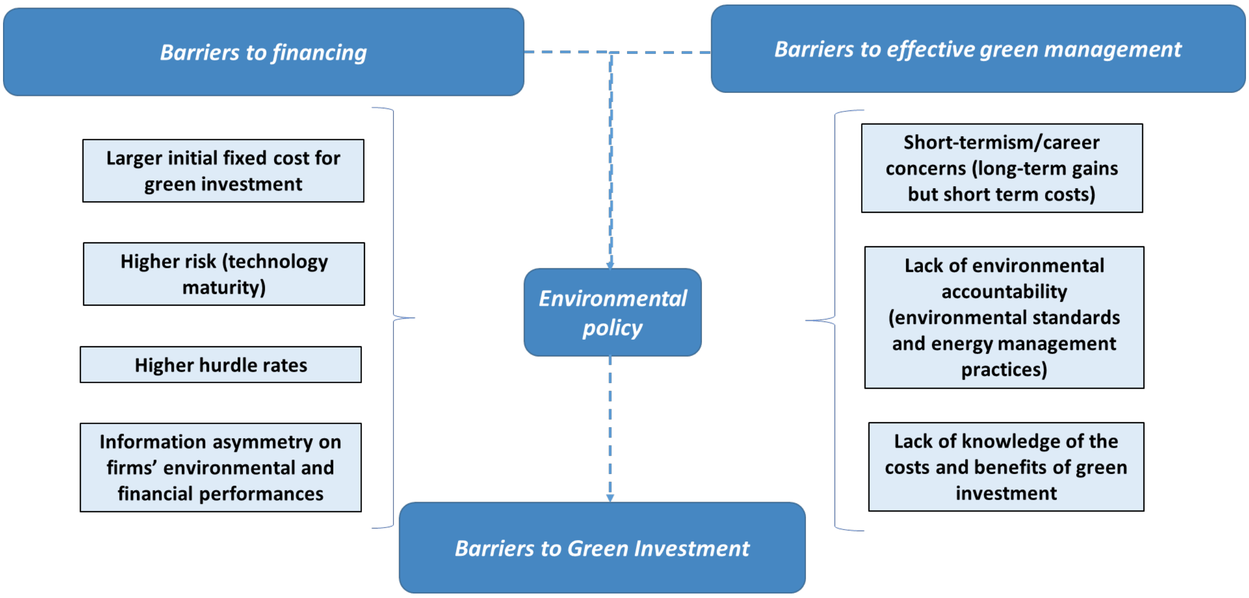
7. The remainder of the paper proceeds as follows. Section 2 presents the conceptual framework underlying the analysis and a brief overview of the related literature. Section 3 describes the data, the empirical setup and the main findings related to the cross-country firm level analysis. Section 4 provides an overview of the firm-level case study of green investment in Portugal. Section 5 concludes by discussing the policy implications of the analysis.

2. Analytical framework

8. Green investment from the private sector tends to fall short of the levels needed to achieve zero-emission objectives for two main reasons.[5] First, the positive externalities associated with it are not fully internalised by firms, despite the increasing role of environmental policies in aligning the social and private rate of return of these investments. Second, even in the absence of externalities, according to neoclassic economic theory, firms should invest in all projects that have a private rate of return exceeding the average cost of capital. However, when it comes to green investment in such projects, firms may face more difficulties in identifying profitable investments and evaluating risks as well as in mobilising capital to seize the identified opportunities. It follows that green management practices and financing capacity may be two important drivers of green investment at the firm level (Figure 1).

[5] The potential lack of viable and profitable green projects may also be an explanation for low investment levels. However, while the profitability of green projects has been low in the past, it is recently increasing with environmental policy stringency and the associated innovation. Our analysis focuses on (firm-level) barriers that are beyond project-specific profitability.

Figure 1. Financing constraints, green management, and environmental policy: analytical framework



Source: OECD.

2.1. Financing constraints

9. Financing constraints in general force firms to forego investing in economically viable projects (those with a positive net rate of return) and opt for only those with the highest expected net present value. This may result in an investment gap (Almeida and Campello, 2007[5]; Campello, Graham and Harvey, 2010[6]; Duchin, Ozbas and Sensoy, 2010[7]).

10. The green transition can exacerbate the investment gap for several reasons. First, a higher risk is generally associated with green investment compared to fossil fuel investment. For instance, some low carbon technologies are still in an early stage of development, and the risk of breakdowns and disruptions might outweigh the potential benefits of reduced energy costs. Second, short-termism blocks both firms from investing and financial institutions from lending to support environmentally innovative projects (Graafland, 2016[8]; Ng, Wang and Yu, 2023[9]).[6] In addition, asymmetric information makes it difficult to evaluate the feasibility of green projects, inciting banks to finance investment in more established areas. Importantly, green investment requires large upfront investments which makes its financing even more challenging (Fowlie, Greenstone and Wolfram, 2018[10]; De Haas and Popov, 2023[11]; Nelson and Shrimali, 2014[12]).[7] Finally, green investment may be treated with low priority by firms, as often attached to other wider investment projects (Schleich, 2007[13]; Venmans, 2014[14]). Box 1 summarizes the main findings from the literature on financing constraints and green performance.

11. Environmental policies supporting the green transition can be key in mediating the effect of financing constraints on the investment gap. They rely on various instruments, such as carbon prices,

[6] Further, firms tend to prioritize short-term financial profits over less profitable climate-friendly projects that show positive externalities (Ng et al., 2023). At the same time, short-termism also contributes to under-estimating the risks associated with brown investments, especially the risk of stranded assets.

[7] Nelson and Shrimali (2014[12]) estimate that upfront capital costs represent 84–93% of total project costs for wind, solar, and hydro energy (compared to 66–69% for coal and 24–37% for gas).

green subsidies, and market regulation, either forcing or incentivising firms to internalise negative externalities despite financing constraints:

- Carbon prices increase the exposition of polluting companies to financial risks, making investment in carbon-intensive technologies less profitable while encouraging investment in energy saving technologies. A set of papers provide indirect evidence that higher energy prices increase incentives to invest in energy-efficiency technologies. Steinbuks and Neuhoff (2014[15]) show that the investment response to energy prices varies considerably across manufacturing industries in OECD countries, being more significant in energy-intensive industries and increasing over time. A similar result is found by Dlugosch and Kozluk (2017[16]), who estimate the energy price and total investment relationship based on a sample of listed firms in 30 OECD countries. Based on a sample of French firms, Marin and Vona (2021[17]) also find that an increase in energy price generates an increase in the capital stock in the long term. However, strong price signals alone may not suffice to bridge the current gap in low-carbon investment if such investments are not sufficiently profitable and financial intermediaries mobilise only limited funds due to risk aversion, suggesting that a combination of tools may be needed (Acemoglu et al., 2012[18]; Stiglitz, 2019[19]). Additionally, it may be difficult to commit to a carbon price trajectory for governments, and this is necessary for carbon pricing to be effective in generating investment. Even a large carbon price will not generate enough investment if there is a risk the policy is overturned by changing governments. Indeed, Berestycki et al. (2022[20]) find that climate policy uncertainty is negatively related to investment, particularly for most exposed firms.
- Environmental subsidies may play an important complementary role by reducing the cost of green investment as well as in complementing other external funds, which is particularly important given the large upfront financial resources often required for low-carbon technologies. Accetturo et al. (2022[21]) explore the role of government subsidies and its interplay with financing conditions, finding that the more government subsidies are available in a region, the more green investments respond to credit supply. Acemoglu et al. (2012[18]; 2016[22]) suggest that a combination of carbon price and research subsidies can successfully redirect technological change toward cleaner technologies. Eyraud et al. (2013[23]) provide evidence along these lines, showing that feed-in-tariffs and carbon price are important drivers of green investment. Howell (2017[24]) shows that, for US companies, firms benefitting from the Department of Energy's SBIR grant programme generate higher revenue, patent more and are twice as likely to receive venture capital than unsuccessful applicants, especially when these firms are financially constrained.
- Simple, predictable, and clear environmental laws and standards are key to promoting green investment (Hu et al., 2023[25]). They raise awareness of risks associated with high carbon technologies while incentivising financial market participants to pursue more sustainable investment. Ng et al. (2023[9]) find that the effect of financial constraints on carbon emissions is less pronounced in countries that enforce strict environmental laws. At the same time, however, regulation may be fully substitutable to other policies, including an easing of financing constraints: if green investment is made mandatory by law, firms are forced to comply, irrespective of credit constraints (and perhaps foregoing other investments). For instance, de Haas et al. (2022[26]) find that in EU countries, local credit constraints have no impact on hazardous air pollutant emissions locally, when these are subject to strict regulation. Focusing on the US, Xu and Kim (2022[27]) provide evidence that financial constraints only impact firms' toxic emissions when local regulation is lax, as firms are left with some leeway to prioritise other investments over those in pollution abatement.

12. Lastly, macro-prudential rules are increasingly aligned with the needs of the green transition, favouring indirectly a reallocation of resources toward firms complying with the Paris agreement. For instance, the ECB is already gradually integrating climate and environmental risks into its regular

supervisory methodology and is also currently channeling investment in corporate bonds based on firms' climate score (ECB, 2023[28]).

Box 1. Financing constraints and pollution: main findings from the literature

Country-specific studies

- Bartram, Hou and Kim (2022[29]) show how financially constrained firms in California responded to the introduction of a state-level cap-and-trade program by shifting emissions to other states.
- Levine, Lin, Wang and Xie (2018[30]) show how positive credit supply shocks in U.S. counties — due to fracking of shale oil in other counties — reduce local air pollution.
- Goetz (2019[31]) finds that financially constrained firms reduced toxic emissions when their capital cost decreased as a result of the U.S. Maturity Extension Program.
- Cohn and Deryugina (2018[32]) document a negative relationship between U.S. firms' contemporaneous and lagged cash flow and the occurrence of environmental spills.
- Xu and Kim (2022[27]) show that plant-level toxic releases of hazardous pollutants and chemicals increase with the financial constraints of the parent firm.
- Accetturo et al. (2022[21]) find that a one standard deviation increase in credit supply raises the likelihood of firms investing in green technology by between 1.9 and 3.4 percentage points (around 15% of its standard deviation). In contrast, a similar analysis on general investments did not yield any significant results.

Cross-countries studies:

- Ng et al. (2023[9]) show that financial constraints significantly increase corporate direct carbon emissions even after controlling for firm-specific characteristics. However, this effect is less pronounced in countries that enforce strict environmental laws and countries that commit to climate change mitigation after the Paris Agreement.
- Kalantzis et al. (2022[33]) based on survey data show that firms that are financially constrained are less likely to pursue mitigation measures. Contrarily, financial constraints appear not to affect the type of green investment made.
- Guerin and Santheim (2021[34]) examine ESG scores of listed companies in 62 countries and show that tighter financial constraints as well as economic downturns are associated with weaker environmental performance and lower levels of green investments by firms.
- De Haas et al. (2022[26]) cover 10K firms in 22 merging countries and show that firms' financing constraints hold back green investment and the abatement of emissions.

2.2. Green management practices

13. Managers play an important role in the green transition through their influence on investment decisions. Managers' incentives to invest in green projects may be weakened by present-bias, as energy cost-saving takes time to materialise and green investment is generally perceived as relatively riskier (Allcott and Greenstone, 2012[35]; Schleich, 2007[13]; DeCanio, 1993[36]). In addition, insufficient information on the energy-saving opportunities or lack of accountability on energy consumption may also lead to sub-optimal decisions and a significant energy efficiency gap (Schleich, 2007[13]; Caffall, 1995[37]); Box 2).

Box 2. Green management practices and energy efficiency: main findings from the literature

Energy efficiency gap

- Ates and Durakbasa (2012[38]) examine energy management practices in energy-intensive industries in Turkey and show that only 40% of the surveyed Turkish companies developed a formal energy policy.
- Apeaning and Thollander (2013[39]) rely on surveys to assess various energy-efficient technologies and provide evidence of a relatively low adoption rate of available energy efficiency technologies.
- Vickers et al. (2009[40]) report that one-third of UK SMEs expenditure on energy is wasted through inefficient practices.

Internal training

- Liu et al. (2012[41]) conducted an empirical study based on a sample of 125 small and medium-sized companies in Taicang China industries and show that internal training on energy saving is a key determinant of a company's involvement in energy saving activities.
- Similarly, Suk et al. (2013[42]) interview energy-intensive companies in Korea and find that internal training specific to energy saving is a key determinant of company's involvement in environmental saving activities.

Top management

- Martin et al. (2012[43]) interviewed managers of 190 randomly selected manufacturing plants in the UK and find that firms are more likely to adopt climate-friendly management practices if there is an environmental or energy manager, and if this manager is close to the CEO.
- Gordić et al. (2010[44]) investigate Serbian car manufacturers and show that the most crucial managerial spot is the position of an energy manager who should have direct access to top management and a strong cross-functional information base.
- Blass et al. (2014[45]) examine a sample of 752 small and medium-sized U.S. manufacturing firms and find that the involvement of top operations managers with a clearly operationally focused position significantly increases the adoption of energy-efficiency initiatives, while there is no effect for top managers without an operational role.

Source: Schulze et al. (2016[46]).

14. Green management practices, such as adopting environmental strategies, providing green training, or defining environmental targets, can make the difference in steering firms' environmental orientation, adding to the positive effect of good management practices (Bloom and Van Reenen, 2007[47]; Bloom and Van Reenen, 2010[48]), by making environment part of their business decisions. Green-conscious managers are generally better informed about the costs and benefits of energy efficiency investment and suffer less from present-biased preferences (Allcott, Mullainathan and Taubinsky, 2014[49]; Martin et al., 2012[43]; De Haas et al., 2022[26]).[8] Overall, good environmental management practices are associated with improvements in resource efficiency at firm level and of firms' competitive position (Aragón-Correa et al., 2008[50]; Delmas and Pekovic, 2015[51]; Testa et al., 2013[52]).

15. Environmental policies play an important role in mediating the effects of green management practices on investment. Clear environmental regulation supports investors and firms to adopt a long-term

[8] In certain sectors, green technologies are potentially as efficient as brown technologies, but not adopted due to a path dependency to brown technologies.

perspective by modifying their perception of risks and integrating environmental challenges in their business model. In particular, establishing energy performance standards can help managers select the most effective energy-efficient technologies (Leiter, Parolini and Winner, 2011[53]; Wiel and McMahon, 2003[54]). Importantly, regulation design matters and allowing managers to choose technologies that best fit their production techniques and organisational structures is preferable to strict regulation (Hottenrott, Rexhäuser and Veugelers, 2016[55]). Also, as awareness of environmental challenges and of the benefits of environmental engagement increase in the company, the effect of clear and stable environmental policies may increase because green-oriented businesses are better prepared to respond to policies with investment (Accetturo et al., 2022[21]; Perron, Côté and Duffy, 2006[56])).

3. Firm capacity, environmental policy and green investment: cross-country analysis

3.1. Data

16. Our main empirical analysis employs four main pieces of information: i) firm-level green investment and emission data from Refinitiv Datastream's ESG module (Thomson Reuters Group); ii) firm-level balance sheet data from Bureau van Dijk's Orbis database; iii) country-level information, including environmental policy stringency data from the OECD, and iv) sector-country-level information, including energy prices. The first two datasets were merged using common firm identifiers. The final dataset contains information on 6,812 companies across 33 countries between 2004 and 2020.[9, 10] A summary of the data is available in Table A.1.

Firm-level environmental information

17. Refinitiv reports annual information used to measure ESG scores for large listed firms, of which we focus on information on the Emissions category from 2004 and 2020. Specifically, our main dependent variable measures whether a firm has made environmental investments and expenditures. We use the answer to the question "Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities?".[11] We alternatively use information on the firms' emission intensity (total CO_2 equivalent emission to revenues) to analyse whether firm capacity is linked directly to emissions. These data have been increasingly used in recent research, namely Gonec and Scholtens (2017[57]), Guérin and Suntheim (2021[34]), Al-Dosari et al. (2023[58]), and Hege et al. (2023[59]).

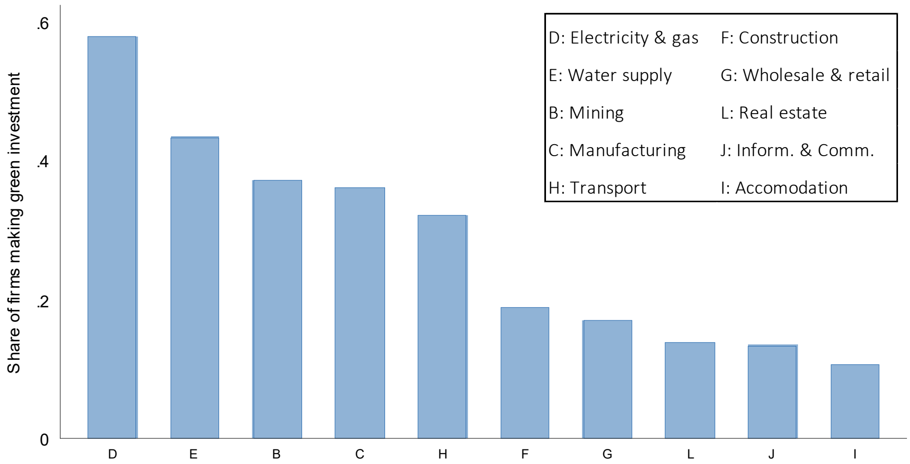
[9] The countries included are: US, JP, GB, CN, DE, FR, AU, SE, IN, ZE, ES, NL, IT, CA, IE, FI, BE, DK, ID, TR, AT, PL, GR, LU, PT, RU, HU, CZ, MT, KR, SI, RO, BG. Figure A.1 shows the number of unique firms and sectors in the sample. For robustness, we estimate the main regression specification excluding any country with less than 100 observations (8 countries in total). The results are not affected by this modeling choice.

[10] The number of firms observed in each year increases over time (Figure A.2). However, the inclusion in the database is driven by the size of the firm and not by its environmental performance, and as such should not bias our results.

[11] Environmental investments or expenditures are defined in the survey as those to reduce future risks or increase future opportunities related to the environment, on new technologies to increase future opportunities, as well as expenditure on treatment of emissions (e.g., expenditures for filters, agents) and installation of cleaner technologies. Alternatively, Refinitiv also reports the total amount of environmental expenditures. However, this variable is only available for 24% of firms that report the binary investment variable, and as such we focus our analysis on the dichotomous variable.

18. Figure 2 shows the distribution of the environmental investment variable aggregated at the NACE Rev. 2 single-digit sector, averaged over time. The observed values can be interpreted as the fraction of firms in any given sector that report environmental investment activity. The figure shows that there exists strong sectoral heterogeneity in terms of environmental investment, with emission intensive sectors (e.g. manufacturing and electricity) or sectors where environmental concerns have large implications (e.g. water supply) showing much larger investment shares.

Figure 2. Average firms making environmental investment for key sectors



Note: Average share of green investment indicator by single-digit NACE Rev. 2. We exclude the five sectors with the least investment, namely professional and scientific activities, administrative and support activities, human health and social work, arts entertainment and recreation, and other services.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis 2004-2020.

19. In order to measure environmental management practices, we use two variables indicating whether a firm employs a team with specific functions dedicated to environmental management (using the answer to the question "Does the company have an environmental management team?") and whether a firm provides environmental training to its employees (using the answer to the question "Does the company train its employees on environmental issues?"). Next, we sum the two measures, generating an indicator that takes the values zero, one, or two. On average, 57% of firms in the sample employ some form of environmental management practice: 44% of firms in the sample employ a team with specific environmental management objectives, and 48% provide environmental training to their staff.

Firm-level financial information

20. In order to proxy for firms financing constraints, we use the Orbis database, an umbrella product provided by Moody's that combines information from regulatory and other sources to collect balance sheet and ownership data about companies worldwide. Currently, Orbis is the largest cross-country firm-level dataset available and accessible for economic and financial research. These data are cleaned through the procedure described in Gal (2013[60]) with the aim to ensure comparability across countries and sectors (see Annex B for details).

21. Firm-level financing constraints are not directly observable using balance sheet information. As the literature has proposed a wide range of competing measures, each presenting its own advantages and

disadvantages, and none outperforming the others[12] — we horse-race several financial constraints indices as follows. To start, we compute two financial ratios that are widely used, the financial leverage ratio (i.e. the ratio of bank and bond debt over total assets) and the interest coverage ratio (i.e. the ratio of firms profitability, proxied by the EBITDA, over interest expenses). These two ratios capture firms' financial conditions in terms of stocks and flows respectively, potentially accounting for the bulk of firms' constraints in a very simple and directly measurable way.

22. However, reliance on a single variable would not allow us to have a comprehensive view of firms' financial conditions: a firm might be over-indebted, but strong fundamentals and high profitability could compensate for the temporary financial distress; or, similarly, a firm may have low debt, but low profitability could impair its access to financial markets. Hence, we combine information from several financial variables to replicate some composite indices proposed in the literature. In particular, we compute the index proposed by Ferrando et al. (2015[61]) based on the SAFE survey, extrapolating coefficients out of sample as in Ferrando and Ruggieri (2018[62]) in order to weight the contribution of each variable to the composite indicator – henceforth SAFE index. Next, following Schauer et al. (2019[63]), we calculate in a similar way a second indicator which focuses on a smaller set of variables and uses different weighting coefficients -- henceforth SEB index. The details of the financial variables included in each index and of the computations are presented in Annex B.[13]

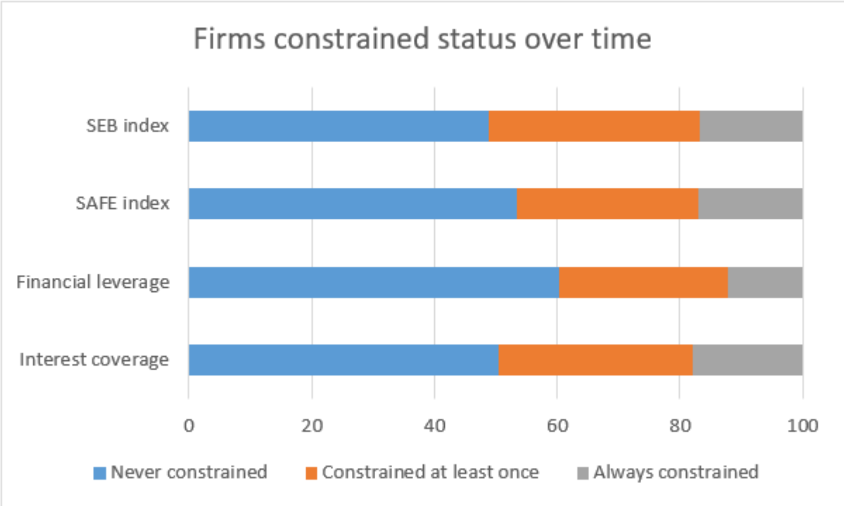
23. Finally, for each of the financial ratios and financial composite indices described above, we define a dummy variable taking value 1 if a firm belongs to the top quartile of the financial leverage, SAFE index and SEB index distribution or to the bottom quartile of the interest coverage distribution and 0 otherwise. The distribution is evaluated separately for each sector-year pair, and results are robust to the use of terciles rather than quartiles or to ranking firms by sector but pooling the sample over time. The use of binary variables provides two advantages in our setting. First, the listed firms in our sample tend to face milder constraints compared to private firms and the categorization allow us to focus on investment patterns of the most constrained firms. Second, with respect to the composite indices, the extrapolation of coefficients out of sample may affect the precision of the estimates, but firms relative ranking, especially classifying firms in two groups, is definitely less impacted.

24. According to our quartile-based baseline measures, almost 10% of firm-year observations are classified as constrained independently of the financial indicator used to proxy firms financing frictions, while slightly more than 40% of observations are classified as constrained by at least one measure. Interestingly, firms financial constrained status evolves over time, though to a limited extent (Figure 3). Approximately 30% of firms change their status over time, while half of the firms in the sample are relatively unconstrained throughout the sample period and the remaining 15-20% of firms are contrarily always constrained over time.

[12] See Farre-Mensa and Ljungquist (2016[116]) for a review.

[13] Results are also qualitatively unchanged when using a third composite index, following Mulier et al. (2016[106]). Details are also presented in Annex B. For the sake of brevity, the outcome is not presented in the paper.

Figure 3. Firms' financial conditions over time



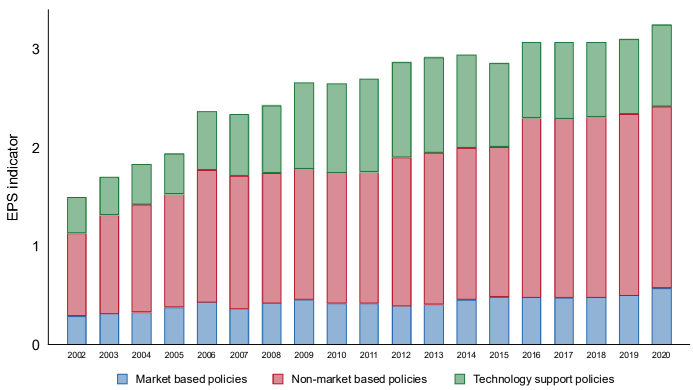
Note: The details on the financial ratios and composite indices are provided in Annex B.
Source: OECD calculations based on Orbis data matched to the Refinitiv ESG database, 2004-2020.

Country-level Environmental Policy Stringency

25. In order to measure the stringency of environmental policy at the country level we use the Environmental Policy Stringency (EPS) indicator from the OECD (OECD, n.d.[64]; Kruse et al., 2022[65]). The EPS indicator is available from 1990 to 2020, across 40 countries and 13 policy instruments, with a focus on climate change and air pollution policies. The indicator ranges from 0 to 6, where a larger number implies a more stringent environmental policy. It is made up of three parts weighted equally: market-based policies, including carbon taxes and emissions trading schemes (ETS), non-market-based policies, including emission limit values (ELV) and diesel sulphur content limits, and technology support policies. The latter includes public research and development expenditure (R&D), and renewable energy support for solar and wind energy, including feed-in-tariffs. Environmental policy stringency has been on a generally increasing trend for the average of countries in the sample, with a larger growth rate for the period up to 2010 with considerable heterogeneity across countries (Figure 4, Figure A.3).

Figure 4. Environmental policy stringency has been increasing on average

Average EPS indicator and its subcomponents in the sample throughout time



Source: OECD calculations based on OECD data (OECD, n.d.[64]; Kruse et al., 2022[65]).

26. Finally, as an alternative proxy to measure market-based environmental policy stringency, we also use country and sector specific energy prices faced by firms – see Annex B. Using energy prices allows us to proxy the impact of future more stringent carbon pricing policies, which will raise energy prices. Energy prices are available at a more granular level than indicators of market-based environmental policy stringency, which are available only at the country level. They also provide an alternative that is not subject to human coding of policy.

3.2. Empirical strategy

Baseline estimations

27. In our baseline model outlined in equation (1), we regress an indicator variable for whether green investment was made by firm *i* in country *c*, sector *s* and year *t* ($1(green\ investment)_{icst}$) on an indicator for the firm capacity to invest ($Capacity_{ics,t-1}$), proxied by being financially constraint (FC) in the past year, or/and having implemented environmental management practices (EM). Our main coefficient of interest is β_1, which is identified by relative changes of the financial position and green management practices of firms within their economic sector and over time.

28. To account for macroeconomic shocks as well as sectoral trends that might affect green investment, we include country-by-sector-by-year fixed effects (θ_{sct}). These fixed effects control for both observed and unobserved factors that might affect country-industries pairs heterogeneously over time. We further include lagged control variables at the firm level, $X_{ics,t-1}$, accounting for differences in firm size, age as well as their overall economic performance, namely sales growth, return on assets and the ratio of tangible fixed assets to total assets.

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

29. We estimate the baseline model with OLS, clustering standard errors at the firm level, the unit of the panel. Compared to maximum likelihood specifications like logit, linear probability models have the benefit of not assuming a specific functional form for the data generating process. They also allow us to include a rich fixed effect structure. Moreover, this choice follows Timoneda (2021[66]), who finds that linear probability models with fixed effects produces more accurate estimates than maximum likelihood specifications when the dependent variable has less than 25% of positive observations. Nonetheless, to ensure our results are not driven by a specific modelling choice, we also estimate a non-linear maximum likelihood (logit) model.

30. Next, we analyse whether financial and managerial constraints impact emissions at the firm level. To do so, we analyse a variant of equation (1) in which we use emission intensity of revenues as dependent variable. Finally, in order to understand how environmental policy alters the relationship between firms' capacity to invest and their actual green investments, we augment equation (1) with an interaction term between the lagged firm capacity variables and different measures that account for the stringency of environmental policy.

Reducing endogeneity concerns about financing constraints

31. OLS estimates of the impact of financing constraints may be biased for example if firms that have grown faster and invested recently find themselves credit constrained (introducing an upward bias in our estimates) or if firms that invested previously and want to continue to invest are more likely to access financing (D'Arcangelo et al., 2023[67]) (introducing a downward bias in our estimates).

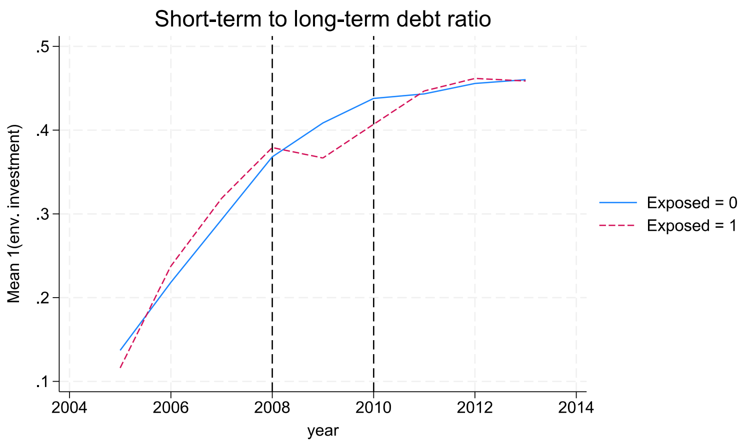
32. To further advance towards a causal interpretation of our estimates, we proceed in two complementary ways. First, we take advantage of the Global Financial Crisis in 2008-2010, which provided

a large, unexpected shock to firms' finances. This allows us to credibly analyse a period in which financing constraints played a role even for large, listed firms. To do so, we follow the literature (Duval, Hong and Timmer, 2020[68]) and focus on debt maturity defined as the ratio of short-term debt to long-term debt: firms are considered to be more exposed to the financial shock (exposed = 1) if during the pre-crisis period 2005-2006 the average short-to long-term debt ratio was in the highest quartile (defined at the NACE2 Rev.2 level), because these firms could not roll over their debt or only at high costs. We then keep this definition fixed throughout and follow the group of firms over time. Figure 5 shows the average investment profile for both groups and provides some first descriptive evidence that before the crisis the average investment followed a parallel trend – i.e., the parallel trend assumption holds. Yet, during the financial crisis firms with a shorter debt maturity respond more strongly. We formally test for this relationship:

$$1(green\ investment)_{icst} = \beta_0 + \beta_1 DebtMaturity_{ics} * PreGFC_t + \beta_2 DebtMaturity_{ics} * GFC_t + \beta_3 DebtMaturity_{ics} * PostGFC_t + \gamma X_{ics,t-1} + \theta_{sct} + \varepsilon_{it} \quad (2)$$

33. where notation is consistent with Equation 1, $DebtMaturity$ stands for an indicator variable for the ratio of short-term debt over long-term debt at the outset of the GFC and $PreGFC$, GFC, $PostFC$ are period dummies covering respectively the 2006-2007, 2008-2009 and 2010-2011 periods. If financing frictions impact green investment, we expect the β_2 coefficient to be statistically significant and negative, indicating that more exposed firms reduced investment when the shock hit, and the coefficients β_1 and β_3 to be non-significant.

Figure 5. Average green investment propensity for firms that are exposed and firms less exposed to a credit supply shock during the Global Financial Crisis



Source: OECD calculations based on Refinitiv ESG data matched to Orbis 2004-2020.

34. Next, the second strategy to address endogeneity concerns consists in adopting an approach similar in spirit to Rajan and Zingales (1998[69]). We use either the lending interest rate or central bank's policy rate to proxy for the easiness and tightness of financing conditions at the country-year level and exploit firms' relative exposure to financial conditions to identify the link between finance and green investment at the firm level. This framework is effective if the following two assumptions are met: i) a subset of firms is more affected than other firms by the level of and changes in the lending or policy interest rate; and ii) the green investment decisions of a single firm are not impacting neither the average lending rate nor the setting of the policy rate. Concerning the former condition, we assume that financially constrained

firms' investment decisions are ex-ante more influenced by lending or policy rates, as their limited ability to obtain external financing is more impacted by aggregate financing conditions – i.e., if lending standard tightens, banks tend to disproportionately allocate funds towards safer financially healthy firms. The second hypothesis also appears reasonable, as the consequences of the green investment decisions of a unique firm are plausibly not large enough to influence macro financing conditions or aggregate prices and other central bank objectives (e.g., employment) to an extent that requires a change in the monetary policy stance.

35. Analytically, we estimate the following equation:

$$1(green\ investment)_{icst} = \beta_0 + \beta_1 FC_{ics} * Rate_{ct} + \gamma X_{ics,t-1} + \theta_{sct} + \delta_i + \varepsilon_{it} \quad (3)$$

where notations is again consistent with Equation 1. FC_{ics} stands for a binary variable capturing firms financing conditions (i.e., constrained or not) either at the beginning of the sample or on average during the sample period according to the measures described in Section 3.1. The inclusion of firm fixed effects (δ_i) controls for time invariant firm characteristics, hence allowing to estimate a purely differential effect of the lending or policy rate ($Rate_{ct}$) across different types of firms. The coefficient of interest is β_1, which we expect to be negative if tighter financing conditions (i.e., higher rates) slow down green investment.

Reducing endogeneity concerns about green management

36. Also in case of management practices, reverse causality is a concern. First, because firms that are investing in green technologies are more likely to adopt environmental management practices and hire staff with more environmental knowledge and awareness. This would lead to an upward bias in our estimates. On the contrary, some environmental practices can be used as an alternative to green investment for firms that are under pressure from consumers or stakeholders to become greener, introducing a downward bias in our estimates.

37. To deal with this concern, we follow De Haas et al. (2022[26]) and construct a leave-out, jackknife-style instrument where the management quality of other firms in the same country in different sectors is used as an instrument for a firm's own managerial quality. The authors argue that the quality of management depends on information about good management practices, and that this information flows from some firms to others. Because the instrument varies only at the country-year level, the instrumental variables estimates include sector-year and country-sector fixed effects.

3.3. Main findings

Financing constraints

38. Column (1) of Table 1 reports the main results for regression model (1) and shows that being financially constrained reduces the likelihood that a firm carries out green investment by 2.5 percentage points. This corresponds to an increase in the probability to invest of around 8%. These effects are comparable for different measures of financial constraints and statistically significant at least at the 5% level (Table C.1 and Figure C.1 in Annex C).[14] [15]

[14] The dataset does not allow us to reliably compare the sensitivity to financing constraints of green investment with the one of total investment. However, the country-specific case study in Section 4 provides such evidence.

[15] It is worth noticing that these findings are not at odds, but rather complementary, with the recent literature showing that greener firms tend to face lower financing costs, as they face lower transition risks compared to their browner competitors (D'Arcangelo et al. (2023[67])and Degryse et al. (2023[131]). Indeed, we focus on financial barriers

39. In addition to the discrete investment variable, we also report the results when focusing on the green investment amounts as dependent variable in Table A.5, confirming a negative relationship.[16] Column 2 presents the results when estimating a maximum likelihood specification. While the coefficients are not directly comparable, we also see a negative significant effect of financing constraints on the probability of green investment. We further show in the appendix that the main effects are robust to alternative thresholds to define firms as financially constraints as well as modelling and data choices (Tables C.2 to C.4).[17]

Table 1. Financially constrained firms invest less in green technologies

Marginal estimated impact of being financially constrained on green investment

Dependent variable	Green investment	
	(1)	(2)
Estimation by	OLS	Logit
Lagged Financial Constraints	**-0.025****	**-0.137***
	(-2.1)	**(-1.6)**
Observations	22,961	24,648
R-squared	0.465	Yes
Controls	Yes	Yes
Ctry-Yr + Sect-Yr FEs	Subsumed	Yes
Ctry-Sect-Yr FEs	Yes	No

Note: Dependent variable: indicator variable for green investment. Estimation results for equation (1) as a linear probability model with OLS (column 1) and as a maximum likelihood specification, logit (Column 2). Financial constraints are defined as firms within the highest quartile of the SAFE indicator at NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020.

40. To reduce concerns with respect to endogeneity issues, we exploit the Global Financial Crisis (GFC). As described in the empirical strategy in Section 3.2, we take advantage of the debt ratio during the pre-crisis period to define the exposure of firms during the financial crisis and follow it over time. Comparing investment of firms exposed to the shock and firms less exposed provides additional evidence that green investment is affected by financing frictions. Figure 6 below plots the main coefficients (annual, panel A, and by periods, Panel B) when limiting the estimation sample to the years 2006 to 2011. To obtain these coefficients we interact the exposure measure (as firms within the highest quartile of short-term to long-term debt at NACE2 rev.2 - year in the base-period 2005-2006) with time dummies and do not omit

preventing firms to invest in green technologies, hence comparing firms on the basis of their financial status rather than "green vs brown" status.

[16] These estimates have to be, however, treated with caution, as many firms that report making investments do not report the investment amount or only report zeros, which might lead to biased OLS estimates if selection is non-random. We therefore treat this rather as additional evidence that financing constraints can impact both the intensive and extensive margin of green investment.

[17] More specifically, our findings are robust to using terciles rather than quartiles of the financing constraints indicators distribution to define firms' financial status, to changes in the set of firm-level control variables, as well as to the use of a different fixed effects structure. Moreover, results are consistent when excluding 2020 from the analysis due to the COVID pandemic and / each of the six mostly represented countries in the sample, but the US, which accounts for roughly 44% of the total sample.

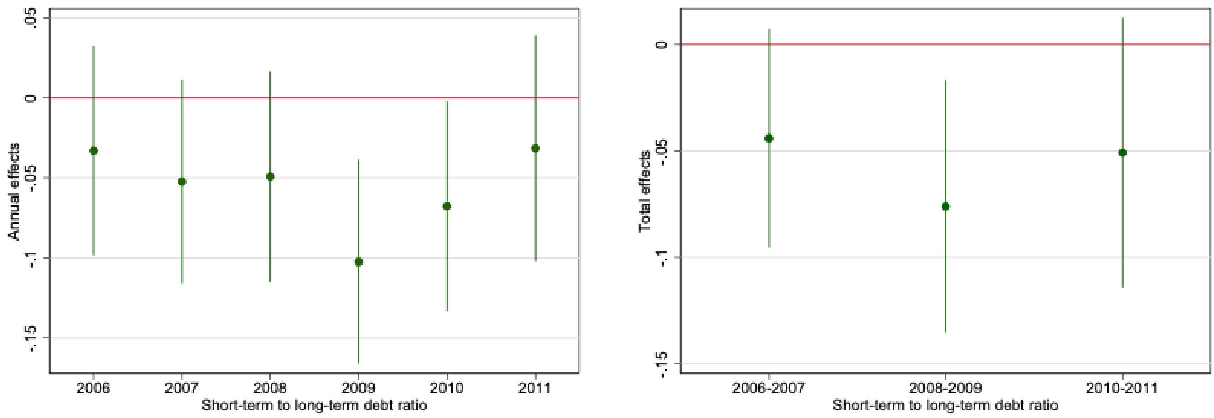
any base category, so the coefficients can be interpreted as the total difference between firms more and less affected by the GFC in terms of financial constraints.

41. We find that the group of firms with a high short-term debt ratio on average invest less than firms with a lower debt ratio, but that this difference has not been statistically different before the crisis period. In 2009, we find a large drop of approximately 5% in green investment propensity for the constraint group, coinciding with the main effects of the GFC. This effect was reduced in 2010 and in 2011 we no longer detect statistically significant differences between the two groups from 2011 onwards. These findings are in line with the idea that the GFC had a short-term impact on green investment. However, our findings also indicate that this impact was short-lived and did not impact green investment in the long run.

Figure 6. GFC and investment propensity

Panel A: Annual effects

Panel B: Period effects



Note: Main estimation results for equation (2) with debt-ratio as proxy for financial constraint. We interact the main coefficient with annual (period) dummies. Full regression results in Table C.6.
Source: OECD calculations based on ESG data matched to Orbis. Main sample: 2006-2011

42. Finally, the findings from the analysis a la Rajan and Zingales (1998[69]), presented in Table 2, confirm that finance matters for green investment. A higher lending interest rate, which is expected to tighten credit conditions, is estimated to reduce relatively more the propensity to invest in green of financially constrained firms, which are identified using the SAFE composite index, either evaluated at the beginning of the period or on average over the sample period (specifications 1 and 2).[18] Consistently, though significant only when evaluating financing constraints at the beginning of the sample, we find that a sharp reduction in the lending rate – i.e. an easing of financing conditions -- spurs the propensity to invest of constrained firms relatively more (specifications 3 and 4).[19] Results are qualitatively and quantitatively unchanged when using the policy rate in place of the lending rate (Table C.7).

[18] More specifically, firms' constraints and thus exposure to monetary policy is captured with a dummy variable taking value 1 if a firm belongs to the top quartile of the SAFE index distribution and zero otherwise. Results are consistent to the use of different thresholds to define firms as financially constrained (e.g. terciles rather than quartiles and/or a different reference group) as well as to the use of alternative measure of financial constraints.

[19] A sharp change in the lending interest rate is defined as a yearly variation larger than a one percentage point.

Table 2. Financing constraints reduce investment propensity, alternative approach

Dependent variable: Dummy for green investment				
	(1)	(2)	(3)	(4)
Exposure Firm Level Var	SAFE index			
Type of Exposure	Initial	Average	Initial	Average
Macro Financial Conditions Proxy	Lending interest rate			
Type of Macro Financial Variable	Lagged Level		Lagged sharp rate reduction	
Firm Exposure * Macro Fin. Conditions	**-0.014****	**-0.015***	**0.034***	**0.022**
	(-2.0)	**(-1.7)**	**(1.8)**	**(0.9)**
Observations	17,955	19,411	17,955	19,411
R-squared	0.791	0.789	0.791	0.789
Controls	YES	YES	YES	YES
Country by Sector by Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

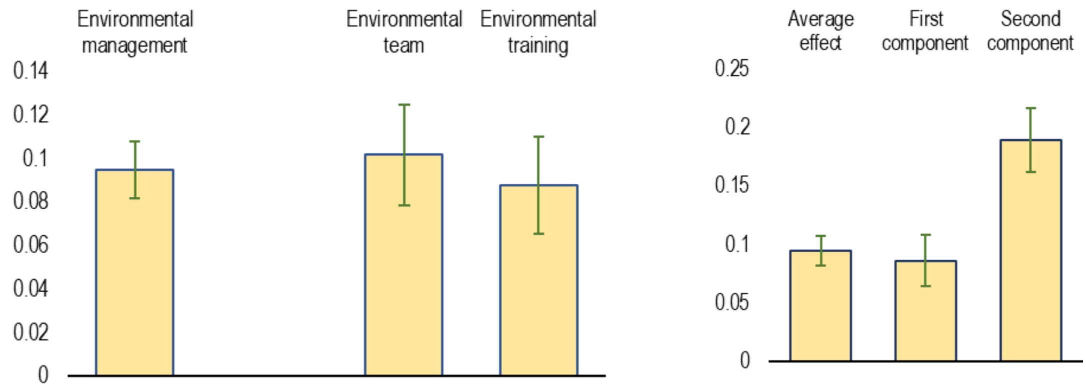
Note: Main estimation results for equation (3). Financially constrained firms (i.e. those more exposed to monetary policy) are those belonging to the top quartile of the SAFE index distribution either at the beginning of the period (models 1 and 3) or those being on average more in the higher quartiles of the distribution during the sample period (models 2 and 4). A sharp change in the policy rate is defined as a yearly variation larger than a one percentage point. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

Green management practices

43. Figure 7 Panel A presents the main results when estimating the effect of green management practices on the probability to invest. The three measures of green management are positively related with a firm's probability of making green investments. Specifically, focusing on our combined measure of environmental management (column 1), firms adopting green management practices have a 9.5 percentage points higher probability of investing in green technologies than other firms. Both components of environmental management have a similar positive significant impact on investment. The marginal effect of these forms of management practices seems to be constant in the number of practices: having two forms of management practices increases the probability of investing relative to not having any by around double the amount that having one form of practice does (Figure 7 Panel B).

Figure 7. Green management practices positively affect the probability of investment

Panel A: Environmental management and probability to invest   Panel B: Breakdown of effect



Note: Estimates from equation (1). The large yellow bars represent the estimated coefficients and the green whiskers the 90% confidence intervals. Panel A depicts the coefficients for environmental management variables reported in columns (1)-(2) of Table 3 and Panel B depicts the coefficients for environmental management variables in column (1) of Table 3 and column 5 of Table C.11 in Appendix C.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Table 3. Green management practices affect green investment decisions

Effect of measures of environmental management practices on green investment

	(1)	(2)	(3)	(4)	(5)
Management variable	OLS			Logit	IV
	Env. Man.	Disagg.	Environmental management		
Lagged env. management	**0.095*****		**0.095*****	**0.682*****	**0.222***
	(11.3)		**(11.3)**	**(11.7)**	**(1.8)**
Lagged environ. team		**0.102*****			
		(7.2)			
Lagged environ. training		**0.088*****			
		(6.4)			
Financing constraints			**-0.023***		
			(-1.8)		
Controls	Firm level, all	Firm level, all	Firm level, all	Firm level, all	Firm & ctry level
Macro controls	No	No	No	No	Yes
Observations	24,605	24,605	21,779	19,129	27,986
R-squared	0.470	0.470	0.476	-	-
Sect-Yr	Subsumed	Subsumed	Subsumed	Yes	Yes
Ctry-Yr	Subsumed	Subsumed	Subsumed	Yes	No
Ctry-Sec	Subsumed	Subsumed	Subsumed	No	Yes
Ct-Sec-Yr	Yes	Yes	Yes	No	No

Note: Dependent variable: indicator variable for green investment. Results from estimating Equation (1) where firm capacity is measured by the indicators of environmental management. The environmental management indicator is equal to 1 if a firm either provides environmental training or has an environmental team, to 2 if both are true, and to 0 if neither are true. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1. Financial constraints are defined as firms within the highest quartile of the SAFE indicator at NACE2 rev.2 – year.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

44. The result is robust to a range of specifications (Table 3). Namely, when including at the same time environmental management practices and financing constraints, the positive and significant effect of green management on green investment is maintained (column 2).[20] The result is also maintained when using a maximum likelihood specification (column 4).[21] Using our instrumental variable, the resulting estimate is positive and significant, showing that environmental management practices cause an increase in the probability of investing in green technologies (column 5). Finally, results are also robust to taking out the year 2020 and each of the six largest countries in the sample in turn (Table C.10), to including a different set of control variables, a less restrictive fixed effect structure, and can also be seen on the amount of green investment in US dollars (Table C.11 columns (1) and (2)).

The mediating role of environmental policy

45. To understand how environmental policy mediates the impact of financing conditions on green investment, Columns 1-4 of Table 4 interact the lagged financing constraint represented by the SAFE index with the Environmental Policy Stringency index and its sub-elements described in Section 3.1: market-based instruments, non-market instruments, and technological support.[22] [23]

46. We find that the negative effect of financing constraints on green investment are counteracted by market-based environmental policy, as can be seen by the positive and significant interaction effect in column 2. We find that market-based EPS reduces the negative effect of financing constraints until, for sufficiently large values of market-based EPS, the negative effect of financing constraints for green investment disappears (Figure 8). This could be explained by the fact that carbon pricing modifies the private rate of return of green investments, strongly incentivising firms and/or allowing firms obtain financing to invest in green technologies whatever their financial constraints.[24] Noteworthy, the mediating impact of market-based policy instruments is not mimicked by other types of environmental policy.[25] One explanation is that subsidies and regulations are not large or binding enough to cover initial upfront costs and/or firms lack the resources to advance the money for the investment. Another explanation relates to the strong path dependency on brown technologies which implies that subsidies need to be very large before being a game changer.

[20] The interaction of the two variables is however not significant, indicating that their effects could be independent from each other. A potential extension would be to check the extent to which financing conditions and green management practices could also affect each other. On the one hand, firms with green managers may have higher possibilities to obtain external funding for green investments. On the other hand, financially constrained firms have lower opportunities to hire green managers. Investigating these interactions is, however, beyond the scope of this paper.

[21] The model does not converge when including country-sector-year fixed effects, so when estimating a logit model we include only country-year and sector-year fixed effects.

[22] Given the aggregate nature of the environmental policy variables, the main policy effects are absorbed by our demanding fixed-effects structure, and as such we cannot estimate the effect of EPS on its own.

[23] The EPS indicator has a focus on policies to decrease greenhouse gas emissions and air pollution and does not cover other areas where firms may invest in as such water, biodiversity, or waste management.

[24] In other words, both demand and supply side effects could be at play. Unfortunately, the data infrastructure does not allow us to disentangle the two channels. Furthermore, the productivity consequences of regulation-driven investment in the presence of financing constraints are uncertain and left for future research.

[25] The finding that public subsidies do not mediate the impact of financing constraints on green investment is confirmed also when using a different dataset to proxy for public support, namely the IEA Energy Technology RD&D Budgets database, which collects central or federal government budgets, as well as the budgets of state-owned companies, for spending on a range of sectors including energy efficiency, renewables, nuclear power, fossil fuels, hydrogen and fuel cells, and others.

47. This effect for market-based regulation is confirmed when looking at energy prices in column 5, although less precisely estimated. As energy prices closely reflect carbon pricing policies, given the high degree of price pass-through, we confirm the findings from column 2 in the positive coefficient of column 5. The appendix shows similar tables for the financial leverage ratio and interest coverage ratio and confirms these findings (Table C.8).

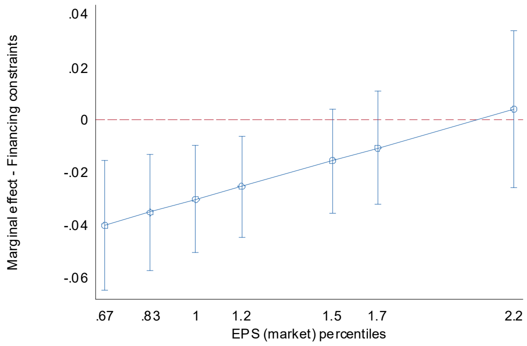
Table 4. Financial Constraints and Environmental Policy

	(1)	(2)	(3)	(4)	(5)
Financial constraints (FC)	SAFE Index				
Environmental policy (env)	EPS (lagged)				Energy Price (lagged)
	Total	Market	Non-Market	Tech. Sup.	
Lagged FC	**-0.038**	**-0.066*****	**-0.022**	**-0.011**	**-0.291+**
	(-0.9)	**(-2.7)**	**(-0.5)**	**(-0.5)**	**(-1.6)**
Lagged FC X Lagged env.	**0.005**	**0.033****	**-0.001**	**-0.007**	**0.045+**
	(0.3)	**(2.0)**	**(-0.1)**	**(-0.6)**	**(1.5)**
Observations	22,906	22,906	22,906	22,906	14,261
R-squared	0.463	0.464	0.463	0.463	0.417
Controls	Yes	Yes	Yes	Yes	Yes
Ctry-Sect-Yr Fes	Yes	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment. Financial constraints are defined as firms within the highest quartile of the SAFE index at NACE2 rev.2 - year. Environmental policies are proxied either by the EPS and its components or the sectoral indicator of energy prices. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

Figure 8. Financing constraints are less binding for investment at high market-based EPS levels

Marginal effect of financing constraints on green investment at different percentiles of the market EPS indicator



Note: Dots represent estimated marginal effects and vertical lines represent the 90% confidence intervals around them. Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Financial constraints are defined as firms within the highest quartile of the SAFE index at NACE2 rev.2 – year. Full regressions in Table 4.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

48. Environmental policy seems to have a complementary role with that of green management practices. Specifically, the positive effect of green management practices on green investment is larger

the more stringent environmental policy is (Figure 9, Panel A and column 1 Table 5). This overall effect is mainly driven by the technical, or subsidy, component of EPS. The larger this component, the larger the effect of environmental management practices on the probability of green investment (Figure 9, Panel B and column 4 Table 5). One explanation is that subsidies are likely to require knowledge of environmental technologies in order to be used effectively for investment. Finally, the positive effect of green management practices on environmental investment is not statistically significantly different by different levels of non-market-based and market-based EPS (columns 2 and 3 Table 5).

Table 5. Environmental management and EPS

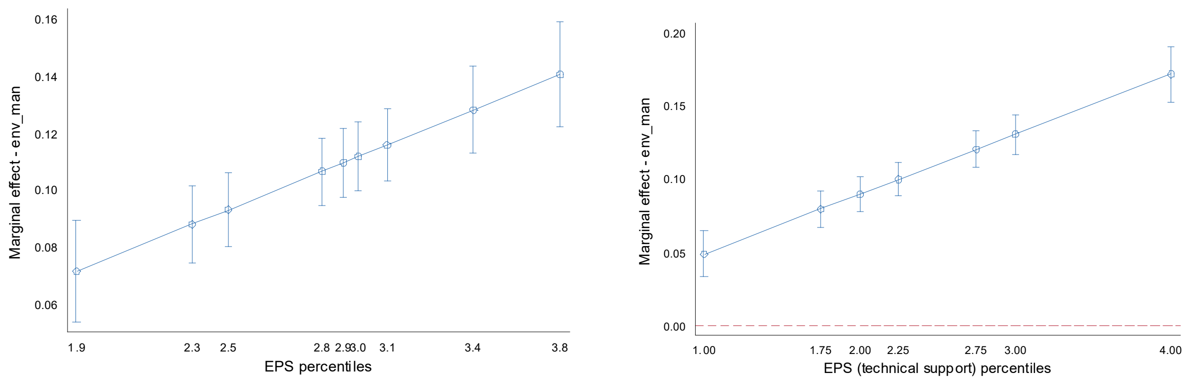
	(1)	(2)	(3)	(4)
Measure of policy	EPS (lagged)	Market EPS (lagged)	Non-market EPS (lagged)	Technical support EPS (lagged)
Envir. management	**0.004**	**0.098*****	**0.100*****	**0.009**
(lagged)	**(0.2)**	**(6.7)**	**(3.5)**	**(0.6)**
Envir. management	**0.034*****	**0.001**	**-0.000**	**0.039*****
(lagged) x EPS	**(3.4)**	**(0.1)**	**(-0.0)**	**(6.3)**
Observations	28,385	28,385	28,385	28,385
R-squared	0.465	0.465	0.465	0.468
Ct-Sec-Yr	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Environmental management is equal to 1 if firms have either an environmental team or provide environmental training to staff, two if both and zero if neither. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Figure 9. Environmental policy generally complements the effect of green management practices

Panel A: Marginal effect of environmental management by percentiles of total EPS

Panel B: Marginal effect of environmental management by percentiles of technical support EPS



Note: Dots represent estimated marginal effects and vertical lines represent the 90% confidence intervals around them. Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Environmental management is equal to 1 if firms have either an environmental team or environmental strategy, two if both and zero if neither. Full regressions in Table 5, columns (1) and (4).
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

Impact on Emissions

49. Finally, we are interested in how far our results of green investment carry over to environmental outcomes at the firm level, such as firm emissions. To do so, we run the main set of regressions, based on Equation (1), but substitute the dependent variable (indicator variable for green investment) with the firms' emission intensity defined as total CO_2 equivalent emissions normalised by revenues.[26] This is an important test as it allows us to confirm in how far differences in investment behaviour can impact firm level outcomes and can lead to aggregate emission impacts. Additionally, emission data is in principle an objective measure, while whether a firm is making investments that can be considered environmental has some degree of subjectivity due to a lack of standardisation and reporting controls.

50. Table 6 column (1) shows the main results for the financial constraints measure based on the SAFE indicator and confirms that financially constraint firms are more emission intensive than their non-constraint counterparts within the same country, sector and year and controlling for firms' characteristics[27]. This finding is in line with the previous results that showed that financially constraint firms invest less in green technologies, which might lead to higher emission intensities. The main point estimates for SAFE in column 1 are also economically important as they represent approximately 5.5% of the standard deviation of the emissions intensity measure. Finally, and consistently, column (2) shows that some environmental management practices, specifically providing environmental training, can also directly impact firms' emission intensity.[28] According to the point estimates reported, the effect of environmental training is similar in size to that of the financial constraint measure.

Table 6. Financially constrained firms have higher emission intensity

Baseline results: Impact of firm capacity on firms' emission intensity

	(1)	(2)
Firm capacity measure	SAFE Index	Environmental training
Lagged Financial Constraints	**0.115*****	**-0.091****
	(2.7)	**(-2.0)**
Observations	27,410	27,281
R-squared	0.446	0.442
Controls	Yes	Yes
Ctry-Sect-Yr FEs	Yes	Yes

Note: Dependent variable: Emission intensity defined as CO_2 equivalent emissions / firm revenues. Results from estimating Equation (1) $1(green\ investment)_{icst} = \beta_0 + \beta_1 Capacity_{ics,t-1} + \gamma X_{ics,t-1} + \theta_{sct} + \varepsilon_{it}$. Column (1): Financial constraints are defined as firms within the highest quartile of the SAFE indicator at NACE2 rev.2 - year. Column (2): Environmental training is equal to 1 if firms provided environmental training to staff. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

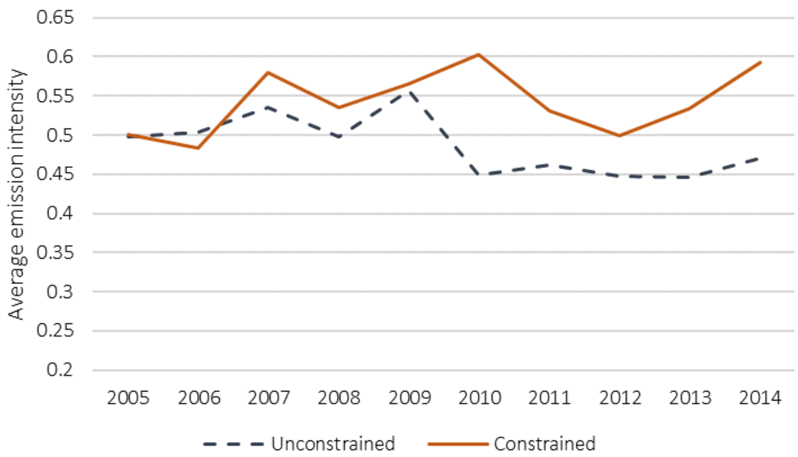
[26] CO_2 equivalent emission were chosen instead of for example scope 1 emissions because of the inclusion of different sectors in the analysis. As the revenue measure is not available for all firms and all years in the sample, we make use of Orbis to interpolate missing observations (see Annex B for details).

[27] These results are robust to other measures of financial constraints.

[28] The coefficient for the combined measure of environmental practices is positive but not statistically significant at conventional levels.

51. To get a better sense of how emission intensity is impacted over time, Figure 10 simulates the paths for emissions for the average firm when it is financially constrained compared to the case it is not financially constrained, focusing on the global financial crisis period.[29] As financing constraints during this period had a particularly strong impact on green investment, we similarly expect to find an effect on firms' emission intensity. Further, this effect might be lagged if green investment takes time to translate into emission reductions (e.g., time-to-build). Results confirm that while during the period leading up to the GFC, the emission intensity of constrained and unconstrained firms was very similar, the two diverge in 2010 and a gap remains for the following years. Calculating the average emission intensity for constrained and unconstrained firms over the period 2005 to 2014 shows that constrained firms had on average a 11.5% higher emission intensity, in line with the main coefficient in column 1 in Table 6.

Figure 10. Average emission intensity for financially constrained and unconstrained firms over time



Note: Figure plots the annual average emissions intensity (defined as total CO_2 equivalent emissions over revenues) of firms that have not been financially constraint following the SAFE index definition. To obtain the counterfactual for constraint firms, we rely on the regression coefficients in which we regress emission intensity on our measure of financial constraint interacted with time dummies. Full regressions in Table C.9.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

52. In conclusion, our results suggest that, at the firm level, improving firm capacity contributes decisively to increasing green investment and reducing emissions per output produced, in line with the recent literature (Acceturro et al., (2022[21]); De Haas et al., (2023[11]); Ng et al., (2023[9])). From an aggregate perspective, this contribution could be even larger than the sum of the firm-level effects if firms performing green investment also gain market share relative to non-green-investing and plausibly more polluting companies. In other words, if firms becoming greener thanks to investment are growing faster than others, improving firm capacity could have an even larger effect to facilitate the achievement of the ambitious carbon neutrality targets that most countries have set. Box 3 provides some preliminary evidence on the potential relevance of these between-firm effects.

[29] Figure 10 is based on the coefficients reported in Table C.9 where we interact the SAFE indicator with time dummies, focusing on the period around the GFC (2005-2014).

Box 3. Green investment, financing conditions and labour reallocation: are there relevant between-firm effects?

To investigate whether firms performing green investment tend to attract more labour and grow faster compared to their counterparts and whether financing conditions are altering the relationship between green investment and growth, we adapt the standard models of dynamic allocative efficiency – see for instance Adalet McGowan et al. (2017[70]) for an empirical application – and estimate the following equation:

$$\Delta Empl_{icst} = \beta_0 + \beta_1 GreenInv_{ics,t-1} + [\beta_2(GreenInv_{ics,t-1} * FinConditions_{c,t-1})] + \gamma X_{it-1} + \theta_{sct} + \varepsilon_{it} \quad (4)$$

where notation is consistent with previous equations and $\Delta Empl$ stands for employment growth, computed as the yearly difference in log employment. *GreenInv* is a lagged dummy variable taking value 1 if the firm invested in green and zero otherwise, while *FinConditions* captures lagged aggregate financing conditions, proxied again by either the lending interest rate or the policy rate set by central banks. To control for potential catch-up effects – i.e., smaller firms displaying higher growth rates – the firm-level controls include the quintiles of the lagged number of employees, in addition to profitability, age and leverage. Country by sector by time fixed effects control for any shock occurring at the country-sector level. As before, the equation is estimated by OLS and standard errors are clustered at the firm level.

Table 7. Green investment spurs growth when financial conditions are eased

	Dependent Variable: Employment Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Conditionality	Unconditional		Financial conditions (LR Levels)		Financial conditions (Sharp LR decrease)	
Timing of green investment	1 Lag	Avg of 4 Lags	1 Lag	Avg of 4 Lags	1 Lag	Avg of 4 Lags
Green Investment	**0.003**	**0.001**	**0.021*****	**0.024*****	**0.003**	**0.000**
	(0.7)	**(0.3)**	**(3.1)**	**(3.0)**	**(0.7)**	**(0.1)**
Green Investment * Macro Fin. Conditions			**-0.004****	**-0.007*****	**0.042****	**0.050+**
			(-2.6)	**(-2.9)**	**(2.5)**	**(1.5)**
Observations	23,401	15,203	18,886	12,002	18,886	12,002
R-squared	0.242	0.268	0.221	0.253	0.221	0.253
Controls	YES	YES	YES	YES	YES	YES
Country by Sector by Year FE	YES	YES	YES	YES	YES	YES

Note: Main estimation results for equation (4). Control variables include the quintiles of the lagged number of employees, in addition to profitability, age and leverage. Macro financing conditions are proxied by the lending interest rate. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

[B3.1] Results are robust to the inclusion of total investment as an additional explanatory variable – firms investing more overall are found to grow faster, as expected. Further, they are consistent when using the policy rate, rather than the lending interest rate, to proxy for macro financial conditions (Table C.12).

53. Table 7 shows that firms performing green investment do not display a growth advantage (nor a disadvantage) with respect to their counterparts (specification 1). The potential advantage does not materialise even when adjusting the model to look at a longer time span for investment, that is by averaging the green investment during the previous 4 years (specification 2). However, specifications 3 and 4 show that when financing is easier due to cheaper borrowing conditions, green investing firms grow relatively larger than non-investing ones and this differential vanishes with the tightening of lending standards; in a similar vein, the growth benefits of green investment appears to materialise only following a substantial decrease in the cost of credit (specifications 5 and 6).[B3.1] Altogether, these findings suggest that green investment may not be per se growth enhancing and that easing financing frictions could be essential to allow greener firms making the complementary investments that are needed to prevail in the market.

4. Firm capacity and different types of investment: a Portuguese case study

4.1. A complementary approach

54. Our findings suggest that different measures of firm capacity, such as financing constraints and the quality of management, impact the uptake of green investment. Some important questions however remain unanswered, as a deeper understanding of the characteristics of these relationships and the conditions under which they are observed requires more disaggregated data, not currently available in a cross-country setting. One important issue is whether investment in green technologies by small and medium enterprises (SMEs) reacts differently to capacity constraints than that of the larger companies. An effective green transition will need to rely on investment across all firms and individuals. Another important question is whether the dynamics of green investment are different from those of other types of investment, and whether the type of green investment, whether of integrated technologies or end-of-line solutions, affects them.[30] An effective policy strategy for boosting green investment will depend on these answers.

55. In order to explore these issues, we rely on more granular information on green investment and firm capacity available for Portuguese firms. The focus was on Portuguese data since a very complete and large dataset was easily accessible and was made available in a short time frame that allowed for its inclusion in the analysis.[31] The data are described in detail in Annex C. Our empirical strategy follows closely that of Section 3.2 but where we augment equation (1) with an interaction term between firm capacity and firm size, or where we change the dependent variable.[32] Specifically, we use four main dependent variables: logged deflated investment in green technology, a dichotomous variable equal to one if a firm has made investment in green technologies, and logged deflated investment in two components: integrated technologies and end-of-line equipment. We further use investment in green technologies, as well as the two components, over total investment (GFCF) to measure how green investment behaves with respect to total investment. Finally, we offer some insights on the timing of environmental policy relative to the salience of natural disasters and its effectiveness (Box 4).

[30] Previous research has found that the determinants of green investment vary by the type of investment (Frondel, Horbach and Rennings, 2006[109]; Hammar and Löfgren, 2010[3]).

[31] We remain open to discussing access to similar data for other countries.

[32] We include sector-region-year fixed effects and cluster standard errors at the sector-year.

4.2. Main findings

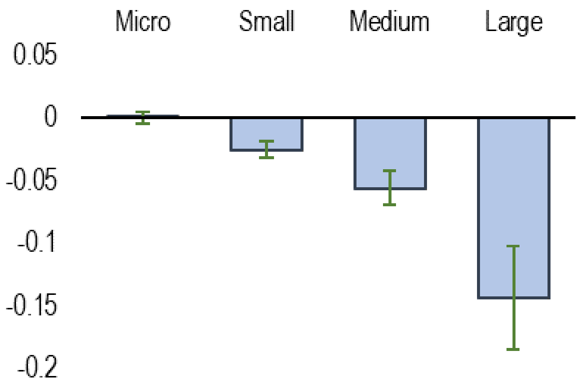
Heterogeneity across firms' size

56. Our results show that firm capacity as measured by their financing constraints and environmental management practices relate to firms' green investment differently depending on their size. Particularly, the estimated marginal effect of financing constraints on the probability to invest in green technologies is larger for larger firms (Figure 11, Panel A). Within large firms, financially constrained firms are 14 percentage points less likely to invest than their financially unconstrained counterparts, a value three times larger than that for medium firms. Firms' propensity to invest is also more highly related to the implementation of environmental management practices the larger a firm is (Figure 11, Panel B). Implementing one additional environmental management practice is associated to an increase in large firms' propensity to invest by 25 percentage points, around twice as much as the association for medium firms.

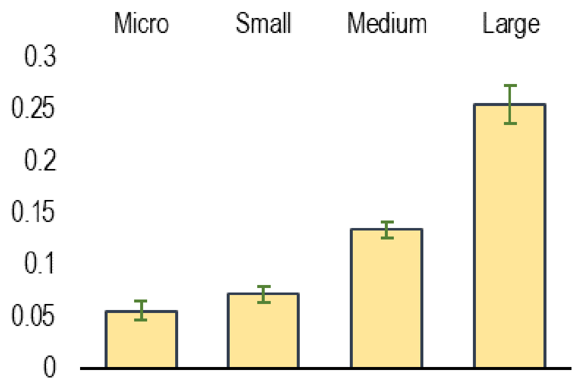
57. These findings are in line with Accetturo et al. (2022[21]), who show that the elasticity of green investments to credit supply is driven by more profitable, more liquid, more solvent, larger and older firms – that is, firms with more financial resources. An explanation could be that SMEs have overall less incentives to invest in green technologies, for instance due to the large upfront investment costs or less binding regulations, and thus their financial health matters less in determining their green investment decisions. As a result, if investment in green technologies is more elastic to financing constraints for large firms and large firms are the most likely to invest in green technologies, and invest the most (Figure D.1), then reducing financing constraints is likely to have a large impact for boosting green investment.

Figure 11. The effect of capacity on the probability to invest in green technologies varies with size

Panel A: Marginal effect of financing constraints on probability to invest



Panel B: Marginal effect of environmental management practices on probability to invest



Note: Size of firms defined by the number of employees: Micro: [1,10]; Small:]10, 50], Medium:]50,250], Large:]250, max]. In Panel A financing constraints are represented by the binary indicator based on interest coverage rates. Full description of variables and full table with results are available in Annex D (Table D.1).
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

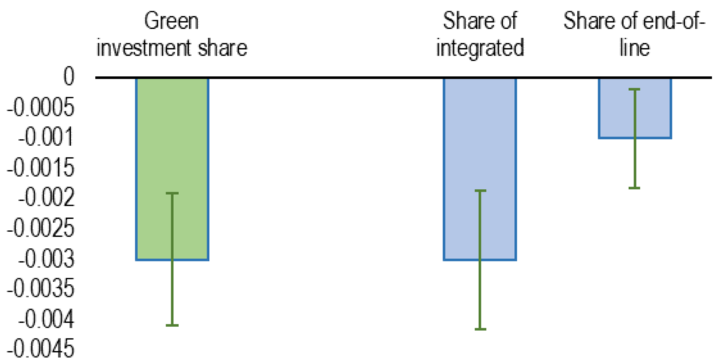
Heterogeneity across investment type

58. The analysis also shows that the negative impact of firms' financial constraints on green investment is larger than their effect on total investment (Figure 12 Panel A). This is true for all firms apart from micro firms; that is, the effect of being financially constrained on green investment as a share of total investment is negative for small, medium, and large firms (Figure 12 Panel B). These findings may be due

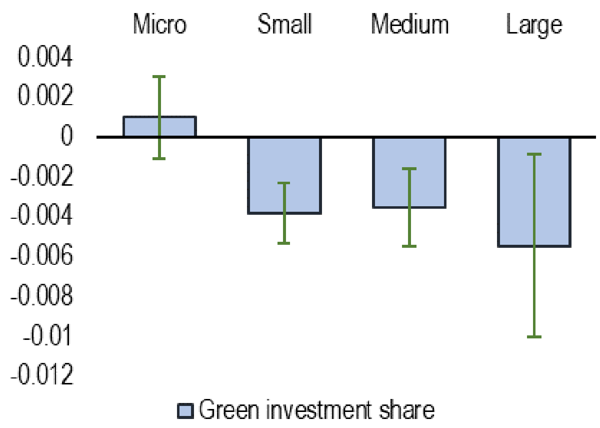
to the fact that green investment tends to be riskier and more uncertain, such that financially constrained firms may decide to postpone it.[33]

Figure 12. Green investment responds more to financing constraints than overall investment

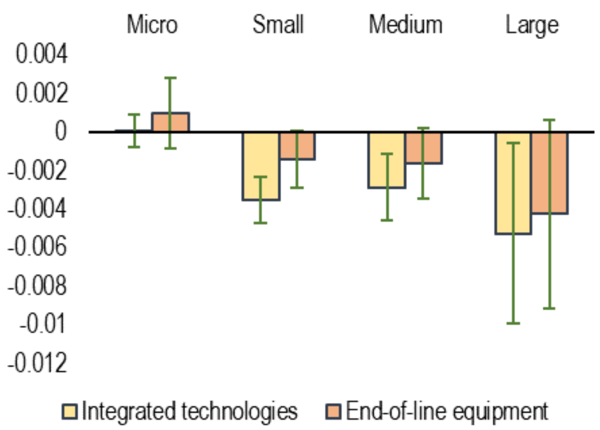
Panel A: Marginal effect of financing constraints on the share of green investment and components



Panel B: Marginal effect of financing constraints on the share of green investment



Panel C: Marginal effect of financing constraints on the share of green investment in integrated technologies and end-of-line equipment



Note: Columns represent estimated coefficients and the vertical lines the 90% confidence interval around them. Size of firms defined by the number of employees: Micro: [1,10]; Small:]10, 50], Medium:]50,250], Large:]250, max]. Financing constraints are represented by the binary indicator based on interest coverage rates. Dependent variable is green investment as a share of total investment (Panels A and B) and investment in integrated technologies and end-of-line equipment as a share of total investment (Panels A and C). Full description of variables and full table with results are available in Annex D (Tables D.2 and D.3).
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

59. Further, this is driven almost solely by the impact on investment in integrated technologies and this is true for firms of all sizes (Figure 12, Panels A and C).[34] Integrated technologies aim to reduce pollution production at the source by changing the production process, thereby increasing the efficiency of

[33] Please refer to Section 2 for more details on how green investment may be more reactive to financing constraints than other types of investment.

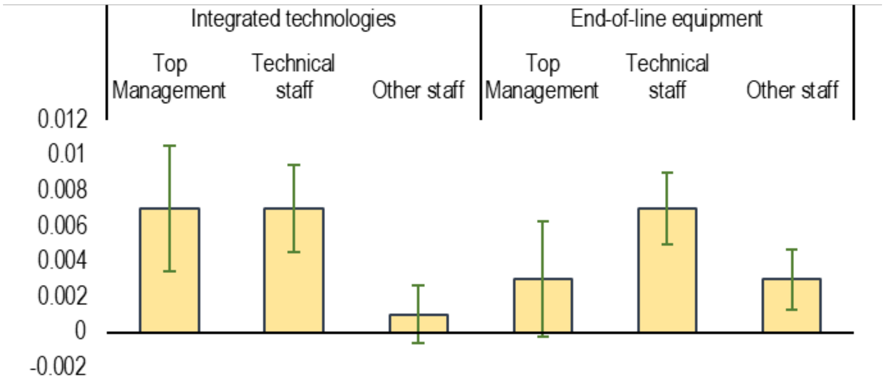
[34] End-of-line equipment is used to decrease emissions by implementing add-on measures, like pollution filters, that are largely independent of production decisions (Christin, Nicolaï and Pouyet, 2021[108]; Frondel, Horbach and Rennings, 2006[109]). Integrated technologies entail integrating cleaner or more energy-efficient methods directly into production processes.

input use (Hammar and Löfgren, 2010[3]). Compared to end-of-pipe solutions, they may respond more to financing constraints because they are less often performed just to comply with regulation and their costs are less easily measured (Porter and van der Linde, 1995[4]), and they involve often larger initial upfront costs.

60. Finally, environmental management practices also seem to be related to green investment differently than other investment, and within this, the two types of green investment seem to differ in the way they are related to green management. First, as expected, green investment is more related to the quality of green management than total investment, using both the indicator of environmental management practices and the number of green staff (positive coefficients in Table D.4, columns 1-3). Second, we find that while the number of green technical staff is positively related to both types of investment, green top management is significantly related only to investment in integrated technologies (Figure 13). This provides additional evidence that green investment requires specific green skills and that involvement of top, or upper, managers is likely key to achieve progress in the green transition (See Box 2).

Figure 13. Green top management matters most for integrated technology investment

Marginal effect of green staff on the share of green investment



Note: The dependent variables are in turn investment in integrated technologies as a share of total investment and investment in end-of-line equipment as a share of total investment. Staff numbers are increased with one and logged. Full description of variables and full table with results are available in Annex D (Table D.4 columns 4-5).
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

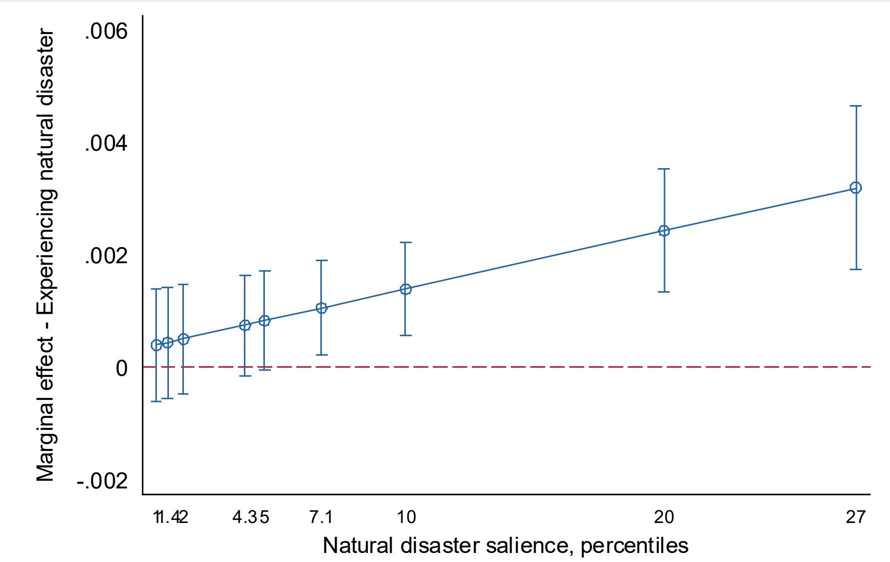
Box 4. Environmental awareness and effectiveness of environmental policy

Different factors may contribute to raise awareness of climate change threats and increase investment in environmental protection. In particular, previous research finds that the salience of climate change and concerns about physical risks posed by climate change can contribute to boost investment in low-carbon technologies and improve environmental disclosure (Smith, 2022[71]; Huang et al., 2022[72]; EIB, 2023[73]).

To understand how exposure to and salience of natural disasters can affect investment, and how this can interact with the effectiveness of environmental policy in promoting investment, we conduct an additional analysis for the case of Portugal. We use the number of climate-related large natural disasters (including heat waves, floods, droughts, and fires) experienced in the previous year in each region of Portugal to proxy for the exposure of firms in the same region to natural disasters. We use this along with a regional measure of the salience of these natural disasters across years. Specifically, we use Google Trends to measure the intensity of searches for the topics “flood”, “heat wave”, and “drought” in each region and year[B1]. We use this information to understand how firms in each region invest in green technologies differently depending on how much they experience natural disasters and how salient they are.

We find that being located on a region that experienced natural disasters is significantly associated with having a larger share of green investment out of total investment, conditional on natural disasters being sufficiently salient. The more salient natural disasters are, the stronger the association between experiencing natural disasters and investing in green technologies (Figure 14).

Figure 14. The association between experiencing natural disasters, their salience, and investment



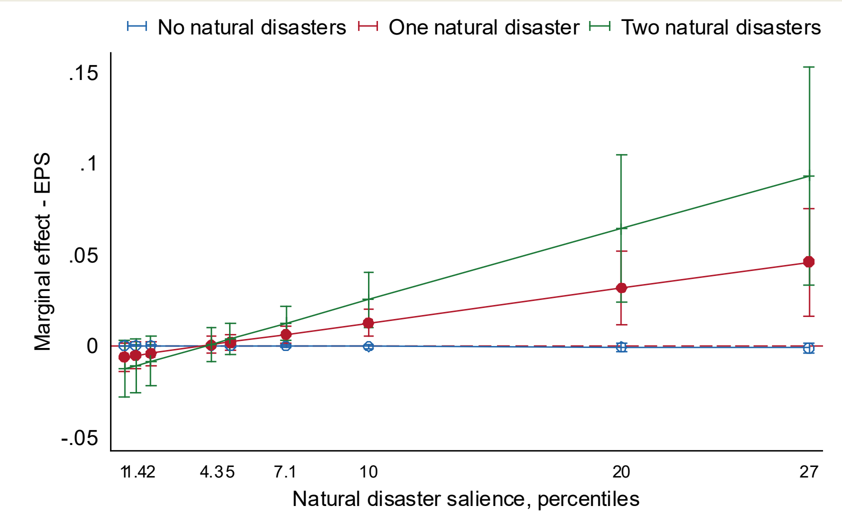
Note: The dots correspond to point estimates and the vertical bars are the 90% confidence interval. Estimations from equation $\text{GreenShare}_{irst} = \beta_0 + \beta_1 Occurrence_{r.t-1} + \beta_2 Salience_{r.t-1} + \beta_3 Occurrence_{r.t-1} x\ Salience_{r.t-1} + \gamma X_{ics.t-1} + \theta_{sr} + \rho_{st} + \varepsilon_{it}\ (B1)$ where Occurrence is the variable measuring the number of natural disasters and Salience the variable measuring their salience, and firm-level controls include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets.
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education

A natural question is whether the incentives provided by environmental policy are affected by the awareness created by the experience and salience of natural disasters, and in that case whether these factors are substitute or complementary to each other. In order to understand this, we augment our estimation with interactions of the variables measuring natural disasters and the EPS indicator, as well as a triple interaction (see Annex C for a description of EPS in Portugal).

We find that the association between environmental policy stringency and green investment as a share of total investment is stronger the larger the natural disaster salience and that this relationship depends on the occurrence of natural disasters in the region (Figure 15). Two non-exclusive explanations may explain this relationship. One is that managers in regions with higher awareness of climate change risks are more likely to have adequate knowledge about the available technology (De Haas et al., 2022[26]). The second one is when the risks of climate change are more salient, the acceptability of environmental policy increases, although the latter hypothesis has less empirical support (Dechezleprêtre et al., 2022[74]).

These results imply that environmental policy could have a larger impact on directing investment towards green technologies when awareness of the risks imposed by natural disasters is greater, as for example after periods of prolonged news coverage.

Figure 15. Environmental policy is more effective when firms experience natural disasters



Note: The dots correspond to point estimates and the vertical bars are the 90% confidence interval. Estimations from Equation B1 augmented by interactions with the Environmental Policy Stringency indicator with occurrence and salience, as well as a triple interaction. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets.
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education

[B1] Google Trends has been shown to be an adequate tool to measure the salience of a range of issues (Chykina and Crabtree, 2018[75]; Mellon, 2013[76]) and has been used in the context of natural disasters (Kam, Stowers and Kim, 2019[77]).

5. Policy discussion and concluding remarks

5.1. Deepening supply and demand of finance for green investment

61. Our findings provide evidence that policies easing access to finance are key to support the green transition. This is particularly the case for investment in integrated technologies, for which financing constraints were found to be even more relevant and which tend to provide larger co-benefits, particularly in terms of efficiency (Hammar and Löfgren, 2010[3]) and productivity (Porter and van der Linde, 1995[4]). The following policy discussion focuses on how to mobilise funding towards green investment, and especially so from the private sector, which is essential to progress towards the green transition (IEA, 2021[1]). The empirical analysis does not allow to investigate the different drivers of financing conditions at the firm level. Therefore, the policy discussion relies mainly on the literature to suggest a menu of policy options, both from the supply and demand sides.

62. On the supply side, easing access to finance can be achieved both through bank and/or capital market financing. De Haas and Popov (2023[11]) suggest that equity financing tends to channel investment towards carbon-efficient companies and facilitates the adoption of cleaner technologies in polluting industries, while credit markets tend to channel investment towards 'dirtier' sectors, increasing per capita pollution. At the same time, recent evidence shows that a positive bank lending supply shock lowers

emissions and spurs green investment (Levine et al., 2018[30]; De Haas et al., 2022[26]; Goetz, 2019[31]) (Campiglio, 2016[78]). Overall, bank and equity financing are likely complementary and policy makers could usefully harness both of them. While equity financing is particularly suited for green investment which carries a higher risk, banks still constitute an important source of finance for corporations and hence have a role to play in financing the green transition (Demmou and Franco, 2021[79]).

63. Barriers hindering the development and integration of capital markets more generally may also affecting the provision of equity financing for green investments. Therefore, policies aimed at deepening equity markets, spurring both the demand and supply of equity, could help mobilise risk capital to finance the green transition. Among the different policy options identified in the literature,[35] policy makers may especially consider to:

- Remove tax advantages (e.g., interest payments deductibility) provided to debt-over-equity financing, in order to increase the demand for equity finance, especially from SMEs.
- Simplify access to Initial Public Offerings (e.g., reduce costs and administrative burdens) and increase awareness of equity instruments through financial literacy to enlarge the market.
- Ensure that the structure of equity markets supports the provision of patient and engaged capital, in particular venture capital for green innovation and green infrastructure.
- Promote a Green European Capital Market Union, which requires continuing the ongoing efforts to enhance the comparability and standardisation of sustainable finance products as well as to enhance their verification and supervision.

64. Meanwhile, several complementary actions could be taken to adjust banks business model to the new needs triggered by green transition:

- Adopting best practices with respect to insolvency regimes could spur green lending by reassuring banks that green assets can be liquidated effectively in case of firms' insolvency. For instance, the recent harmonizing of insolvency regimes in the EU is going in the right direction (André and Demmou, 2022[80]).
- Launching a secondary market for brown assets (resulting from the securitization of banks exposures to carbon intensive activities) could also help (Fanizza and Cerami, 2023[81]) to mitigate the risks from elevated stranded assets and increase banks' available capital for green investment.
- Creating a secondary market for green investment is also critical to be able to redirect assets to different investors according to their risk profiles along the life cycle of the project. For instance, banks may have a higher risk tolerance at the initial stage of a green infrastructure project, but as time goes by, the removal of this risky assets from banks' balance sheets through secondary markets (e.g. to institutional investors) could allow to free resources for new projects (OECD, 2021[82]).

65. Access to transparent, harmonized and accurate reporting of firms' environmental performance could ensure that both banks and equity investors take informed investment decisions. To this aim, monitoring tools, especially ESG (Environmental, Social, and Governance) standards, and their improvement and reliability deserve a specific discussion. On the one hand, reporting has improved over the last decade: while only 20% of S&P500 companies published ESG reports in 2011, 96% did so in 2021; certain top ESG rating companies, like MSCI, are becoming more transparent about their methodology (Pons and Alphalex-Consult, 2021[83]; G&A, 2022[84]). On the other hand, ESG metrics are available only for listed companies and several important asset classes (e.g. private equity, real estate, infrastructure and sovereign bonds) are still not covered systematically, neglecting a wide range of activities and physical assets responsible for significant portions of GHG emissions (OECD, 2017[85]; Noels and Jachnik, 2022[86]). Furthermore, the methodology underlying ESG metric is also relatively new, and terminology is not yet

[35] See Demmou and Franco (2021[79]) for a detailed literature review.

standardized across countries or even across markets (Pons and Alphalex-Consult, 2021[83]; Noels and Jachnik, 2022[86]). In line with this, recent OECD work has shown that environmental scores often do not align with current carbon emissions exposures and that the lack of standardisation and reporting controls makes it difficult to assess risks (Boffo, Marshall and Patalano, 2020[87]), also leaving room for potential greenwashing practices.[36][37]

66. Governments and International Organisations could have an important role to play to push for standardizing existing methodologies and also for establishing specific metrics for SMEs.[38] The Task Force on Climate-related Financial Disclosures, involving 31 members countries (and including all G20 countries) is a promising initiative in this respect. Recently, the European Union has put in place a transparency framework, namely the EU Sustainable Finance Disclosure Regulation (SFDR), which aims to make the sustainability profile of funds more comparable and better understood by end-investors. Since January 2023, the regulation imposes and specifies the exact content, methodology and presentation of the information to be disclosed, thereby improving its quality and comparability (EC, 2022[88]). Several actions from central banks could also be taken to help private banks dealing with the challenges posed by the green transition (see Box 5).

67. Last, but not least, public sector funding can also be harnessed to help facilitate raising and directing private investment towards green technologies. The use of de-risking instruments may be particularly relevant to ease firms' access to finance, because green investments can be riskier than investment in older, more established technologies, while positive externalities associated to such investment may be ignored, leading the private sector to under-invest in low-carbon/mitigation technologies (see Section 2.1; (Avgousti et al., 2023[89])). Blending public and private sector finance can be used to transfer extra risk to the public sector and create a risk profile more acceptable to private investors. This can be achieved for example with first loss investment, co-financing, private-public partnerships (PPPs) or State guarantees (IMF, 2022[90]; OECD, 2021[82]). Green investment banks (GIB) can be particularly effective at raising private financing through the use of de-risking instruments and especially so in emerging economies. For instance, the UK GIB played a critical role in jump-starting the wind market and the New York GIB in promoting secondary market for loans refinancing (OECD, 2021[82]). In addition, more needs to be done to spread the use of de-risking instruments for riskier technologies as it is for now disproportionally used in already mature technologies (OECD, 2021[82]).

68. On the demand side, firms may face knowledge- and capacity-related challenges that limit their demand for sustainable finance. Coupling measures to increase the supply of finance for green investment with non-financial support could drive up demand, particularly from SMEs (OECD, 2022[91]).Specifically, access to private finance and government support schemes depends on adequate financial literacy and information, and this is particularly relevant for SMEs. For example, the German SME Initiative, Energy Transition and Climate Protection, provides companies with information about financial support for energy saving measures, and bringing companies together with experts (OECD, 2021[92]). Strengthening digital literacy and access to digital tools has also been shown to boost financial literacy and facilitate access to finance (OECD, 2021[93]).

[36] The European Commission recently proposed a regulation of ESG rating providers to increase transparency (European Commission, 2023[130])

[37] In fact, high E scores can positively correlate with high carbon emissions, suggesting that the E score may not be an effective tool to differentiate between companies with respect to their impact on the environment (Boffo, Marshall and Patalano, 2020[87])).

[38] Stock exchanges could also consider issuing guidelines for ESG disclosures designed in collaboration with companies, investors, and regulators while data providers should agree on best practices and become as transparent as possible about their methodologies and the reliability of their data (Kotsantonis and Serafeim, 2019[124]).

Box 5. Harnessing the role of macro-banking supervision policies for the green transition

Supervisory rules

Banking supervisors have a role to play to incentivise banks to properly manage climate risks (ECB, 2020[94]). The ECB is already gradually integrating climate and environmental risks into its regular supervisory methodology. An additional step would be to increasing the costs for banks of holding carbon-intensive assets in their portfolios, for example through haircuts or changes in supervisory requirements depending on if the investment is green or not (Aghion et al., 2022[95]).

Quality of information Disclosure

While banks in the European Union have improved information disclosures, the quality is still insufficient (ECB Banking Supervision, 2023[96])). To this point, a set of reporting standards on environmental, social and governance risks issued by the European Banking Authority (EBA) will apply to some of the most significant EU banks in 2023 and help banks comply with tighter EU regulation on disclosures of climate and environmental risks.

Portfolio rebalancing

Non-standard monetary policy can play a role for decarbonization, though this is not its prime objective. For instance, the ECB is currently applying a flow-based tilting approach, channeling investment in corporate bonds based on firms' climate score. However, this strategy may be less efficient in the future as the tightening of monetary policy means that net asset purchases are progressively phased out, calling for a switch towards a stock-based tilting approach (ECB, 2023[28]).[39]

International organisations with a lending activity are already moving in this direction. A virtuous example is the EBRD, which is fully aligning its own activities with the goals of the Paris Agreement. Since January 2023 the EBRD planned to screen all its financing and practices to ensure that they are on track to limit global warming to no more than 1.5C and that at least half its investment volumes could be classified as green by 2025 (EBRD, 2022[97]).

Importantly, to rebalance their portfolios, IOs and Central Banks rely to varying degree to ESG metrics, making all the more important the need to increase their standardisation and transparency discussed above (See section 6.1 above).

5.2. Promoting environmental knowledge and skills and monitoring environmental performance

69. Our findings show that green management practices are key, allowing companies to better harness green investment opportunities. The knowledge of available environmental technologies and capacity to evaluate their benefits and costs and to implement them at the firm level depends on the firm's environmental approach and available skills.

70. Providing environmental education could help promoting successful environmental management processes. Awareness training for staff and upper management is critical for firms to be able to comply with environmental standards and challenges (Perron, Côté and Duffy, 2006[56]). However, many firms, and especially SMEs, may have limited ability and resources to provide training. To this end, governments could use several instruments to reduce financial barriers resulting in a sub-optimal provision of training.

[39] In other words, this means that, absent any reinvestments, actively reshuffling the portfolio towards greener issuers would need to be considered.

The most commonly used tools are subsidies and tax incentives (e.g., a tax allowance for education or training expenditures, a tax credit against relevant spending), which could help reducing the direct costs of training. For instance, firms offering training to their workers will have lower social contributions to be paid in Spain, while they could obtain a compensation for training costs in Estonia; in a similar vein, the Italy and Japan developed mechanisms to reimburse (a portion of) wage expenses during training (OECD, (2019[98]); Demmou and Franco (2021[79])). Notably, the effectiveness of education and training programs may depend on the average age of employees, as older workers tend to uptake education and training programs less because of a shorter remaining professional life (OECD, 2017[85]). As such, environmental training in such cases may require more targeted approaches (Botta, 2017[99]). Finally, where these skills and practices are not available internally, access and resources for environmental consultancy become necessary.

71. Standards for management practices can also play a key role to promote best practices and provide incentives for taking energy efficiency measures, including by investing in low-carbon technologies. Energy management systems (EnMS) help firms establish energy objectives and processes to achieve those objectives. In particular, the International Organization for Standardization (ISO) provides important practical guidance for firms and specifies minimum requirements for implementing a formal energy management system. However, implementing the large variety of standards is challenging for companies,[40] suggesting that more needs to be done to integrate the different standards, to expand the coverage of such standardization tools, in particular by include further dimensions of sustainability (Mustapha, Manan and Alwi, 2017[100]). Energy audits have also been shown to help overcome informational barriers and lead to investment in energy efficiency (Kalantzis and Revoltella, 2019[101])).

5.3. Aligning environmental policy to boost firms' capacity to invest in green

72. The empirical analysis highlights how institutional settings, notably environmental policies, plays a relevant role in shaping the effects of improved firms' capacity on green investment. The finding that high carbon pricing mitigates the detrimental impacts of financing frictions on green investment is in line with the large body of research showing that carbon-pricing strategies are among the most efficient means of modifying investment behaviours and reducing carbon emissions (Stiglitz, 2019[19]; Acemoglu et al., 2012[18]; Nordhaus, 2019[102]).

73. There is a growing consensus among policy makers and economists (Stiglitz, 2019[19]; Pisani-Ferry and Mahfouz, 2023[103]; Schubert, Pommeret and Ricci, 2023[104]; Blanchard, Gollier and Tirole, 2022[105])that complementary policies to ambitious carbon pricing policy are needed to ensure an investment profile compatible with the net-zero objective by 2050. Our analysis contributes to the debate by showing that the success of environmental policies like carbon taxes or subsidies in promoting investment in green technologies and inputs will likely depend also on complementary policies aimed at decreasing firms' financing barriers and increasing firms' managerial capacity.

74. More research is needed to test the robustness of our results (e.g., expanding the availability of cross-country reliable data on green investment), their economic relevance and thus the extent to which complementary policies could foster the green transition and offset lower carbon pricing stringency than required. Furthermore, the analysis raises additional questions that are left for future research. First, we abstract from the direct effects of the macro determinants (e.g., EPS) of green investment. Second, the consequences of green investment for firm economic performance (e.g., productivity) have not been yet fully established from an empirical standpoint. Finally, it is likely that investments in low-carbon technologies to prevent further climate change will need to co-exist with investment in adaptation measures

[40] Management systems widely used by corporations include: Total Quality Management (TQM), ISO 9001:2008 management system, ISO 50001:2011 Management System, ISO 14001:2004 Management System and Eco-Management and Audit Scheme (EMAS).

to face climate change impacts occurring presently, such as increased heat stress or floods. Effective mitigation policy therefore needs to take into account constraints generated by exposure to climate change (e.g., changes in firm capacity) as well as complementarities with adaptation policies.

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Annex A. Descriptive statistics

Table A.1. Summary statistics

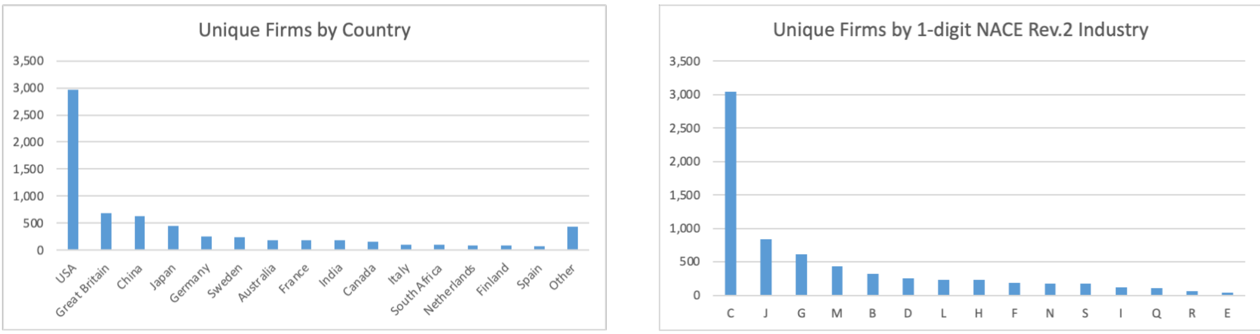
	Mean	Std. dev.	p10	p50	p90	Obs.	Firms
Age (1 if age > 10 years)	0.88	0.32	0.00	1.00	1.00	40,175	6,307
Lag ln(total assets)	22.06	1.65	19.93	22.10	24.18	42,211	6,610
Total employment [thousand]	25.29	68.01	0.47	7.52	58.80	43,205	6,776
Gross output (real) [million]	10,978	33,408	263	2,906	22,547	43,591	6,766
Financial debt (real) [million]	4,058	11,313	1.25	874	9,515	43,391	6,790
Lag SAFE index	-16.50	48.58	-28.32	-5.75	-3.42	35,645	5,766
Lag fin. leverage ratio	0.25	0.20	0.00	0.23	0.50	41,747	6,595
Lag interest cov. ratio	47.55	173.14	2.05	9.72	88.87	36,366	5,836
Lag debt ratio	1.67	14.12	0.00	0.10	1.10	36,885	5,994
1(FC): SAFE index	0.24	0.43	0.00	0.00	1.00	35,645	5,766
1(FC): interest cov. ratio	0.26	0.44	0.00	0.00	1.00	36,366	5,841
1(FC): fin. leverage ratio	0.24	0.43	0.00	0.00	1.00	41,747	6,612
ESG score combined	41.50	19.17	17.29	39.90	68.70	43,836	6,810
Total emissions CO2 equ. [million]	3.18	22.88	0.00	0.12	4.18	43,776	6,812
Environmental investment [million]	1,814.55	23,395.01	0.00	0.00	253	32,601	5,128
1(Env. investment)	0.31	0.46	0.00	0.00	1.00	34,870	5,168
1(Env. management team)	0.42	0.49	0.00	0.00	1.00	43,336	6,804
1(Env. management training)	0.46	0.50	0.00	0.00	1.00	43,389	6,804
1(Emission trading)	0.10	0.30	0.00	0.00	1.00	43,180	6,802
Ln energy price (weights 2005)	6.26	0.55	5.51	6.22	7.00	21,190	2,958
Lag EPS: total	2.78	0.73	1.78	2.92	3.75	43,653	6,765
Lag EPS: market	1.39	0.74	0.67	1.17	2.33	43,653	6,765
Lag EPS: non-market	4.83	1.07	3.00	5.25	5.75	43,653	6,765
Lag EPS: tech. support	2.38	1.14	1.00	2.00	4.00	43,653	6,765

Note: Final estimation sample 2004-2020.

Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Figure A.1. Firms by country and by sector

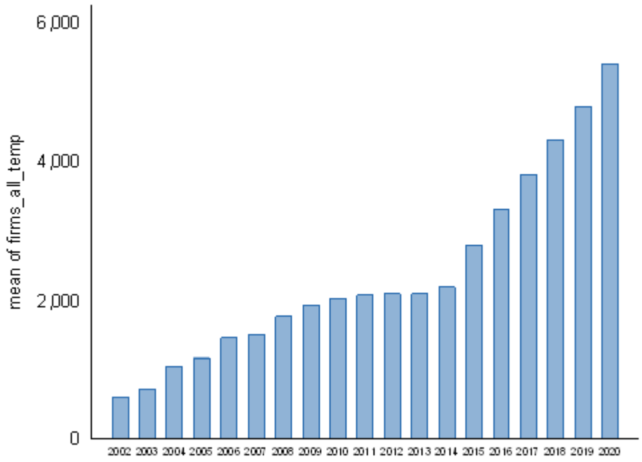
Data coverage: unique firms by country and by sector (Nace Rev. 2, 1-digit)



Source: OECD calculations based on data from Refinitiv.

Figure A.2. The number of firms in the sample is increasing over time

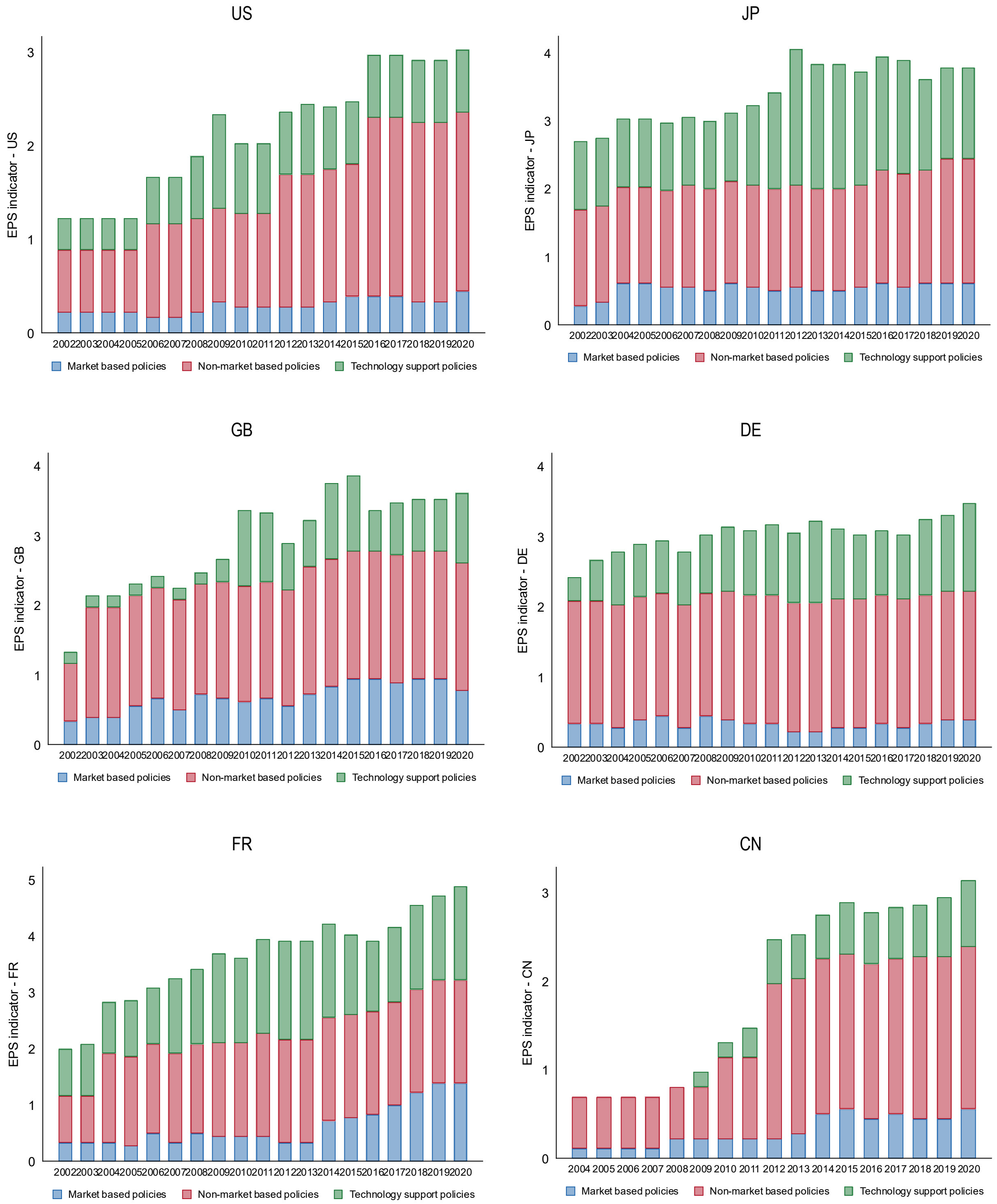
Number of firms in the sample by year



Source: OECD calculations based on data from Refinitiv.

Figure A.3. Environmental policy stringency varied differently across countries

Components of the EPS indicator across time in the six most represented countries in the sample



Source: OECD calculations based on data from OECD (OECD, n.d.[64]; Kruse et al., 2022[65]).

Annex B. Details on data

B.1. Firm-level financial information

Data cleaning

1. We keep only harmonised and consolidated accounts that refer to the entire calendar year, and we 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 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 PPPs, using as a reference 2005 US dollars. Finally, we winsorise all variables included in the regression analysis -- mainly at the 1st and 99th percentile separately for each sector, with few exceptions driven by the peculiar distribution of certain variables.

Composite indices

2. We calculate the SAFE index as follows:

$$\begin{aligned} SAFEindex = {} & -1.88 + (0.71 * FinLeverageRatio) + (-0.51 * ROA) \\ & + (-0.28 * InterestCoverageRatio) \\ & + (-1.20 * CashHoldings) \quad + (-0.21 * AssetsTangibility) \\ & + (-0.05 * LogTotAssets) \end{aligned} \tag{5}$$

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 are defined as in the previous paragraph. 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.

3. Next, we compute a similar index that, focuses on a smaller set of variables and uses different weighting coefficients for each variable:

$$\begin{aligned} SEBindex = {} & (-4.04 * ROA) + (-0.024 * InterestCoverageRatio) \\ & + (-1.716 * CashHoldings) + (-0.123 * LogTotAssets) \end{aligned} \tag{6}$$

where notation is consistent with the one of Equation 1.

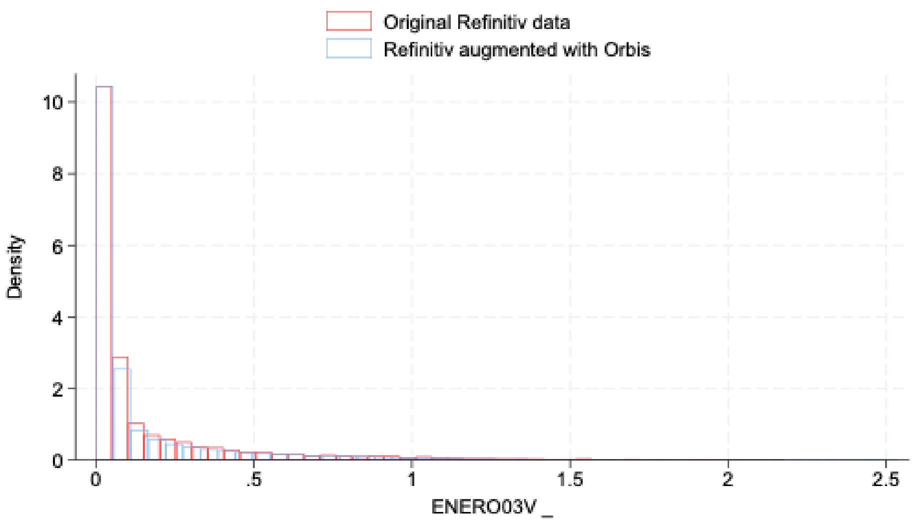
4. Finally, we also build an indicator in the spirit of Mulier et al. (2016[106]). The indicator summarises information from 4 variables: total assets, age, leverage ratio and cash flow to total assets. For each variable, the firm gets a score of 1 if it belongs to the bottom (total assets, age, cash flow to total assets) or top (leverage ratio) half of the distribution within each sector and zero otherwise. The sum of the scores delivers the final indicator.

B.2. Data on emission intensity

5. The Refinitiv dataset includes a variable that reports the emission intensity as "total CO_2 equivalent emission to revenues USD". Yet this variable is only reported for approximately half of the sample due to missing revenue information. To increase sample coverage, we use the variable on estimated total CO_2 equivalent emissions at the firm level and create a second measure of total revenues in USD, based on the information available in Refinitiv and Orbis. To do so, we first use the Refinitiv variables that allow us to recover revenues in USD (total CO_2 equivalent emissions, total energy use, total emissions scope 3) as both the revenues and the share of revenues are reported. We then use the average year-on-year growth rates in nominal revenues in the same sector as reported in Orbis to interpolate missing observations. In case a firm does not report revenues in any of the years in Refinitiv, we use the corresponding measure from Orbis. We use official exchange rates to convert local currencies to USD in case this is needed.

6. Figure B.1 provides a histogram for both the original data series (emission intensity) as well as the newly created data series. While the interpolation procedure relying on Orbis allows us to recover a large number of additional observations (42,306 vs. 22,070), the distribution of the two variables is almost identical. Similarly, we find a correlation coefficient between the two series of 0.98.

Figure B.1. Distribution of emission intensity measure



Note: The distribution is cut at the 95th percentile.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

B.3. Country-sector level energy prices data

7. Industrial sector-level energy prices are obtained from Sato et al. (2019[107]) from 1995-2015 and have been updated to cover also 2016-2020. 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. In order 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.[41]

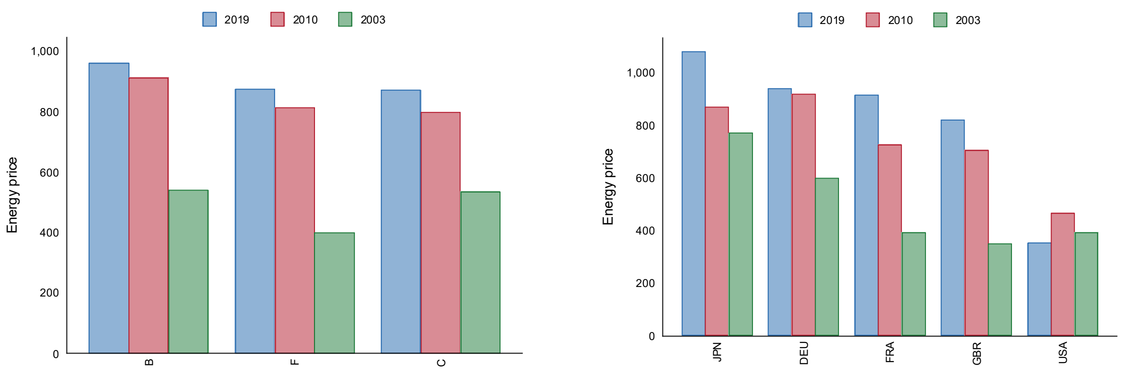
[41] We chose the year 2005 as a baseline as it was close to the beginning of the sample but had less missing information than the fuel mix of 2000. We also experiment with other base years without a change in results.

8. Each sector's consumption of fuel in each country and year is available from the IEA World Energy Balances. The prices of different fuels are retrieved from the IEA Energy End-Use Prices database. The final industrial energy prices include taxes but exclude VAT and recoverable taxes and levies and the indicator uses GDP deflators and exchange rate information to derive real prices in constant 2010 USD. The data cover only the manufacturing and construction sectors and only OECD countries in the sample. When using this information, our analysis is thus restricted to these sectors and covers 30 countries. Energy prices vary across sectors and countries in our sample (Figure B.2.).

Figure B.2. Energy prices differ across sectors and countries

Panel A: Energy price index in mining, construction, and manufacturing

Panel B: Energy price index in the five most-represented countries



Source: OECD calculations based on data from Sato et al. (2019[107]).

Annex C. Full results and robustness checks

C.1. Financing constraints

Table C.1. Financially constrained firms invest less in green technologies

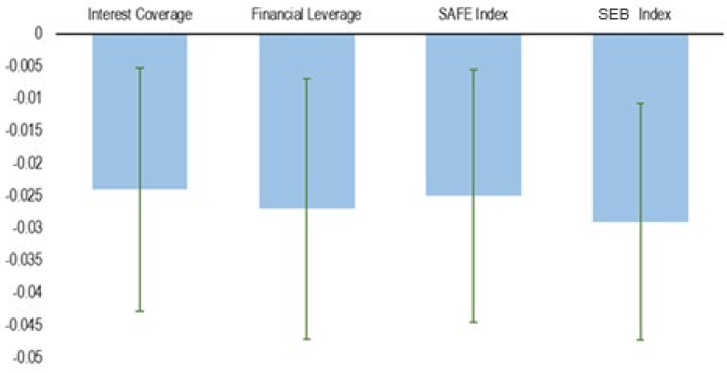
Baseline results: Impact of financing constraints on green investment

Dependent variable	Dummy for green investment			
	(1)	(2)	(3)	(4)
Financial constraints measure	Interest Coverage	Financial Leverage	SAFE Index	SEB Index
Lagged Financial Constraints	**-0.024****	**-0.027****	**-0.025****	**-0.029*****
	(-2.1)	**(-2.2)**	**(-2.1)**	**(-2.6)**
Observations	23,059	26,136	22,961	23,016
R-squared	0.465	0.458	0.465	0.465
Controls	Yes	Yes	Yes	Yes
Ctry-Sect-Yr FEs	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment. Financial constraints are defined as firms within the highest (lowest in case of interest coverage) quartile at NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Figure C.1. Financially constrained firms invest less in green technologies

Marginal estimated impact of being financially constrained on green investment



Note: Main estimation results for equation (1). Main point estimates and 90% confidence intervals. Standard errors are clustered at the firm level. Main regression Table can be found in Appendix, Table C.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020.

Table C.2. Logit model

Robustness results: Non-linear (logit) model

Dependent variable	**Dummy for green investment**			
	(1)	(2)	(3)	(4)
Financial constraints measure	Interest Coverage	Financial Leverage	SAFE Index	SEB Index
Lagged Financial Constraints	**-0.113**	**-0.255*****	**-0.137***	**0.008**
	(-1.4)	**(-3.1)**	**(-1.6)**	**(0.1)**
Observations	24,827	27,988	24,648	24,776
Controls	Yes	Yes	Yes	Yes
Ctry-Yr FEs	Yes	Yes	Yes	Yes
Sect-Yr FEs	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment. Financial constraints are defined as firms within the highest (lowest in case of interest coverage) quartile at NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, and sales growth. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Table C.3. Financial Constraints (SAFE index): taking out 2020 and each of the six largest countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample composition	no2020	noUS	noJP	noGBR	noDE	noFR	noCN
Lagged Financial Constraints	**-0.022*****	**-0.010**	**-0.025****	**-0.032****	**-0.027****	**-0.025****	**-0.023***
	(1.7)	**(-0.6)**	**(-2.0)**	**(-2.5)**	**(-2.2)**	**(-2.0)**	**(-1.9)**
Observations	20,186	12,429	18,915	20,191	21,996	22,139	22,441
R-squared	0.473	0.483	0.455	0.464	0.474	0.463	0.462
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ctry-Sect-Yr FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Financial constraints are defined as firms within the highest quartile of the SAFE Index at NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Table C.4. Main financial constraints variables and classification based on terciles rather than quartiles

Robustness results: Tercile definition

Dependent variable	Dummy for green investment			
	(1)	(2)	(3)	(4)
Financial constraints measure	Interest Coverage	Financial Leverage	SAFE Index	SEB Index
Lagged Financial Constraints	**-0.019***	**-0.017+**	**-0.018+**	**-0.032*****
	(-1.7)	**(-1.5)**	**(-1.6)**	**(-3.0)**
Controls	Yes	Yes	Yes	Yes
R-squared	0.465	0.457	0.465	0.466
Observations	23,059	26,136	22,961	23,016
Ctry-Sect-Yr FEs	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment. Financial constraints are defined as firms within the highest (lowest in case of interest coverage) tercile at NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Table C.5. Financially constrained firms display lower levels of green investment

Impact of Financing Constraints on Green Investment (quantities)

Dependent variable	Log of green investment (USD)			
	(1)	(2)	(3)	(4)
Financial constraints measure	Interest Coverage	Financial Leverage	SAFE Index	SEB Index
Lagged Financial Constraints	**-0.665*****	**-0.662*****	**-0.629*****	**-0.535*****
	(-3.4)	**(-3.1)**	**(-3.2)**	**(-2.9)**
Controls	Yes	Yes	Yes	Yes
R-squared	0.521	0.512	0.520	0.521
Observations	20,583	23,477	20,499	20,547
Ctry-Sect-Yr FEs	Yes	Yes	Yes	Yes

Note: Dependent variable: natural log (1 + total green investment amount in USD). Financial constraints are defined as firms within the highest (lowest in case of interest coverage) tercile at NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Table C.6. GFC and investment propensity

Dependent variable	Dummy for green investment			
	Annual		Periods	
	(1)	(2)	(3)	(4)
Financial constraints measure: Debt maturity 2005-2006	Beta	T-Statistic	Beta	T-Statistic
FC x 2006	**-0.033**	**-0.99**		
FC x 2007	**-0.052+**	**-1.62**		
FC x 2008	**-0.049+**	**-1.47**		
FC x 2009	**-0.102*****	**-3.16**		
FC x 2010	**-0.068****	**-2.03**		
FC x 2011	**-0.032**	**-0.88**		
FC x 2006-07			**-0.046***	**-1.7**
FC x 2008-09			**-0.076****	**-2.46**
FC x 2010-11			**-0.050+**	**-1.52**
Controls	Yes		Yes	
R-squared	0.502		0.502	
Observations	5,085		5,085	
Ctry-Sect-Yr FEs	Yes		Yes	

Note: Dependent variable: indicator variable for green investment. Financial constraints are defined as firms within the highest quartile of short-term to long-term debt at NACE2 rev.2 - year in the base-period 2005-2006. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2006-2011 period.

Table C.7. Financing constraints reduce investment propensity, alternative approach, robustness

Dependent variable: Dummy for green investment				
	(1)	(2)	(3)	(4)
Exposure Firm Level Var	SAFE index			
Type of Exposure	Initial	Average	Initial	Average
Macro Financial Conditions Proxy	Policy interest rate			
Type of Macro Financial Variable	Lagged Level		Lagged Sharp Change	
Firm Exposure * Macro Fin. Conditions	**-0.014****	**-0.015***	**0.031****	**0.015**
	(-2.2)	**(-1.8)**	**(2.4)**	**(1.0)**
Observations	22,129	24,168	22,113	24,153
R-squared	0.799	0.797	0.799	0.797
Controls	Yes	Yes	Yes	Yes
Country by Sector by Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

Note: Main estimation results for equation (3). Financially constrained firms (i.e. those more exposed to monetary policy) are those belonging to the top quartile of the SAFE index distribution either at the beginning of the period (columns 1 and 3) or those being on average more in the higher quartiles of the distribution during the sample period (columns 2 and 4). A sharp change in the policy rate is defined as a yearly variation larger than a one percentage point. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

Table C.8. Financial constraints and EPS, robustness

	(1)	(2)	(3)	(4)	(5)
Policy measure	EPS (lagged)	Market EPS (lagged)	Non-market EPS (lagged)	Technical support EPS (lagged)	Energy Price (lagged)
Panel A: Interest Coverage					
Financial Constraints	-0.042	-0.069***	-0.027	-0.008	-0.319*
(lagged)	(-1.0)	(-2.9)	(-0.6)	(-0.4)	(-1.8)
Financial Constraints	0.006	0.037**	0.000	-0.008	0.051*
(lagged) x EPS	(0.4)	(2.3)	(0.0)	(-0.7)	(1.8)
Observations	23,004	23,004	23,004	23,004	14,319
R-squared	0.463	0.463	0.463	0.463	0.417
Controls	Yes	Yes	Yes	Yes	Yes
Ct-Sec-Yr	Yes	Yes	Yes	Yes	Yes
Panel B: Financial Leverage					
Financial Constraints	-0.097**	-0.067***	-0.088**	-0.039	-0.293+
(lagged)	(-2.1)	(-2.9)	(-2.1)	(-1.4)	(-1.6)
Financial Constraints	0.026+	0.033**	0.013+	0.005	0.043+
(lagged) x EPS	(1.5)	(2.0)	(1.6)	(0.4)	(1.5)
Observations	26,081	26,081	26,081	26,081	16,127
R-squared	0.456	0.456	0.456	0.456	0.419
Controls	Yes	Yes	Yes	Yes	Yes
Ctry-Sect-Yr	Yes	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Financial constraints are defined as firms with the highest (lowest in case of interest coverage) quartile NACE2 rev.2 - year. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

Table C.9. GFC and emission intensity

Dependent variable	Emission intensity	
	Annual	
	(1)	(2)
Financial constraints measure: SAFE index	Beta	T-Statistic
FC x 2005	**0.004**	**0.02**
FC x 2006	**-0.039**	**-0.22**
FC x 2007	**0.084**	**0.52**
FC x 2008	**0.076**	**0.5**
FC x 2009	**0.016**	**0.17**
FC x 2010	**0.342****	**2.53**
FC x 2011	**0.149**	**1.35**
FC x 2012	**0.118**	**1.32**
FC x 2013	**0.197+**	**1.54**
FC x 2014	**0.260****	**2.05**
FC x 2015	**0.100**	**1.29**
FC x 2016	**0.113+**	**1.57**
FC x 2017	**0.162****	**2.12**
FC x 2018	**0.123***	**1.86**
FC x 2019	**0.092**	**1.36**
Controls	Yes	
R-squared	0.448	
Observations	23,401	
Ctry-Sect-Yr FEs	Yes	

Note: Dependent variable: Emission intensity defined as CO2 equivalent emissions / firm revenues. Financial constraints are defined as firms within the highest quartile of the SAFE index at NACE2 rev.2. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2005-2019 period.

C.2. Green management practices

Table C.10. Environmental management: taking out 2020 and each of the six largest countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	no2020	noUS	noJP	noGBR	noDE	noFR	noCN
Environmental management (lagged)	0.096***	0.112***	0.076***	0.103***	0.095***	0.094***	0.093***
	(10.8)	(9.4)	(8.6)	(11.2)	(11.2)	(11.2)	(10.8)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21,531	12,724	20,496	21,592	23,866	24,167	23,695
R-squared	0.479	0.488	0.459	0.471	0.466	0.467	0.478
Ct-Sec-Yr	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Environmental management is equal to 1 if firms have either an environmental team or environmental strategy, two if both and zero if neither. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

Table C.11. Environmental management and green investment: robustness

Dependent variable	Log of green investment (USD)		Dummy for green investment		
	(1)	(2)	(3)	(4)	(5)
Management variable	Environmental management	Disagg.	Environmental management		
Lagged env. management	1.410***		0.096***	0.106***	
	(9.6)		(11.5)	(14.6)	
Lagged environ. team		1.333***			
		(5.4)			
Lagged environ. training		1.485***			
		(6.4)			
Lagged env. man. = 1					0.087***
					(6.5)
Lagged env. man. = 2					0.190***
					(11.3)
Controls	All	All	Four	All	All
Observations	21,978	21,978	24,723	28,058	24,605
R-squared	0.525	0.525	0.465	0.368	0.470
Ct-Sec-Yr	Yes	Yes	Yes	No	Yes

Note: Dependent variable: indicator variable for green investment (dummy equal to 1 if the firm has reported to have made environmental investments or reported positive environmental expenditures). Environmental management is equal to 1 if firms have either an environmental team or environmental strategy, two if both and zero if neither. Control variables include lagged log of total assets, lagged return on assets, a categorical variable for firm age > 10 years, sales growth, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period.

C.3. Between-firm effects

Table C.12. Green investment spurs growth when financial conditions are eased, robustness

Robustness check using the policy rate to proxy financial conditions

Dependent Variable: Employment Growth				
	(1)	(2)	(3)	(4)
Conditionality	*Unconditional*		*Financial conditions*	
Timing of green investment	*1 Lag*	*Avg of 4 Lags*	*1 Lag*	*Avg of 4 Lags*
Green Investment	**0.003**	**0.001**	**0.010****	**0.010***
	(0.7)	**(0.3)**	**(2.1)**	**(1.8)**
Green Investment * Macro Fin. Conditions			**-0.005*****	**-0.008*****
			(-2.9)	**(-3.2)**
Observations	23,401	15,203	23,397	15,203
R-squared	0.242	0.268	0.243	0.269
Controls	YES	YES	YES	YES
Country by Sector by Year FE	YES	YES	YES	YES

Note: Main estimation results for equation (4). Control variables include the quintiles of the lagged number of employees, in addition to profitability, age and leverage. Macro financing conditions are proxied by the policy rate set by central banks. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on Refinitiv ESG data matched to Orbis Financials, 2004-2020 period, and OECD data.

Annex D. Details on Portuguese case study

D.1. Analysis and data

9. Our analysis of the determinants of firm green investment in Portugal requires merging two firm-level datasets, which are provided by the Portuguese Statistics Institute and the Ministry for Education and contain common firm-level identifiers that allow us to merge them. First, we use data from the enterprise system of integrated accounts covering firms' financial and economic results (SCIE). The SCIE contains annual data between 2004 and 2020 for a panel including all the firms in the country. Second, we use data from the enterprise survey on environmental management and protection covering firms' behaviour with respect to the environment (IEGPA). The IEGPA contains annual data between 2010 and 2020, available for a repeated cross-section of representative firms[42]. The final dataset thus contains information on average for around 4000 firms per year between 2010 and 2020.

10. Our main variables of interest include a binary variable equal to one if a firm indicates they have invested in green technologies,[43] a variable measuring the amount in euros a firm has invested in green technologies, and a variable measuring the share between that value and the total amount of firm investment, as measured by the firm's gross fixed capital formation. The amount of green investment is subdivided into investment integrated technology and investment in end-of-line equipment. All the monetary variables are deflated to 2005 prices using industry specific deflators.

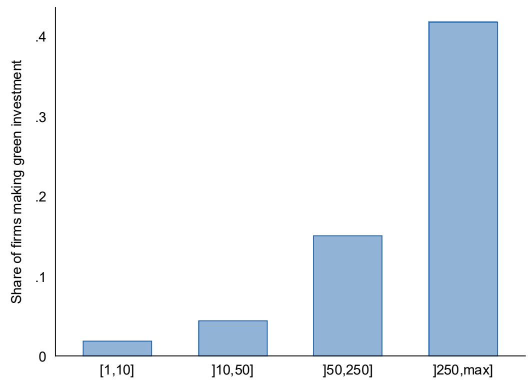
11. The data covers firms of different sizes between one and 5884 employees, allowing us to explore differences within SMEs and across SMEs and large firms. Large firms invest more often in green technologies (Figure D.1 Panel A) and they invest in larger quantities on average (Panel B). However, for SMEs, and in particular for micro firms (less than 10 employees), the share of green investment in total investment is higher than the share for large firms (Panel C). This is indicative of the importance of including also SMEs in the green transition.

[42] Firms with 100 or more workers or at least 50.000.000€ volume were all surveyed.

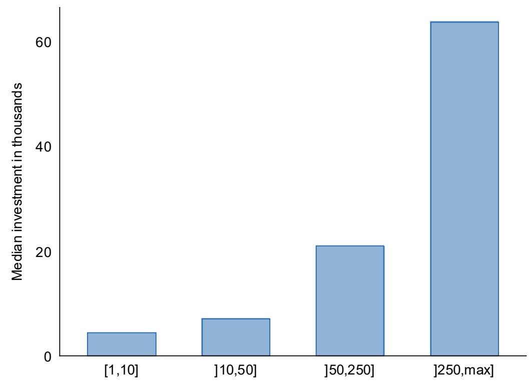
[43] Question: "During the year of reference, did you make investments in technologies and/or equipment with the purpose of reducing environmental impact?"

Figure D.1. Large firms invest more often and in larger quantities than SMEs

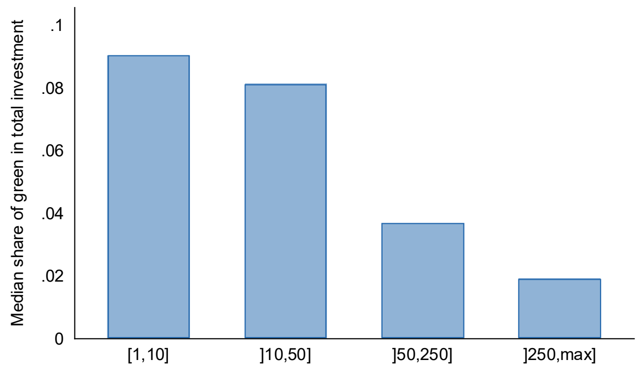
Panel A: Share of firms making green investments by size



Panel B: Median green investment by size for firms investing



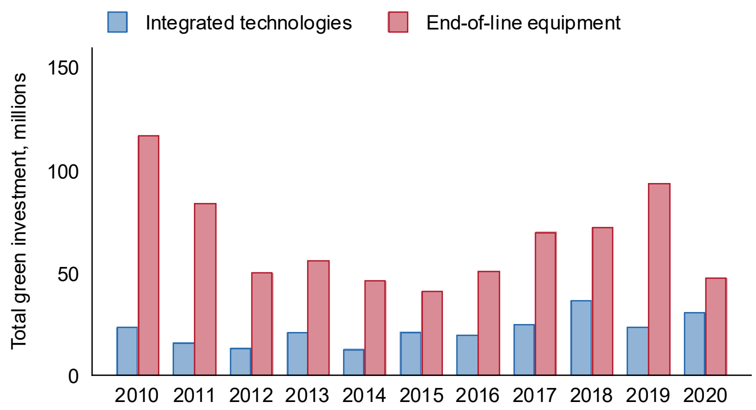
Panel C: Median share of green investment in total investment by firm size for firms investing in green technology



Note: Descriptives by firm size as defined by the number of employees: <=10, 10<x<=50, 50<x<=250, or >250 employees. Panels B and C are the median investment for firms making investment only.
Source: OECD calculations with data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

12. The amount of green investment varies markedly by type, with investment in end-of-line equipment being generally larger than investment in integrated technologies. End-of-line equipment aims to decrease emissions by implementing add-on measures, like pollution filters, that are largely independent of production decisions (Christin, Nicolaï and Pouyet, 2021[108]; Frondel, Horbach and Rennings, 2006[109]). Integrated technologies, on the other hand, entail integrating cleaner or more energy-efficient methods directly into production processes. While integrated technology investment is regarded as more economically and environmentally efficient, it is often underperformed with respect to end-of-line investment because of requiring additional organizational and financial capacity, and because of the incidence of some regulatory measures like standards (Frondel, Horbach and Rennings, 2006[109]). Investment in end-of-line equipment has been larger in Portugal for all of the period under study, but the difference has been decreasing over time (Figure D.2).

Figure D.2. Evolution of total green investment by type



Note: End-of-line equipment concerns treatment or filtration prior to discharging pollution into the environment, while integrated technologies change the process giving rise to pollution. Sum of green investment at constant 2005 prices.
Source: OECD calculations with data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

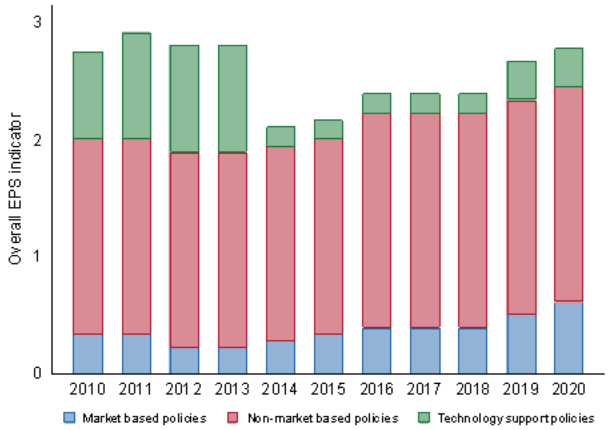
13. In order to measure firms' capacity to make green investment, we use four indicators to measure financing constraints, and two measures of adoption of green managerial practices. The indicators of financing constraints follow closely those of the main analysis, namely a dummy variable taking value 1 if a firm belongs to the top quartile of the financial leverage, SAFE index and SEB index distribution or to the bottom quartile of the interest coverage distribution and 0 otherwise[44]. Managerial quality is defined in turn as an indicator and as a continuous variable. The indicator is equal to 1 if the firm provided environmental training to its staff or if the firm adopted a strategy for the reduction of greenhouse gasses and to 2 if both. The continuous variable measures the number of people occupied either in full or partially with activities of control, reduction and prevention of pollution, and is further subdivided into top management (directors), technical staff, and other staff.

14. Finally, in order to measure the stringency of environmental policy at the country level we again use the Environmental Policy Stringency (EPS) indicator from the OECD (OECD, n.d.[64]; Kruse et al., 2022[65]). During the period of study, the EPS indicator decreased markedly in 2014 (Figure D.3). This was spurred by a marked reduction in technologies support policies, mostly driven by a reduction in feed-in-tariffs.[45] It was followed by a slow increase from then on towards the same level observed between 2010 and 2013, driven by increases in market-based policies in particular in the last years when the price of the European ETS increased to around 20-30 euros per ton of CO_2.

[44] For regressions estimating impacts by firm size, only the first and last indicators are used to allow us to have at least 15% of financially constrained firms within each size group (micro, small, medium, and large). Results by size using the other two indicators variables as a continuous indicator are qualitatively unchanged.

[45] As part of the bailout package, the Memorandum of Understanding (MoU) signed between Portugal, the International Monetary Fund (IMF), the European Union and European Central Bank (ECB) in 2011, committed the Portuguese Government to renegotiating contracts with a view lowering the feed-in tariff and similarly revising new contracts (European Comission, 2014[110]).

Figure D.3. Evolution of Environmental Policy Stringency in Portugal, 2010-2020



Source: OECD calculations based on OECD data (OECD, n.d.[64]; Kruse et al., 2022[65]).

D.2. Full results

Table D.1. The relationship between firm capacity and green investment by size

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Green investment (real log)	Integrated technologies (real log)	End-of-line equipment (real log)	Green investment 1-0	Green investment (real log)	Integrated technologies (real log)	End-of-line equipment (real log)	Green investment 1-0
Constraint	Financial constraints				Environmental management quality			
Capacity	0.002	0.010	0.016	0.000	0.466***	0.348***	0.199***	0.056***
	(0.1)	(0.4)	(0.7)	(0.1)	(9.4)	(7.8)	(5.8)	(10.4)
Capacity x	-0.252***	-0.171***	-0.175***	-0.025***	0.188***	0.069	0.209***	0.016**
small	(-5.3)	(-5.0)	(-4.7)	(-4.8)	(3.0)	(1.3)	(4.7)	(2.3)
Capacity x	-0.588***	-0.323***	-0.410***	-0.056***	0.893***	0.416***	0.834***	0.078***
medium	(-6.9)	(-5.6)	(-5.7)	(-6.4)	(13.3)	(7.6)	(15.5)	(11.1)
Capacity x	-1.647***	-0.720***	-1.393***	-0.143***	2.421***	1.004***	2.337***	0.198***
large	(-5.9)	(-3.7)	(-5.1)	(-5.6)	(18.0)	(9.9)	(19.0)	(16.1)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42,113	42,113	42,113	41,428	41,364	41,364	41,364	41,364
R-squared	0.217	0.110	0.210	0.192	0.281	0.149	0.263	0.256
R-S-Y	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y

Note: Financing constraints are measured by a dummy variable equal to 1 for the bottom quartile of the interest coverage distribution and 0 otherwise. Results using instead a variable equal to 1 if a firm belongs to the top quartile of the financial leverage are available upon request. Environmental management quality is measured by an indicator equal to 1 if the firm provided environmental training to its staff or if the firm adopted a strategy for the reduction of greenhouse gasses and to 2 if both and 0 if neither. All regressions include firm-level controls, namely lagged size (four bins depending on the number of employees being <=10, 10<x<=50, 50<x<=250, or >250), age (less or more than 10 years), revenues growth, lagged return on assets, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

Table D.2. The relationship of green investment relative to total investment and firm capacity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Green investment share	Share of integrated	Share of end-of-line	Green investment share	Share of integrated	Share of end-of-line
Constraint	Financial constraints			Environmental management		
Capacity	-0.003***	-0.003***	-0.001**	0.011***	0.009***	0.007***
	(-4.5)	(-4.3)	(-2.0)	(19.7)	(13.6)	(14.0)
Observations	33,811	31,925	33,040	33,436	31,549	32,665
R-squared	0.079	0.056	0.068	0.101	0.070	0.078
R-S-Y	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y

Note: The dependent variable is the amount of green investment over the amount of total investment. Financing constraints are measured by a dummy variable equal to 1 for the bottom quartile of the interest coverage distribution and 0 otherwise. Results using instead a variable equal to 1 if a firm belongs to the top quartile of the financial leverage are available upon request. Environmental management quality is measured by an indicator equal to 1 if the firm provided environmental training to its staff or if the firm adopted a strategy for the reduction of greenhouse gasses and to 2 if both and 0 if neither. All regressions include firm-level controls, namely lagged size (four bins depending on the number of employees being <=10, 10<x<=50, 50<x<=250, or >250), age (less or more than 10 years), revenues growth, lagged return on assets, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

Table D.3. Green investment relative to total investment and firm capacity by size

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Green investment share	Share of integrated	Share of end-of-line	Green investment share	Share of integrated	Share of end-of-line
Constraint	Financial constraints			Environmental management		
Capacity	0.001	0.000	0.001	0.011***	0.012***	0.005***
	(0.8)	(0.2)	(0.9)	(6.1)	(4.5)	(3.5)
Capacity x small	-0.005***	-0.004**	-0.002	-0.001	-0.004	0.001
	(-3.0)	(-2.2)	(-1.6)	(-0.4)	(-1.5)	(0.8)
Capacity x	-0.005***	-0.003*	-0.003*	0.000	-0.004	0.003*
medium	(-2.6)	(-1.7)	(-1.7)	(0.2)	(-1.5)	(1.8)
Capacity x large	-0.007**	-0.006*	-0.005*	0.002	-0.004	0.005**
	(-2.1)	(-1.7)	(-1.7)	(0.8)	(-1.4)	(2.6)
Observations	33,811	31,925	33,040	33,436	31,549	32,665
R-squared	0.079	0.056	0.068	0.101	0.071	0.079
R-S-Y	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y

Note: The dependent variable is the amount of green investment over the amount of total investment. Financing constraints are measured by a dummy variable equal to 1 for the bottom quartile of the interest coverage distribution and 0 otherwise. Results using instead a variable equal to 1 if a firm belongs to the top quartile of the financial leverage are available upon request. Environmental management quality is measured by an indicator equal to 1 if the firm provided environmental training to its staff or if the firm adopted a strategy for the reduction of greenhouse gasses and to 2 if both and 0 if neither. All regressions include firm-level controls, namely lagged size (four bins depending on the number of employees being <=10, 10<x<=50, 50<x<=250, or >250), age (less or more than 10 years), revenues growth, lagged return on assets, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.

Table D.4. The relationship between management quality and types of investment

	(1)	(2)	(3)	(4)	(5)
Dependent variable	Green investment ratio			Integrated technologies ratio	End-of-line ratio
Management variable	Staff number (log)	Env man indicator	Staff number (log)		
Management quality	0.000***	0.011***			
	(4.1)	(19.7)			
Top Management			0.006***	0.007***	0.003
			(3.2)	(3.2)	(1.5)
Technical staff			0.009***	0.007***	0.007***
			(7.0)	(4.7)	(5.7)
Other staff			0.003***	0.001	0.003***
			(3.2)	(1.0)	(2.9)
Observations	33,811	33,436	33,811	31,925	33,040
R-squared	0.079	0.101	0.095	0.063	0.078
R-S-Y	Yes	Yes	Yes	Yes	Yes
Cluster	R-S-Y	R-S-Y	R-S-Y	R-S-Y	R-S-Y

Note: Environmental management quality is measured by the logged number of staff with environmental functions or by an indicator equal to 1 if the firm provided environmental training to its staff or if the firm adopted a strategy for the reduction of greenhouse gasses and to 2 if both and 0 if neither. All regressions include firm-level controls, namely lagged size (four bins depending on the number of employees being <=10, 10<x<=50, 50<x<=250, or >250), age (less or more than 10 years), revenues growth, lagged return on assets, and lagged ratio of tangible fixed assets to assets. Standard errors clustered at the firm level. + p<.15, * p<.10, ** p<.05, ***p<0.1.
Source: OECD calculations based on data from the Portuguese Statistics Institute and the Portuguese Ministry for Education.