EXECUTIVE BOARD MEETING

SM/20/156

September 24, 2020

To: Members of the Executive Board

From: The Secretary

Subject: **October 2020 Global Financial Stability Report—Chapter 5 and Online Annex**

Board Action:	Executive Directors' **consideration** (Formal)
Tentative Board Date:	**Wednesday, September 30, 2020**
Publication:	Yes, it is intended that the Executive Summary and Chapter 1 of the October 2020 Global Financial Stability Report will be released to the public at the time of the press conference that is tentatively scheduled for **Tuesday, October 13, 2020,** and the thematic chapters will be made available to the public following the Annual Meetings. The chapters will be made available to the public on the IMF website in advance of the publication of the full document.
Questions:	Mr. Natalucci, MCM (ext. 37108) Ms. Qureshi, MCM (ext. 38942) Mr. Suntheim, MCM (ext. 39084)
Additional Information:	The paper will be revised for publication in light of the Executive Board discussion. If Executive Directors have additional comments, they should notify Mr. Natalucci, Ms. Qureshi, and Mr. Suntheim by **5:30 p.m. on Monday, October 5, 2020**.

5 CORPORATE SUSTAINABILITY

Approved By
Tobias Adrian

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OCTOBER 2020—GLOBAL FINANCIAL STABILITY REPORT

Firms' Environmental Performance and the COVID-19 Crisis

Chapter 5 at a Glance

- Tighter financial constraints and weaker economic conditions can act as a drag on firms' environmental performance.
- The COVID-19 crisis could substantially reduce firms' green investments, reversing gains in their environmental performance made in past years.
- Climate policies and green investment packages are therefore warranted to support a green recovery and the transition to a low-carbon economy.
- Policies aimed at fostering sustainable finance such as better disclosure standards and product standardization could further help mobilize green investments and alleviate firms' financial constraints.

The shutdown in economic activity as a result of the coronavirus disease (COVID-19) crisis has resulted in a temporary decline in global carbon emissions, but the long-term impact of the pandemic on the transition to a low-carbon economy remains uncertain. While the economic fallout from the crisis may constrain firms' ability to invest in green projects, thus slowing down the transition, the COVID-19 crisis could also induce a structural shift in consumer and investor preferences toward environmentally friendly products, providing an opportunity to introduce mitigation policies that help diversify away from fossil fuel production. Looking back at previous episodes of financial and economic stress, this chapter finds that tighter financial constraints and adverse economic conditions are generally detrimental to firms' environmental performance, reducing green investments, and setting back their progress by several years. This suggests that the COVID-19 crisis could potentially slow down the transition to a low-carbon economy. In light of the urgent need to reduce global greenhouse gas emissions, it also underlines the importance of climate policies and green investment packages to support a green recovery and the energy transition. Policies aimed at fostering sustainable finance, such as improved transparency and standardization, could further help mobilize green investments and alleviate firms' financial constraints.

Introduction

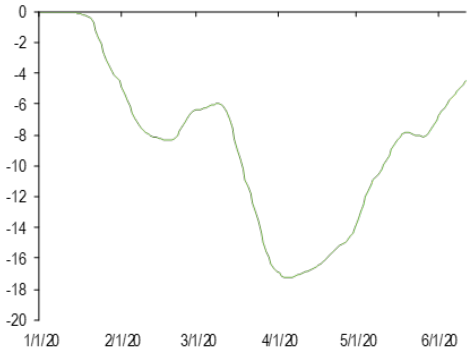
1. The shutdown in economic activity as a result of the COVID-19 crisis resulted in a sharp decline in global carbon emissions (Figure 5.1, panel 1).[1] Daily emissions in early April 2020 fell by about 17 percent compared with 2019 levels, though most of this decline has reversed since then as economic activity has picked up across countries. Such a reversal in emissions is in line with what turned out to be only a temporary decline in the price of carbon emission allowances in March 2020 (Figure 5.1, panel 2). Overall, recent studies forecast a reduction in annual emissions of about 4 to 7 percent in 2020, far from the large and sustained decrease in emissions required under the Paris Agreement to limit the increase in global temperature to well below 2°C (Le Quéré and others 2020).[2]

Figure 5.1. The Energy Transition During the COVID-19 Crisis

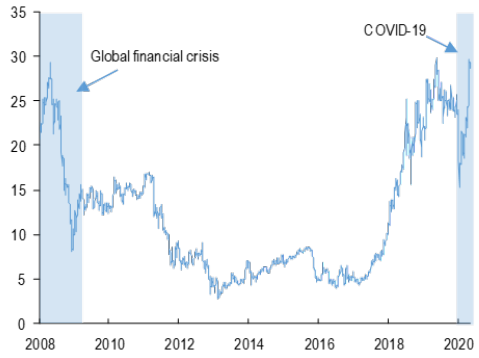
Carbon emissions declined rapidly as COVID-19 became a global pandemic …

… but, unlike during the global financial crisis, the decline has been short-lived, with a rebound in emissions.

1. Change in Daily CO_2 Emissions in 2020 Compared with 2019 Mean Daily Emissions (Percent)



2. Price of European Union Emissions Trading System CO_2 Emission Allowance (Euros per metric ton)



Sources: Global Carbon Project; Refinitiv Datastream; and IMF staff calculations.
Note: Panel 1 shows the reduction in daily CO_2 emissions in 2020 compared with 2019 mean levels. Panel 2 shows the price of futures contracts on carbon emission allowances traded on the Intercontinental Exchange. The European Union Emissions Trading System (EU ETS) was subject to several changes in regulation over the sample period that may have affected the price level.

2. There is also a possibility that the transition to a low-carbon economy could be delayed should the economic scarring from the pandemic crisis run deep, inducing economic agents and policymakers to sideline or postpone environmental objectives. Heightened economic uncertainty, a sharp drop in energy prices, and corporate balance sheet vulnerabilities may result in a reduction in investments and research in long-horizon, capital-intensive green projects. In addition, subsidies or economic rescue packages aimed at softening the impact of the crisis may slow the transition—for example, by supporting firms or activities not compatible with long-term climate mitigation goals.

3. At the same time, the current crisis could also present an opportunity to accelerate the transition to a low-carbon economy by inducing structural shifts in consumer and investor preferences toward

[1] In the short term, there is an almost one-to-one relationship between economic growth and emissions (Hale and Leduc 2020).

[2] UNEP (2019) estimates that emissions need to decline by 2.7 percent annually in order to reach the 2°C goal by 2030.

environmentally friendly products in the event economic agents change their beliefs about the likelihood of other catastrophic events, such as those linked to climate change.[3] In the corporate sector, for example, climate change has become an increasingly important topic since the onset of the pandemic, as is evident from firms' earnings calls transcripts (see Box 5.1). More generally, an increased awareness of the benefits of long-term disaster prevention could facilitate implementation of green policy measures such as carbon taxes.[4]

4. Against this backdrop, this chapter aims to address the following two key questions: (1) How has the COVID-19 crisis affected green financing so far? (2) What can be learned from past economic crises about the likely behavior of the corporate sector in the near and medium terms with respect to the greening of the economy?

The COVID-19 Crisis and Financing the Energy Transition

5. The COVID-19 crisis has not led to a sustained decline in green financing so far. Issuance of green corporate bonds, which has trended up over the past decade, declined in March 2020 in the midst of the financial market turmoil, but it has picked up since, with the share of green bonds in total corporate bond issuance returning to 2019 levels (Figure 5.2, panel 1). In the syndicated loan market, loans to firms with an above-median score in environmental performance have increased over the past decade compared with loans to firms with a below-median score.[5] Lending to both types of firms dropped slightly in the first quarter of 2020 (Figure 5.2, panel 2).

6. Investment funds with a focus on sustainable or environmental investments have continued to attract investors throughout the crisis, , especially fixed-income funds, with only a small drop in aggregate inflows in some asset classes (Figure 5.2, panel 3).[6] A possible driver of the good performance of sustainable and environmental funds may have been the relatively high returns that green investments have experienced during this crisis in general (Figure 5.2, panel 4).

[3] Survey evidence suggests that voters have become more worried about other global threats, such as climate change, after experiencing the COVID-19 pandemic (Geman 2020).

[4] Calls for implementing "green recovery" packages in the aftermath of the COVID-19 crisis have come from different quarters, including the private sector in some cases. For example, in June 2020 more than 100 global investors called for a green European Union (EU) recovery plan. The EU coronavirus recovery package earmarks about 30 percent of the funds (some €550 billion over 2021–27) for climate protection.

[5] Firm-level environmental, social, and corporate governance data come with several caveats. First, the data cover only publicly listed firms, so the results do not necessarily carry over to the entire economy, which includes unlisted small- and medium-sized enterprises. Second, there is a lack of standardization and transparency across data providers, so environmental scores from different providers may capture different features of environmental performance. Third, as some scores are self-reported by firms, accuracy may vary across the sample. See Online Annex 5.1 for a description of the variables used in this chapter. All annexes are available at www.imf.org/en/Publications/GFSR.

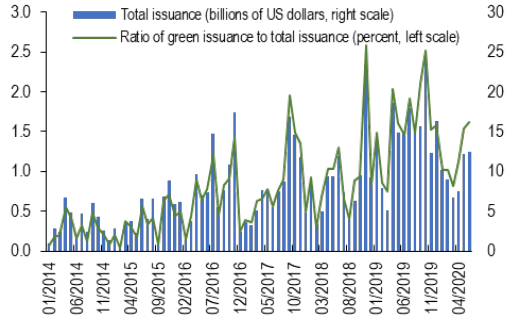
[6] Sustainable funds explicitly indicate all kinds of sustainability; impact; and environmental, social, and corporate governance (ESG) strategies in their prospectus. Environmental funds invest in environmentally oriented industries. See the October 2019 GFSR for a discussion of sustainable finance and financial stability.

7. Overall, the impact of the COVID-19 crisis on the financing of green investments so far seems to have been modest and short-lived. However, given the severity and possible persistence of the shock—in terms of output decline, the extent of potential scarring, and the heightened economic uncertainty—there could be significant strains on corporate balance sheets. It is therefore challenging to forecast whether such trends will continue and ultimately what the overall impact of the crisis will be on firms' environmental performance and on their ability to contribute to global climate change mitigation efforts. In view of this concern, the analysis in the next section examines firms' environmental performance during previous episodes of financial and economic stress to draw possible implications for the current episode.

Figure 5.2. The COVID-19 Crisis and Green Investments

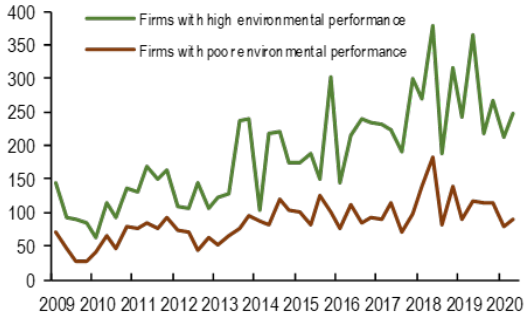
Green bond issuance dropped in the first quarter of 2020 before picking up again beginningin April 2020.

1. Green Corporate Bond to Total Corporate Bond Issuance and Total Green Corporate Bond Issuance



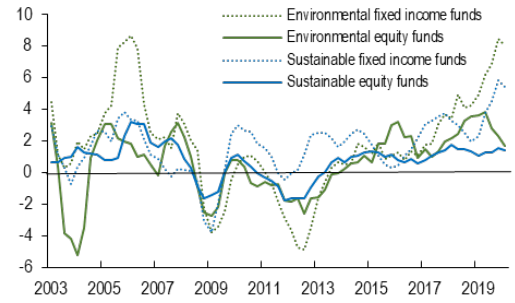
Bank lending has shifted to green firms over the past decade.

2. Total Amount of Syndicated Loans to Firms with Environmental Scores Higher than Median and Firms with Environmental Scores Lower than Median, 2009:Q1–2020:Q1
(Billions of US dollars)



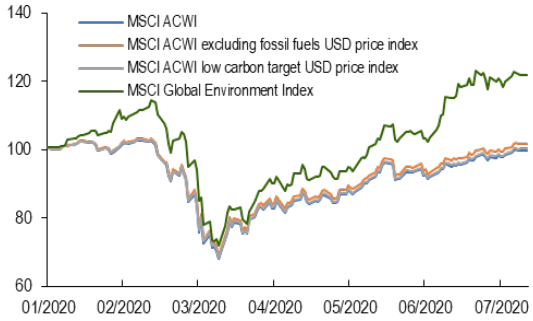
Flows into sustainable and environmental equity funds slowed in the first quarter of 2020 but remained positive.

3. Sustainable and Environmental Fund Flows as a Share of Fund Size, 2003:Q1–2020:Q1
(Moving averages; percent)



Equity indices with a focus on environmental issues performed at least as well as the overall market.

4. Cumulative Returns of Green and Conventional Equity Market Indices
(Percent)



Sources: Bloomberg Finance L.P.; Dealogic; Morningstar; Refinitiv Datastream; and IMF staff calculations.
Note: Panel 1 shows global green corporate bond issues. Panel 3 shows quarterly flows into sustainable or environmental fixed-income or equity funds. MSCI ACWI = Morgan Stanley Capital International All Country World Index.

Lessons from Past Economic Crises for Firms' Environmental Performance During the COVID-19 Crisis

8. Existing research focusing on the United States suggests that the environmental, social, and governance (ESG) performance of financially constrained firms—that is, firms which face difficulties in raising external capital—is generally weaker relative to unconstrained firms (Hong, Kubik, and Scheinkman 2012).[7] Hence, a deterioration in financial or economic conditions that results in a tightening of firms' financial constraints is likely to reduce their ability to invest in green projects and cut greenhouse gas emissions.

9. Extending this analysis to a global sample and specifically analyzing firms' environmental performance shows that tighter financial constraints are indeed associated with worse environmental performance (Figure 5.3, panel 1). Proxying firms' financial constraints by firm size, rating status, interest coverage ratio, ability to pay dividends, and the commonly used Kaplan-Zingales index, the environmental performance of financially constrained firms is in each case significantly weaker than that of unconstrained firms. Specifically, environmental performance falls by 10 points when firm size drops from the median to the 25th percentile of the firm size distribution. When a firm does not pay dividends or when it is not rated, its environmental score is 4 points and 3 points lower, respectively, than the score of dividend-paying and rated firms. The environmental score is 1 point lower when an aggregate measure of financial constraints (the Kaplan-Zingales index) is above the median of the sample distribution. Similar results are obtained when considering firms' carbon intensity instead of their environmental performance.

10. A key channel through which financial constraints can affect firms' environmental performance is a decline in investments in green technologies. Constrained firms may postpone or reduce such investments if they do not directly contribute to revenue generation. Moreover, financially constrained firms may face difficulties in borrowing against future profits to invest in research and development, consequently postponing investments in intangibles that could potentially improve their environmental performance. Regression analysis support these hypotheses and suggest that financially constrained firms are less likely to make investments that reduce future environmental risks, such as treatment of emissions or installation of cleaner technologies (Figure 5.3, panel 2). For example, the probability that a firm will make an environmental investment falls by 6 percentage points when firm size drops from the median to the 25th percentile of the firm size distribution.

11. These results have important implications in the current COVID-19 context. An adverse macro-financial shock that increases uncertainty and amplifies firms' financial constraints is likely to affect firms' environmental performance and has the potential to significantly impede their ability to invest in green projects. To quantify the extent of the impact, two types of shocks are analyzed here: (1) a global financial

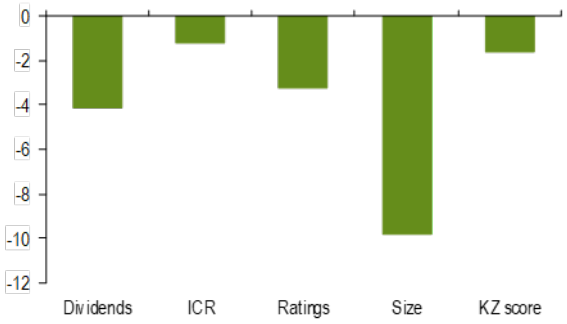
[7] Because financial constraints are not directly observable, different proxies are used in the literature (see Online Annex 5.2): firm size (large firms are expected to be less financially constrained than small firms), rating status (firms with a rating may have easier access to capital markets than those without), the interest coverage ratio (defined as earnings before interest and taxes divided by interest expenses, reflecting a firm's debt repayment capacity with higher values indicating less financially constrained firms), the ability to pay dividends, and the Kaplan-Zingales index (an aggregate measure of financial constraints).

stress shock (proxied by the Chicago Board Options Exchange Volatility Index [VIX]) and (2) a real economic activity shock capturing a sudden drop in domestic output.[8]

Figure 5.3. Financial Constraints, Financial Stress, and Environmental Performance

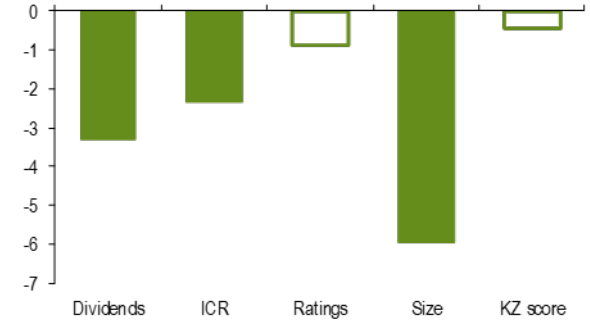
Financially constrained firms have weaker environmental performance …

1. Effects of Financial Constraints on Environmental Score (Index)



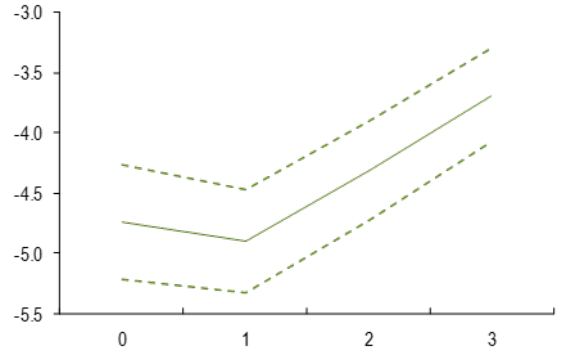
… and are less likely to make environmental investments.

2. Marginal Effects on the Probability of a Firm Making Environmental Investments (Percent)



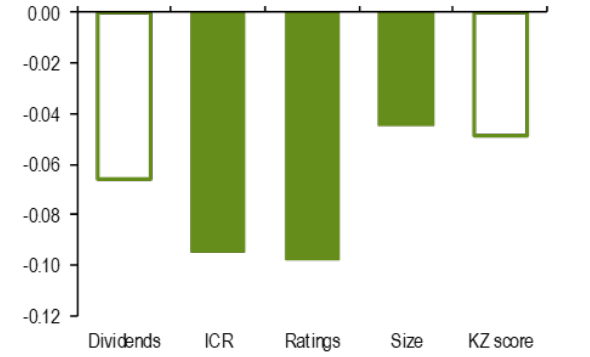
Severe financial stress leads to poorer corporate environmental performance …

3. Response of Environmental Score to a VIX Shock (Index)



… and the effects of financial stress are stronger for financially constrained firms.

4. Coefficient of the Interaction Term between Firm-Level Financial Constraints and a VIX Shock



Sources: Refinitiv Datastream; Standard & Poor's; and IMF staff calculations.
Note: "Dividends" refers to firms that do not pay dividends, "ICR" to firms with earnings below interest expenses, "Ratings" to firms that do not have a rating from Standard & Poor's, "Size" to the log of total assets (the sign of this variable is reversed so that higher values indicate smaller firms), and "KZ score" to firms above the median of the Kaplan-Zingales index score distribution (more financially constrained firms have higher KZ scores). Panel 1 shows regression estimates of environmental scores on financial constraints. Regressions include firm-level controls as well as industry, country, and time fixed effects. Firm-level controls are the log of total assets and earnings, except when using "Size" as a measure of financial constraint, when only earnings are used as a firm-level control. Panel 2 shows the marginal effects of a given financial constraint measure on the probability of a firm making an environmental investment. The probit models include the same control variables and fixed effects as in panel 1. In panel 3, $t = 0$ is the year of the shock. The Chicago Board Options Exchange Volatility Index (VIX) shock is the average value of the VIX over the calendar year. The solid line denotes the response to a 16.3 point increase in the VIX (corresponding to the difference in the average value of the VIX in 2020, using data up to July 31, 2020, relative to the average value in 2019). The dashed lines denote 90 percent confidence intervals. Responses are obtained with the local projection approach from firm-level panel regressions that include firm-level controls, country-specific output gaps, the price of oil, and country and industry fixed effects. Panel 4 shows interaction terms at a one-step horizon between the VIX shocks and the lagged firm-level financial constraint variables. The same control variables as in panel 3 are used. In panels 1, 2, and 4, solid bars indicate significance at the 10 percent level. ICR = interest coverage ratio.

[8] See Online Annex 5.3.

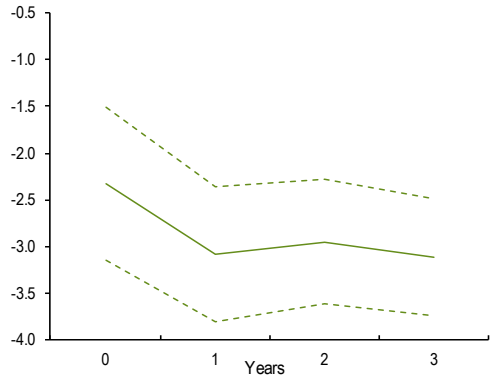
12. The analysis shows that a sudden jump in the VIX, comparable to the average level that prevailed in the first half of 2020 during the COVID-19 pandemic, would lead to a persistent drop in firms' environmental performance by up to 5 points, with the pre-shock performance level not attained for at least three years after the shock (Figure 5.3, panel 3). Absent policy actions and behavioral changes, this would imply that average corporate environmental performance would return to the levels that were last observed in 2006. Moreover, the adverse effect of global financial shocks on environmental performance is magnified when firms are financially constrained (Figure 5.3, panel 4). For example, for firms with an ICR below 1 or for unrated firms in 2019, the global financial stress shock observed thus far in 2020 is estimated to lower environmental performance by 2 additional points, compared to firms with an ICR above 1 or rated firms.[9]

13. A large decline in the output gap (10 percentage points, about 50 percent larger than that observed in the Group of Seven (G7) economies during the global financial crisis), would lead to a 3 point decline in firms' environmental performance in the medium term (Figure 5.4, panel 1).[10] Similarly, firms' carbon intensity—captured by their total carbon emissions relative to revenue—could increase by up to 8.5 percent in the medium term after such a decline in the output gap (Figure 5.4, panel 2), even though the initial response of carbon intensity to economic shocks may be small because of the cyclical dynamics of carbon dioxide emissions observed during recessions (Figure 5.1, panel 1; Hale and Leduc 2020).

Figure 5.4. Economic Shocks and Environmental Performance

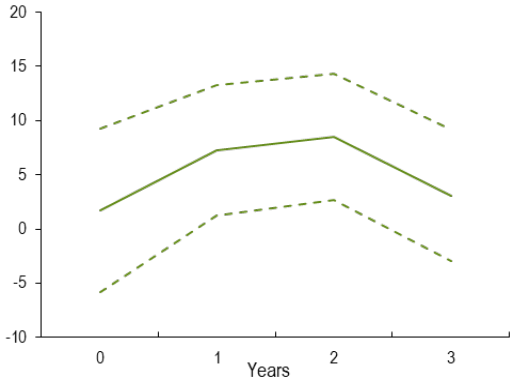
Contractionary economic shocks lead to lower corporate environmental performance …

1. Response of Environmental Score (*y*-axis) over Time (*x*-axis) to a Fall in the Output Gap (Index)



… and carbon intensity deteriorates following contractionary economic shocks.

2. Response of the Logarithm of Total CO_2 Emissions Relative to Revenues (*y*-axis) over Time (*x*-axis) to a Fall in the Output Gap (Percent)



Sources: Refinitiv Datastream; and IMF staff calculations.
Note: In panels 1 and 2, the real economic activity shock is scaled as a 10 percentage points drop in the output gap. The regression includes firm-level controls (log of total assets, earnings, and a dividend dummy variable); the price of oil (log WTI [West Texas Intermediate]); the Chicago Board Options Exchange Volatility Index (VIX); and country and sector fixed effects. Dashed lines represent 90 percent confidence interval.

[9] These economic effects are calculated by multiplying the interaction term by a 16.3 point increase in the VIX (corresponding to the difference in the average value of the VIX in 2020, using data up to July 31, 2020, relative to the average value in 2019).

[10] Other more global measures of economic activity shocks such as the forecast error for the current-year global GDP growth relative to the April WEO or the global economic activity shock from Baumeister and Hamilton (2019) also lead to a fall in corporate environmental performance in the medium term.

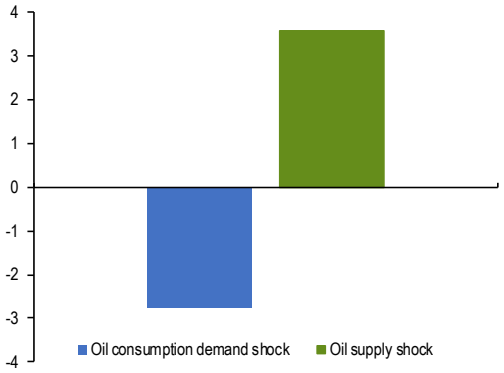
14. In addition to direct global financial and economic shocks, changes in oil prices could also impact corporate environmental performance by affecting firms' incentives and their financial constraints. The onset of the COVID-19 crisis was accompanied by a steep decline in the international price of oil. The effect of such a decline in oil prices on firms' environmental performance is, however, ambiguous. On the one hand, it may relax firms' financial constraints and reduce the incentives for businesses to improve their energy efficiency and shift away from fossil fuels, including by hindering the development of clean energy sources by making investments in new projects less profitable.[11] On the other hand, low oil prices could benefit the energy transition, by hurting the profitability of the oil sector, and leading to lower investments in the fossil fuel sector and a decline in production, thereby making it easier for clean energy firms to compete.

15. In principle, the effect of an oil price shock on environmental performance is likely to depend on the underlying source of the shock—that is, whether it is a demand or supply driven shock. A negative global demand shock associated with a decline in economic activity that reduces the demand for oil could be associated with lower corporate environmental performance as investments into cleaner energy sources are delayed because of already tight financial conditions for firms. Conversely, a drop in oil prices due to an oil supply shock could trigger an increase in global economic activity (Baumeister and Hamilton, 2019), easing firms' financial constraints and allowing them to improve their environmental performance.

Figure 5.5. Oil Market Shocks and Environmental Performance

Lower oil prices due to demand factors are associated with lower corporate environmental performance.

Response of Environmental Scores to Oil Market Shocks that Lower the Real Price of Oil across all Industries (Index)



Sources: Refinitiv Datastream and IMF staff calculations.
Note: The oil market shocks are obtained from Baumeister and Hamilton (2019). All shocks are unit shocks that lead to a fall in the real price of oil. Responses at a 2-year horizon are represented. Controls in the regression are the log of total assets, earnings, a dividend dummy variable, country-specific output gaps, the Chicago Board Options Exchange Volatility Index (VIX), and the price of oil (log WTI [West Texas Intermediate]). The regressions include country and sector fixed effects. Solid bars indicate significance at the 10 percent level.

16. Econometric analysis suggests that the source of the oil price fluctuation is indeed key to understanding firms' environmental response to a shock. Historically, when oil prices have fallen due to demand-side factors, environmental corporate performance has been weaker. By contrast, when oil prices have declined due to an oil supply shock, environmental performance of firms has improved (Figure 5.5). To the extent that the COVID-19-induced oil price shock is largely a demand-driven shock, firms' environmental performance is thus likely to suffer.[12]

[11] Acemoglu and others (2019) discuss the long-term effects of the shale gas boom, which reduces carbon dioxide emissions from coal in the short term, while increasing aggregate production and directing energy innovation to shift away from clean energy to fossil fuels.

[12] Difficulties to reach an agreement among the OPEC+ coalition also contributed to the collapse in oil prices in early 2020, but a decomposition of the oil price shock in March and April 2020 suggests that it was largely driven by demand-side factors. See Online Annex 5.3.

17. Overall, these results indicate that tighter financial constraints are associated with weaker corporate environmental performance. Adverse global financial and output shocks that increase uncertainty and amplify firms' financial constraints weigh significantly on their environmental performance. Furthermore, a reduction in oil prices against the backdrop of a decline in global economic activity is unlikely in itself to lift corporate environmental performance. Thus, absent strong supportive policy actions, tighter financial constraints and weaker economic activity related to the COVID-19 crisis are likely to act as a drag on firms' environmental performance in the future.

Conclusions and Policy Recommendations

18. The COVID-19 crisis has resulted in a temporary decline in global carbon emissions, but its long-term impact is uncertain. On the one hand, the crisis may increase awareness of catastrophic risks and bring about a major shift in consumer preferences, corporate actions, and investor behavior. On the other hand, the historical evidence presented in this chapter suggests that there is a real possibility that, barring public interventions, investment by firms to improve their environmental performance may decline in this time of macro-financial stress.

19. To achieve the reduction in emissions needed to keep global warming below 2°C, an increase in green investments, in combination with steadily rising carbon prices, is critical (October 2020 WEO; October 2019 *Fiscal Monitor*). Public policies and green recovery packages are important to offset the potential deterioration in firms' environmental performance resulting from the crisis (see the October 2020 *Fiscal Monitor).*

20. In addition, to alleviate firms' financial constraints and to aid green investment, it will be key to put in place policies that support the sustainable finance sector, such as better disclosure standards, development of green taxonomies, and product standardization (see the October 2019 GFSR).

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Box 5.1. Climate Index Based on Firms' Earnings Calls

To measure how firms' exposure to and awareness of climate change have evolved over time, a firm-level climate index was constructed for this chapter based on quarterly earnings call transcripts using a climate change dictionary built from four climate change glossaries.[1] To construct the index, earnings call transcripts from 4,109 firms located in 46 countries are used.

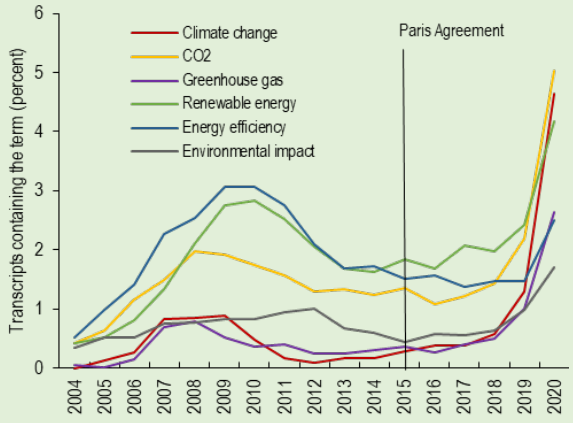
Panel 1 of Figure 5.1.1 shows the share of earnings call transcripts that mention specific phrases related to climate change, such as "climate change," "CO_2," or "emissions." A sharp increase in discussions involving climate change topics is observed in 2020, coinciding with the COVID-19 pandemic. This could, for example, be the result of the COVID-19 crisis increasing firms' focus on catastrophic events and long-term risks.

The *climate change discussion index* is then constructed for each firm by assigning a value of 1 to each earnings call transcripts that contains a phrase included in the dictionary. Panel 2 shows the average of the index over time. It is noteworthy that in the earnings calls of energy sector firms, mentions of climate-change-related terms spiked after the Paris Agreement in 2016, highlighting the importance of policy risk for this sector. The increase in discussions involving climate change over the past few years is consistent across countries (Online Annex 5.4).

Figure 5.1.1. Climate Index

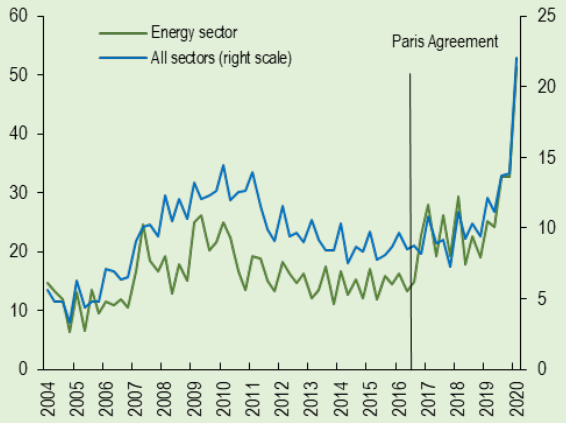
Climate change discussions have increased during the COVID-19 crisis.

1. Annual Share of Earnings Call Transcripts Containing Specific Climate-Change-Risk-Related Terms
(Percent)



After the Paris Agreement, firms in sectors exposed to transition risk became more aware of climate risks— or opportunities.

2. Quarterly Share of Firms with Climate Discussions, All Sectors and Energy Sector
(Percent)



Sources: FactSet; and IMF staff calculations.

This box was prepared by Alan Feng and Germán Villegas Bauer.

[1] Following a similar approach as Engle and others (2020), the glossaries are obtained from the British Broadcasting Corporation, the Intergovernmental Panel on Climate Change, the United Nations, and the US Environmental Protection Agency. See Online Annex 5.4 for a list of all terms. All annexes are available at www.imf.org/en/Publications/GFSR.

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Firms' Environmental Performance and the COVID-19 Crisis — Online Annexes 5.1–5.4

CONTENTS

Online Annex 5.1. Data Sources

Online Annex Table 5.1.1. Data Sources

Variable	Description	Source
Macroeconomic and Financial Variables		
Exchange Rate	The exchange rate used to convert balance sheet items into US dollars	Refinitiv Datastream
Global Economic Activity	Industrial production index for OECD economies and six non-OECD economies (Brazil, China, India, Indonesia, the Russian Federation and South Africa)	Updated series from Baumeister and Hamilton (2019)
Global Oil Inventories	Constructed as in Baumeister and Hamilton (2019)	U.S. Energy Information Administration
Oil Price	Spot oil price: West Texas Intermediate (US dollars per barrel)	Haver Analytics
Output Gap	Output gap, constant prices in national currency, percent	IMF, World Economic Outlook
Real Gross Domestic Product	Gross domestic product, constant prices in national currency	IMF, World Economic Outlook
Short-Term Nominal Interest Rate	Short-term deposit rate	IMF, World Economic Outlook
U.S. Consumer Price Index	U.S. consumer price index for all urban consumers: all items	Federal Reserve Bank of St. Louis
VIX	CBOE Volatility Index	Refinitiv Datastream
World Oil Production	World oil production measured in thousands of barrels of oil per day	U.S. Energy Information Administration
Firm-Level Variable		
Cash and Short-Term Investments	The sum of cash and short-term investments	Refinitiv Datastream
Cash Dividends	The total common and preferred dividends paid to shareholders of the company	Refinitiv Datastream
Date of Incorporation	The date the company was incorporated	Refinitiv Datastream
Debt-to-Asset Ratio	The ratio of total debt relative to total assets, where total debt represents all interest bearing and capitalized lease obligations and is the sum of long- and short-term debt	Refinitiv Datastream
Dividends per Share	Total dividends per share declared during the calendar year for US corporations and fiscal year for non-US corporations; includes extra dividends declared during the year	Refinitiv Datastream
EBIT	The earnings of a company before interest expense and income taxes. It is calculated by taking the pre-tax income and adding back interest expense on debt and subtracting interest capitalized.	Refinitiv Datastream
Interest Coverage Ratio (EBIT relative to interest expense)	Interest expense represents the total amount of interest paid by a bank or other financial company.	Refinitiv Datastream
Market Capitalization	Current total market value of a company based on current price and current shares outstanding.	Refinitiv Datastream
Operating Income Before Depreciation and Amortization	The operating income of a company before depreciation and amortization expenses have been deducted.	Refinitiv Datastream
Ratings	Long-term issuer rating.	Standard & Poor's
Total Assets	The sum of total current assets, long-term receivables, investment in unconsolidated subsidiaries, other investments, net property plant and equipment and other assets.	Refinitiv Datastream

Online Annex Table 5.1.1. Data Sources (concluded)

Other Indicators		
Carbon Dioxide (CO2) Emission	Estimated global historical carbon dioxide emission; estimated change in global daily carbon dioxide emission in 2020.	The Global Carbon Project
Carbon Price	Settlement price of futures contracts on CO2 EU allowances traded at the Intercontinental Exchange.	Refinitiv Datastream
Climate Change Commercial Risk /Opportunities	Measures a company's awareness that climate change can represent commercial risks and/or opportunities.	Refinitiv Datastream
Climatic Disaster Classified by IMF	Six types of natural disasters related to climate change: floods, droughts, landslides, wildfires, storms, and extreme temperature.	EM-DAT
Coverage of National Carbon Pricing Schemes	Coverage of greenhouse gases by a carbon pricing scheme as share of total emissions within a jurisdiction.	IMF and the World Bank
Emissions Category Score	This score measures a company's commitment and effectiveness towards reducing environmental emission in the production and operational processes.	Refinitiv Datastream
Enforcement of Environmental Regulations	Executive Opinion Survey: "How would you assess the enforcement of environmental regulations in your country? (1 = very lax; 7 = among the world's most rigorous)".	World Economic Forum
Environmental Investments Initiatives	Binary variable providing the answer to the question: "Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities?".	Refinitiv Datastream
Environmental Score	The Refinitiv Asset4 Environmental Pillar Score. The weighted average relative rating of a company based on the reported environmental information and the resulting three environmental category scores.	Refinitiv Datastream
Environmental Policy Stringency Index	A country-specific and internationally comparable measure of the stringency of environmental policy; it covers 33 countries.	Organisation for Economic Co-operation and Development
ESG Score	Overall company score based on the self-reported information in the environmental, social, and corporate governance pillars.	Refinitiv Datastream
Management Score	Measures a company's commitment and effectiveness towards following best practice corporate governance principles.	Refinitiv Datastream
Resource Use Category Score	Reflects a company's performance and capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management.	Refinitiv Datastream
Sautner Climate Change Physical Exposure	The variable is equal to 1, if the transcript contains a climate change physical-related bigram (of a set developed by the authors), and to 0, otherwise.	Sautner and others (2020)
Sautner Climate Change Regulation Exposure	The variable is equal to 1, if the transcript contains a climate change regulation-related bigram (of a set developed by the authors), and to 0, otherwise.	Sautner and others (2020)
Stringency of Environmental Regulations	Executive Opinion Survey: "How would you assess the stringency of your country's environmental regulations? (1 = very lax; 7 = among the world's most stringent)".	World Economic Forum
Total CO2 Equivalent Emissions to Revenues	Total CO2 and CO2 equivalents emission in tonnes divided by net sales or revenue in US dollars.	Refinitiv Datastream

Online Annex 5.2. Financial Constraints and Firms' Environmental Performance

Explaining Environmental Scores with Financial Constraints

Empirical Approach:

The following model is estimated to evaluate the linkages between financial constraints and environmental performance (environmental score):

$$E_{i,s,c,t} = \alpha_s + \gamma_c + \lambda_t + \beta_1 Constraints_{i,t-1} + \mu' X_{i,t-1} + \varepsilon_{i,s,c,t} \quad (1)$$

Where *i* is a firm, *s* is a sector, *c* is the economy and *t* is time (year). $E_{i,s,c,t}$ is the environmental score from Refinitiv and in the range of 0 (low performance)-100 (high performance). α_s, γ_c, and λ_t are sector, country, and time fixed effects, respectively. The choice of the fixed effects specification follows Dyck and others (2019), who use this dataset for cross-country analysis of firms' environmental and social responsibility. Sectors correspond to the 69 industries from the Global Industry Classification Standard. $X_{i,t-1}$ are firm-level controls: the logarithm of total assets and earnings before interest and taxes. The variable $Constraints_{i,t-1}$ is one of the following five firm-level financial constraints, commonly used in the literature, and defined as a dummy variable (equal to one if the firm is financially constrained and zero otherwise) except for size which is defined as a continuous variable:[1]

- Size is the logarithm of total assets. The sign of this variable is reversed such that higher values indicate smaller firms;[2]
- Dividends: a firm is constrained if it does not pay dividends;
- ICR: a firm is constrained if its interest coverage ratio is below one;
- Ratings: a firm is constrained if it is not rated according to Standard and Poor's and has a positive debt-to-asset ratio;[3]
- KZ score: a firm is constrained if its Kaplan-Zingales score is above the median of the Kaplan-Zingales score distribution.

[1] There is an extensive literature evaluating how financial constraints affect firm behavior, using firm size, firm payout, ratings, or indices based on linear combinations of observable firm characteristics as measures of financial constraints (Almeida, Campello, and Weinback 2004; Duchin, Ozbas, and Sensoy 2010). However, Farre-Mensa and Ljungqvist (2016) argue that listed firms classified as constrained by standard financial constraint proxies have no difficulties in raising debt, suggesting that results based on such measures might have to be interpreted cautiously.

[2] The rationale for using size as a measure of financial constraints is that small firms are typically young and less well known, hence more vulnerable to capital market imperfections (Almeida and others (2004)).

[3] This approach is akin to Duchin and others (2010), who consider firms as unconstrained if they have zero debt and no rating.

The dataset comprises about 7,000 listed firms from 62 economies for which environmental scores are available.[4] The estimation frequency is annual, and the sample extends from 2002 to 2019. Standard errors are clustered at the firm-level.

Robustness Analysis:

To control for additional factors that could influence the links between financial constraints and environmental performance, a range of robustness checks have been performed:

- Alternative definitions of the financial constraint variables: defining that a firm is constrained if its total assets are below the median of the firm size distribution by total assets, the KZ score as a continuous variable, whether a firm's long-term issuer rating is below investment grade according to Standard and Poor's, and the long-term issuer rating;
- Alternative definitions of the dependent variable: the two sub-categories of the environmental score directly related to climate change, the emissions and resource use subcategories, as well as firms' carbon intensity;
- Using firm age as an additional firm-level control variable;
- Alternative specification of fixed effects: firm-level, country-year, or industry-year fixed effects;
- Country fixed effects are replaced by climate policies: country-specific environmental policies obtained from the OECD's environmental policy stringency index or information from the World Economic Forum survey regarding the strictness and enforcement of environmental laws;
- The use of a balanced panel of firms, starting from 2005 or 2010.

The original conclusions are robust to these changes.

Explaining Firms' Environmental Investment Decisions with Financial Constraints

Empirical Approach:

The specification of the probit model is the following:

$$P(I_{i,s,c,t} = 1) = \Phi(\alpha_s + \gamma_c + \lambda_t + \beta_1 Constraints_{i,t-1} + \mu' X_{i,t-1}) \quad (2)$$

Where Φ is the cumulative distribution of the normal function and $I_{i,s,c,t}$ is a binary variable that indicates whether firm *i,* in sector *s*, economy c undertakes environmental investments in year *t*.[5] α_s, γ_c, and λ_t are

[4] Refinitiv's firm-level environmental scores are obtained using 68 metrics covering three environmental categories: resource use, Emissions, and Innovation. Category scores are calculated using a rank scoring methodology to evaluate firms' environmental performance relative to all other firms each year, firms' overall environmental scores are then calculated from a weighted average of the category scores, where the category weights vary by industry.

[5] Specifically, it is the answer to the following question that is one of the metrics of the Emissions category of the Refinitiv's environmental score: "Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities? (i) investment made in the current fiscal year to reduce future risks and increase future opportunities related to the environment; (ii) investments made in new technologies to increase future opportunities; (iii) treatment of emissions (e.g., expenditures for filters, agents); (iv) installation of cleaner technologies.

sector, country, and time fixed effects, respectively. $Constraints_{i,t-1}$ is one of the five firm-level financial constraints defined above, and $X_{i,t-1}$ are the same firm-level controls as in the previous analysis (the logarithm of total assets and earnings before interest and taxes).

The dataset comprises about 7,000 listed firms from 48 economies.[6] The estimation frequency is annual, and the sample extends from 2002 to 2019. Standard errors are clustered at the firm-level.

Robustness Analysis:

Several checks have been performed to assess the robustness of this analysis:

- Alternative definitions of the financial constraint variables: defining a firm as constrained if its total assets are below the median of the firm size distribution by total assets, the KZ score as a continuous variable, whether a firm's long-term issuer rating is rated below investment grade according to Standard and Poor's, and the long-term issuer rating;
- Country fixed effects are replaced by climate policies: country-specific environmental policies obtained from the OECD's environmental policy stringency index or information from the World Economic Forum survey regarding the strictness and enforcement of environmental laws;
- To circumvent the incidental parameters problem that may arise in non-linear panel data models, replacing fixed effects by macroeconomic and financial control variables: the lagged country-specific output gaps, the lagged price of oil (the logarithm of the WTI) and the lagged VIX;
- The use of a balanced panel of firms, starting from 2005 or 2010.

The original conclusions are robust to these changes.

[6] The number of economies drops in this analysis, since firm coverage is very low for several emerging market and developing economies.

Online Annex 5.3. Firms' Environmental Performance, Financial, Economic, and Oil Market Shocks

Empirical Approach

The following model is estimated to evaluate the dynamic responses of environmental performance (environmental score) to financial, economic, and oil market shocks:

$$E_{i,s,c,t+h} = \alpha_s + \gamma_c + \beta^h shock_t + \delta'^h Firm\ controls_{i,t-1} + \gamma'^h Macro\ controls_{t-1} + \in_{i,s,c,t+h} \quad (1)$$

Where i is a firm, s is a sector, c is the economy and t is time (year). h denotes the horizon of the projection. $E_{i,s,c,t}$ is the environmental score from Refinitiv. α_s and γ_c are sector and country fixed effects, respectively. Sectors correspond to the 69 industries from the Global Industry Classification Standard. Firm-level controls are the logarithm of total assets and earnings before interest and taxes. The macroeconomic controls include the price of oil (logarithm of the WTI), country-specific output gaps and the VIX.[7] The shocks are obtained as follows:

- Financial shock: The annual average of the VIX is used directly in the regression;
- Economic shock: The domestic economic shock is the change in the annual output gap obtained from the World Economic Outlook database;
- Oil market shocks: The oil supply and oil consumption demand shocks are obtained from the structural VAR model of Baumeister and Hamilton (2019). The shocks are derived from the median of the posterior distribution of the relevant parameters.[8] The shocks are aggregated at an annual frequency by taking an average of the monthly values over the calendar year.[9] Historical decompositions of the price of oil indicate that oil price fluctuations in early 2020 were predominantly driven by demand factors: the world economic activity shock and the oil consumption demand shock explained 75 percent of the drop in the price of oil on average from February to April 2020 (Figure 5.3.1).

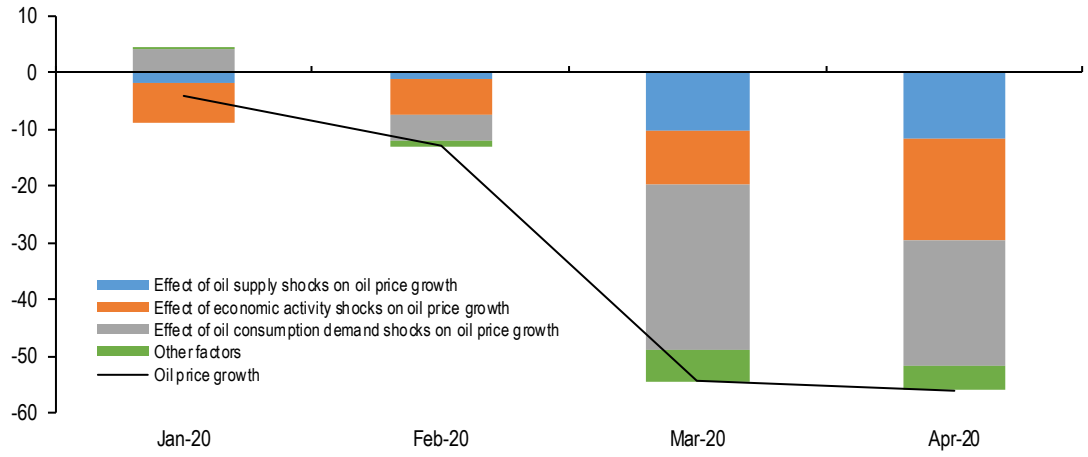
The dataset comprises about 6,900 listed firms from 53 economies. The estimation frequency is annual, and the sample extends from 2002 to 2019. Standard errors are clustered at the firm-level.

[7] When the shock is defined in terms of the output gap, it is not included as a control variable.

[8] We are grateful to Christiane Baumeister for making available the structural shocks from the energy market VAR of Baumeister and Hamilton (2019).

[9] We exclude from this analysis the oil inventory demand shock (also referred as a "speculative demand shock" in the oil market literature), since this shock plays a limited role in explaining oil price fluctuations and it leads to a fall in world economic activity in the VAR model of Baumeister and Hamilton (2019). Contractionary world economic activity shocks, which lead to a fall in environmental scores, are also excluded from this analysis for brevity.

Online Annex Figure 5.3.1. Decomposition of the Oil Price
(Percent)
Demand factors accounted for the bulk of the drop in the price of oil in the early stages of the COVID-19 crisis.



Sources: Federal Reserve Bank of St. Louis; U.S. Energy Information Administration; Updated data from Baumeister and Hamilton (2019); and IMF staff calculations.
Note: The solid line represents the actual change in the real price of oil. Bars indicate the median estimate of the historical contribution of the structural shocks of the energy market VAR from Baumeister and Hamilton (2019) to the price of oil. "Other factors" include the oil inventory demand shocks and the unexplained component.

Robustness Analysis

To control for additional factors that could influence the links between financial, economic activity, oil market shocks and environmental performance, a range of robustness checks have been performed:

- Alternative definitions of the dependent variable: the two sub-categories of the environmental score directly related to climate change, the emissions and resource use subcategories;
- Alternative specification of fixed effects: firm-level fixed effects;
- Alternative definition of financial stress shocks: An autoregressive model of order one for the monthly VIX is estimated over the period extending from January 1990 to December 2019 instead of using directly the VIX. The monthly residuals of that regression are aggregated at an annual frequency by taking an average of the monthly values over the calendar year;
- Alternative definitions of the economic shocks: global economic shocks defined from the forecast error for current year global GDP growth from the IMF's April World Economic Outlook, and the global economic activity shock from Baumeister and Hamilton (2019);
- A dummy variable for the years 2008 and 2009 to control for the severe impact of the global financial crisis for firms' environmental performance.

The original conclusions are robust to these changes.

Online Annex 5.4. Climate Change and Disaster Indices

Index Construction

Firm-level exposure to climate change may materialize as physical risk, such as climatic disasters, or transition risk, e.g. through the impact of regulation aimed at reducing climate change. Both may have positive or negative effects on firms, depending among other things on the products or services that firms produce. For example, a renewable energy firm may benefit from a higher carbon tax whereas fossil fuel energy producers may be harmed.

By using textual analysis on Earnings Call Transcripts of 4,109 firms from 46 economies over the period 2004-2020, two firm-level indices are constructed to measure the exposure to these risks and opportunities.

First, the *climate change discussion index* is constructed based on a dictionary of climate change-related terms composed of phrases included in four climate change glossaries (Intergovernmental Panel on Climate Change, IPCC; the United States Environmental Protection Agency; the United Nations; and the British Broadcasting Corporation, BBC). Each earnings call transcript is assigned a value of one if it contains any phrase included in the dictionary, and zero otherwise.[10] Second, the *climate disaster discussion index* is constructed in a similar way but using climatic disaster terms obtained from various sources.

Online Annex Tables 5.4.2 and 5.4.3 show all the climate change and climate disaster phrases included in the two dictionaries, together with the percentage of transcripts in which each phrase appears, respectively.

Online Annex Table 5.4.1. Countries and Number of Firms

United States (2246), United Kingdom (304), Canada (260), Australia (203), Germany (129), France (112), Switzerland (77), Japan (74), Italy (69), Brazil (47) Spain (45), Sweden (45), Taiwan (41), Russia (38), Finland (34), Korea (34), Norway (33), New Zealand (31), Netherlands (30), Turkey (28), Denmark (26) Mexico (22), Belgium (21), Poland (18), Hong Kong (16), Israel (14), Philippines (14), Indonesia (9), Ireland (9), Thailand (9), Austria (7), Portugal (7), United Arab Emirates (6), Argentina (5), Qatar (5), Chile (3), Colombia (2), Egypt (2), Kuwait (2), Saudi Arabia (2), Czech Republic (1), Hungary (1), Morocco (1) Oman (1), Pakistan (1), Peru (1)

Sources: FactSet; and IMF staff calculations.

[10] Only the Management Discussion Section of the transcripts is analyzed but results are robust to including the Q&A section as well. All results are robust to assigning to each transcript a value equal to the share of its sentences containing climate change-related terms.

Online Annex Table 5.4.2. Climate Change Related Terms and Percentage of Transcripts Including Them

emissions (3.272%), renewable energy (1.964%), energy efficiency (1.864%), co2 (1.517%), electric vehicle (0.8426%), environmental impact (0.7252%), climate change (0.5626%), wastewater (0.5255%), greenhouse gas (0.4803%), sustainable development (0.4128%), biofuel (0.4081%), carbon footprint (0.373%), alternative energy (0.3407%), opec (0.3353%), fossil fuels (0.2921%), carbon dioxide (0.2003%), renewable resources (0.1794%), energy star (0.1484%), glacier (0.145%), clean technology (0.1342%), carbon capture (0.1194%), iceberg (0.1119%), global warming (0.1072%), bunker fuels (0.0978%), air pollution (0.0964%), carbon price (0.0924%), carbon neutrality (0.0883%), energy security (0.0863%), carbon intensity (0.0829%), ozone (0.0809%), greenhouse gases (0.0789%), bioenergy (0.0748%), zero carbon (0.0708%), biodiversity (0.0519%), food security (0.0452%), municipal solid waste (0.0391%), international energy agency (0.0384%), tundra (0.031%), Paris agreement (0.0303%), reforestation (0.0283%), carbon market (0.0276%), clean coal technology (0.0269%), climate risk (0.0249%), biomass fuels (0.0249%), fuel switching (0.0249%), cap and trade (0.0236%), carbon offsetting (0.0236%), nitrous oxide (0.0202%), weather risk (0.0195%), Kyoto protocol (0.0188%), deforestation (0.0188%), environmental plan (0.0188%), o3 (0.0155%), anthropogenic (0.0148%), climate target (0.0134%), carbon sequestration (0.0128%), climate system (0.0114%), clean development (0.0114%), biosphere (0.0107%), climate neutrality (0.0087%), blue carbon (0.008%), weather-resistant (0.008%), ipcc (0.008%), soil moisture (0.0074%), troposphere (0.0074%), climate model (0.006%), greenhouse effect (0.004%), green infrastructure (0.004%), carbon sink (0.004%), umbrella group (0.0033%), n2o (0.0033%), Montreal protocol (0.0033%), removal unit (0.0026%), climate variability (0.0026%), sea ice (0.0026%), geosphere (0.002%), climate projection (0.002%), decarbonisation (0.002%), thermal expansion (0.002%), geoengineering (0.002%), unfccc (0.0013%), fluorinated gases (0.0013%), albedo (0.0013%), enhanced weathering (0.0013%), stern review (0.0013%), carbon budget (0.0013%), black carbon (0.0013%), southern oscillation (0.0013%), geological sequestration (0.0013%), integrated water resources management (0.0006%), sulfate aerosols (0.0006%), ice core (0.0006%), fluorocarbons (0.0006%), earth system model (0.0006%), world climate conference (0.0006%), carbon cycle (0.0006%), carbon leakage (0.0006%), climate services (0.0006%), enteric fermentation (0.0006%), ultraviolet radiation (0.0006%), conference of the parties (0.0006%), united nations environment programme (0.0006%), global average temperature (0.0006%), soil carbon (0.0006%), risk weather (0.0006%)

Sources: FactSet; Intergovernmental Panel on Climate Change, IPCC; the United States Environmental Protection Agency; the United Nations; the British Broadcasting Corporation, BBC; and IMF staff calculations.

Online Annex Table 5.4.3. Climate Disaster Related Terms and Percentage of Transcripts Including Them

hurricane (4.746%), flood (2.362%), drought (0.8642%), severe weather (0.8224%), adverse weather (0.6409%), tsunami (0.4209%), wildfire (0.4176%), extreme weather (0.3717%), severe winter weather (0.3177%), tornado (0.2833%), cyclone (0.2064%), typhoon (0.2044%), lightning (0.1936%), blizzard (0.1646%), snowstorm (0.1544%), windstorm (0.1079%), heat wave (0.0971%), monsoon (0.0924%), thunderstorm (0.0539%), inundation (0.0505%), snowpack (0.0472%), whirlwind (0.0296%), adverse winter weather (0.0222%), severe rain (0.0182%), storm surge (0.0148%), weather extreme (0.0121%), firestorm (0.0101%), extreme climate (0.0074%), tropical cyclone (0.0074%), severe snow (0.0053%), sea level rise (0.0033%), extreme rain (0.0033%), extreme precipitation (0.0026%), severe summer weather (0.0013%), extreme snow (0.0006%), sea level change (0.0006%)

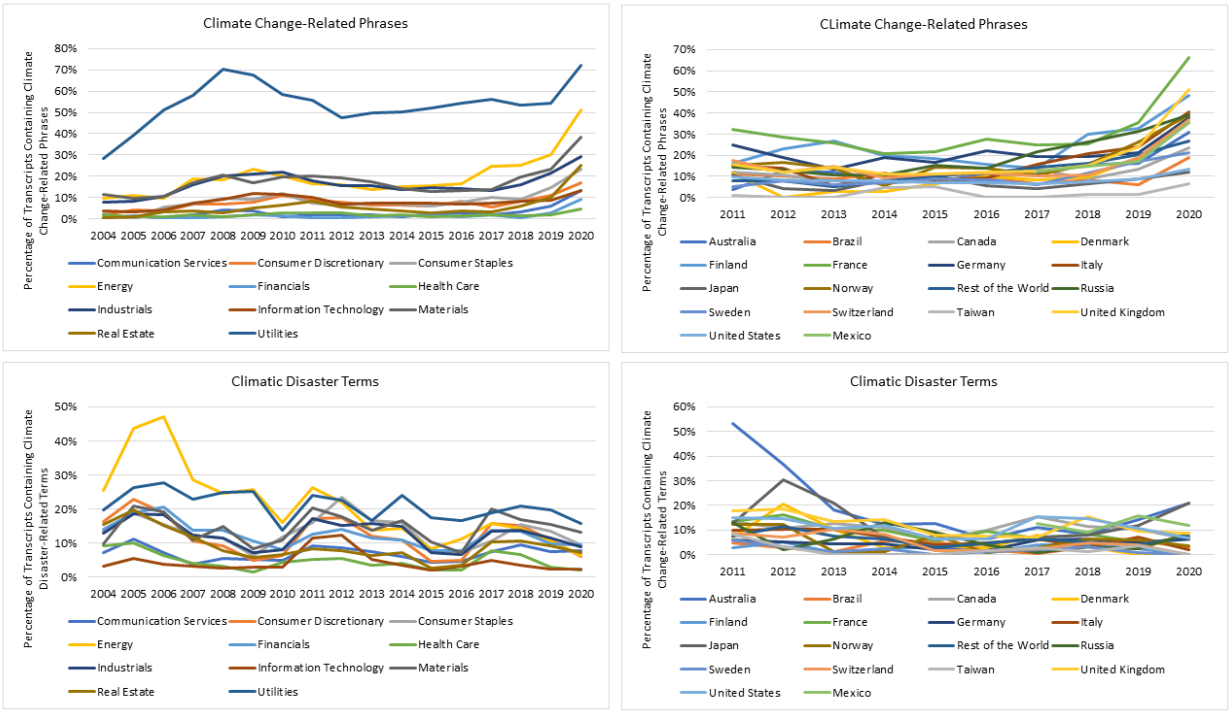
Sources: FactSet; and IMF staff calculations.

Recent Trends

Looking at the constructed indices, there seems to be a sharp increase in corporate discussions involving climate change-related topics in the last few years, and especially during the COVID-19 pandemic, across sectors and countries. No such increase is observed in climatic disasters-related discussions, suggesting that firms' awareness of physical risks has generally remained stable over the last decade. The steady uptick in climate change-related discussions since 2016 suggests that the Paris Agreement has affected awareness about regulatory risk and opportunities related to climate change..[11]

[11] These trends are robust to using a constant set of firms across time.

Online Annex Figure 5.4.1. Evolution of Country and Sector-Level Climate Change and Disaster Indices



Sources: FactSet; and IMF staff calculations.

Index Validation

To better understand the dimensions of climate change captured by the indices, they are regressed against proxies for climate change opportunities (firms' self-disclosed climate change commercial opportunities, firms' environmental score), climate change transition risk (firms' carbon intensity, firms' self-disclosed climate change commercial risks)[12], and climate change physical risk (a dummy equal to 1 if there was a climatic disaster in the country of the firm's headquarter in the quarter prior to the conference call). Results are shown in Online Annex Table 5.4.4.[13]

Firms that discuss climate change-related topics are more likely to have climate change commercial risks/opportunities and higher environmental scores as well as higher emissions intensity, suggesting that the *climate change discussion index* captures both firms' awareness of climate change risks and opportunities. The index is not correlated with climatic disaster events, which suggests it does not capture short-term physical risk.

In contrast, the *climate disaster discussion index* does capture short-run physical risk as measured by the occurrence of climatic disaster events in the previous quarter. The *climate disaster discussion index* is also

[12] The variables used as proxies for climate change risk and opportunities are obtained from Refinitiv DataStream. Online Annex 5.1 contains their descriptions.

[13] Results are generated using linear regressions and are robust to using the probit model.

positively correlated with climate-change related opportunities, though to a lower extent than the *climate change discussion index* when considering the environmental score.[14]

Online Annex Table 5.4.4. Correlations with Measures of Climate Change Opportunities and Risk

Dependent variable: *Climate change discussion index*								
Climate Change Commercial Risks/Opportunities	0.046***	0.021***						
	-0.004	-0.003						
Environmental Score			0.056***	0.038***				
			-0.004	-0.003				
Direct Emissions / Assets					0.082***	0.015**		
					-0.011	-0.006		
Disaster Classified by IMF (t-1)							0.005	-0.004
							-0.008	-0.008
Constant	0.1	-0.087**	0.092	-0.077*	0.025	-0.117*	-0.008	-0.075***
	-0.069	-0.04	-0.063	-0.046	-0.072	-0.067	-0.021	-0.018
Observations	88,025	87,839	87,242	87,057	33,224	33,203	117,165	113,984
R-squared	0.041	0.149	0.045	0.155	0.075	0.184	0.018	0.126
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	No	Yes	No	Yes	No	Yes	No	Yes
Size Control	No	Yes	No	Yes	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dependent variable: *Climate disaster discussion index*								
Climate Change Commercial Risks/Opportunities	0.027***	0.017***						
	-0.003	-0.003						
Environmental Score			0.015***	0.010***				
			-0.003	-0.003				

[14] Results from Online Annex Table 5.4.4 are robust to controlling for management scores.

Online Annex Table 5.4.4. Correlations with Measures of Climate Change Opportunities and Risk (concluded)

Direct Emissions / Assets					0.022***	0.003		
					-0.005	-0.005		
Disaster Classified by IMF (t-1)							0.023***	0.020***
							-0.007	-0.007
Constant	0.032	-0.022	0.014	-0.037	-0.035	-0.063	-0.032	-0.061*
	-0.04	-0.026	-0.038	-0.024	-0.07	-0.066	-0.023	-0.034
Observations	88,025	87,839	87,242	87,057	33,224	33,203	117,165	113,984
R-squared	0.059	0.078	0.055	0.077	0.058	0.08	0.05	0.074
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	No	Yes	No	Yes	No	Yes	No	Yes
Size Control	No	Yes	No	Yes	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Sources: Emergency Events Database (EM-DAT); FactSet; Refinitiv DataStream; and IMF staff calculations.
Note: Disaster Classified by IMF is a dummy variable equal to one if a large climatic disaster event took place on the country were the firm's headquarter is located. Large climatic disasters are classified according to April 2020 GFSR Chapter 5. Size is measured as firms' total assets. Firm Cluster means that standard errors are clustered at the firm-level.

The constructed indices also compare well with similar indices developed in the literature. For example, Sautner and others (2020) also construct indices based on earnings call transcripts.[15] The *climate change discussion index* tracks closely their regulatory and opportunities climate change exposure measures whereas the *climate disaster discussion index* tracks their physical exposure measure (Online Annex Figure 5.4.2).

Additional Results and Robustness Tests

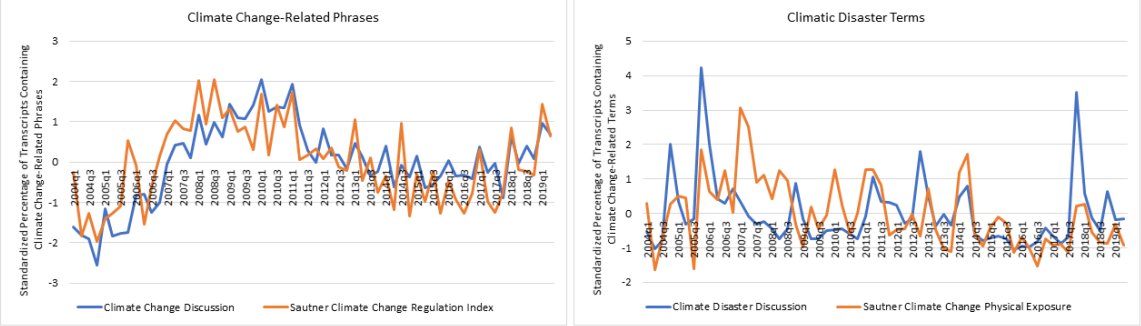
To assess other firm characteristics that tend to be associated with climate change-related discussions, the impact of firms' management quality is analyzed. Both the *climate change discussion index* and the *climate disaster discussion index* are positively correlated with firms' management quality, suggesting that better managed firms are more likely to be aware of both possible climate change risks and opportunities. This result holds when controlling for transcript length.

In addition, as a robustness check, for each of the previously analyzed dictionaries, a version of the indices is created in which the transcripts receive a value of one if they contain a phrase from the dictionary appearing together in the same sentences with the word "risk", the word "uncertainty", or any of their synonyms. Results

[15] The difference lies in the construction of the dictionaries: Sautner and others (2020) start from a small set of bigrams that are related to climate change and its sub-categories, and use an adaptation of a machine learning algorithm developed by King and others (2017) to produce a larger set of bigrams related to each sub-topic.

are very similar to the ones presented in the box and this annex. Similarly, results are robust to assigning each transcript a value equal to the share of sentences that contain both a phrase from the dictionary and a risk or uncertainty synonym.

Online Annex Figure 5.4.2. Climate Change and Disaster Indices Compared with Sautner and others (2020)'s Measures



Sources: FactSet and IMF staff calculations.

Online Annex Table 5.4.5. Are Better Managed Companies More Aware of Climate Change and Disaster Risks and Opportunities?

Dependent variable: *Climate change discussion index*					Dependent variable: *Climate disaster discussion index*				
ESG Score	0.036***	0.029***			ESG Score	0.015***	0.013***		
	-0.004	-0.003				-0.003	-0.003		
Management Score			0.020***	0.007***	Management Score			0.017***	0.012***
			-0.003	-0.003				-0.003	-0.002
Constant	0.078	-0.087*	0.051	-0.116**	Constant	0.014	-0.034	0.004	-0.045**
	-0.064	-0.047	-0.062	-0.045		-0.038	-0.024	-0.034	-0.02
Observations	87,273	87,087	87,273	87,087	Observations	87,273	87,087	87,273	87,087
R-squared	0.033	0.152	0.026	0.147	R-squared	0.055	0.077	0.056	0.077
Year-Quarter FE	Yes	Yes	Yes	Yes	Year-Quarter FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Country FE	Yes	Yes	Yes	Yes
Sector FE	No	Yes	No	Yes	Sector FE	No	Yes	No	Yes
Size Control	No	Yes	No	Yes	Size Control	No	Yes	No	Yes
Firm Cluster	Yes	Yes	Yes	Yes	Firm Cluster	Yes	Yes	Yes	Yes

Sources: FactSet; Refinitiv DataStream; and IMF staff calculations.
Note: Size is measured as firms' total assets. Firm Cluster means that standard errors are clustered at the firm-level.

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