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## Keywords

Institutional investors, pension funds, ESG risks, climate risks, downside risks

## Disciplines

Economics

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Abstract

Due to their long-term horizons, pension funds face enhanced exposures to the long-lived effects of many ESG risks. Moreover, given the potential consequences of being underfunded, pension funds are particularly exposed to ESG-related downside risks, especially those related to climate change. We discuss the implications of these risks and provide evidence on institutional investors' perspectives on climate-related downside risks and how these risks are priced in financial markets. We also document how institutional investors address climate risks in the investment process, with a focus on the role of engagement versus divestment.

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JEL Codes: G11, G23, G32, Q54

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Analyzing a firm from an ESG perspective allows pension fund managers to potentially identify risk exposures that would be missed using just traditional investment analysis. The types of risks most likely to be uncovered using an ESG lens can be categorized as reputation risk, human capital management risk, litigation risk, regulatory risk, corruption risk, and climate risk. In addition, the components of risk (e.g., systematic risks, tracking error, and downside risks) can be affected differentially by ESG issues. Some of the risks, notably climate risk, have changed in importance over time and even for others, such as corruption risk, the ESG lens can provide a heightened way in which to examine the effects of the risks on pension portfolios.[1]

Due to their long-term horizons, pension funds face enhanced exposures to the long-lived effects of many ESG risks, especially those that arise from climate change. In addition, the long-term nature of pension funds combined with the potential consequences of being underfunded leaves their portfolios, particularly those for defined benefit plans, more exposed to the repercussions of downside risks, that is, to sharp declines in asset values. Specifically, many pension funds face large liabilities towards their beneficiaries, and the failure to meet those liabilities because of significant negative ESG-related events carries large penalties. Thus, with wealth protection being an important dimension, pension funds should have a strong preference to identify and address ESG-related downside risks. Downside risks have also become important for pension funds from a more general portfolio construction perspective, as mounting evidence shows that asset returns are typically skewed. Left-skewed asset returns in particular violate a key assumption of the standard mean-variance investment framework, and asset allocation models have in turn been developed that explicitly incorporate the resultant downside risks.

In this paper, we first review different types and sources of ESG-related risks, with a focus on climate-related downside risks. We then report evidence on institutional investors' perspectives on the importance of climate-related downside risks and how such risks are priced in financial markets. We also demonstrate whether and how institutional investors address climate-related risks in the investment process.

**Types of ESG-related Risks**

**Reputation risk.** ESG issues pose significant reputational risks to the firms in which pension funds invest. The increasingly public discussion of firms' ESG activities through internet media sources and social media have created the possibility that management missteps in these areas result in material effects on firms' reputations. Moreover, the effects of reputational risk on market value can be quite large given that estimates of the value of intangible assets for firms in the S&P 500 have increased from about 17 percent in 1975 to 90 percent in 2020 (Ocean Tomo 2020).[2] In a recent survey, firms were asked to rank their top three most important subclasses of intangible assets beyond intellectual property and information assets (Ponemon 2020). Among the top responses, 69 percent of the firms stated their third-party relationships, such as with customers, suppliers, vendors, and supply chains, and 47 percent stated their brand as being the top three most important subclasses of intangible assets. These two types of intangible assets would be particularly vulnerable to reputational penalties imposed on a firm because of ESG controversies or poor ESG practices.

Further evidence that ESG reputation risk can be significant is reflected in the fact that most of the ESG ratings agencies now include some type of controversy rating to ensure that their client investors are aware of the existing controversies that can affect a firm's reputation. For example, Sustainalytics states that ESG controversies ratings identify 'companies involved in incidents and events that may pose a business or reputation risk to a company due to the potential impact on stakeholders or the environment' (Sustainalytics 2021: 1). In fact, because of their contributions to a firm's ESG risk exposures, the controversies ratings have become a central part of most ESG ratings services. For example, a study by the EU Commission on sustainability-related ratings (European Commission 2020) has a section on 'Controversy Ratings.' This section specifically points to the different ESG ratings agencies, who provide news sentiment and controversy alerts so that investors become aware of the behaviors and practices of firms and countries that are not compatible with the investors' policies, and that could lead to reputational risks.[3] For some of the rating agencies, a firm's controversy level is a significant part of the overall ESG score; for others it is reported as a separate score. In addition, for one agency, RepRisk, the controversy issues represent the total score. The EU Commission's study points out that 'Increasingly sustainability-related ratings providers are factoring controversies, allegations and negative news into their assessments of companies as a means of layering in risk exposure and signalling (potential) poor management' (European Commission 2020: 99). Again, these controversy ratings are consistent with the argument that using an ESG lens allows investors to go beyond traditional valuation models to assess risks that would not be captured by those models.

The controversy ratings have allowed ESG rating agencies to give warnings, thus helping investors assess, or even avoid, firms with greater ESG risk exposure. For example, MSCI argues that in the two years prior to the emissions scandal, they had flagged Volkswagen on controversies related to product and service quality, bribery and fraud, and collective bargaining (MSCI 2015).

**Human capital management risk.** Although human capital management risk has long been an aspect of ESG risk, it has come under heightened scrutiny during the COVID-19 pandemic because the pandemic highlighted firms' treatments of their employees. That is, the crisis highlighted how a firm's handling of social issues, of which human capital is a key component, affects firm performance. Recent evidence shows that investors became more concerned about how firms treat their human capital (Albuquerque et al. 2020; Cheema-Fox et al. 2020).

**Litigation risk.** Litigation related to ESG issues can increase for firms considered to have poor ESG practices. For example, a number of jurisdictions (counties and cities) have filed lawsuits against oil firms, seeking compensation for climate change damages (e.g., New York City, Oakland, San Francisco, Boulder, San Mateo County, and Marin County). Recently, PG&E had to file for bankruptcy as a result of legal claims related to the Californian wildfires exceeding $10 billion. Similarly, BP had to pay more than $18 billion to settle legal claims related to the oil spill at its Deepwater Horizon offshore drilling rig.[4]

**Regulatory risk.** Regulatory risk recognizes that new (costly) regulations related to ESG can arise, and such regulations have been increasing over time. For example, according to an October 2018 report by Datamaran, during the previous three years ESG-related regulations grew by more than 100 percent in the UK, US, and Canada (Datamaran 2018). Recently, the EU established new regulation that requires all financial market participants and financial advisors to disclose specific information on their approaches to the integration of a 'sustainability risk' into their investment decisions. They also have to disclose the extent to which their decision-making process and their investment products take into account the consideration of 'sustainability factor' adverse impacts. A 'sustainability risk' is defined as an 'environmental, social or governance event or condition that, if it occurs, could cause an actual or potential material negative impact on the value of the investment.'[5] Regulatory risk is a particularly important component of climate risk (along with physical risk and technological risk) and will be discussed in more detail below.

**Corruption risk.** The risks related to corruption lead to both financial and reputational risks. Beck et al. (2005) provide evidence that corruption can hamper firm growth. In line with this evidence, institutional investors consider corruption risk to be a highly important risk. In a recent PwC survey of institutional investors, the investors identified anti-corruption along with climate change as their top two ESG concerns (PwC 2016).

**Climate risk.** As pointed out by Litterman (2016) and Krueger et al. (2020), climate risk can negatively affect asset values, particularly for long-term investors such as pension funds. Thus, climate risk is an important consideration for the asset allocation and risk management of pension funds. Climate risk can originate from physical risks (e.g., sea level rise, storms, or extreme temperature), regulatory risks (regulation to combat climate change), or technological risks (technological climate-related disruption), all of which can be financially material. The problem is that climate risk can be difficult to price and hedge due to its systematic nature, the fact that there does not exist sufficient disclosure by many firms that could be incorporated into the risk consideration, and the difficulty in finding suitable hedging instruments. Not surprisingly, institutional investors, corporate executives and policy makers have shown increased concerns regarding climate risk and climate risk disclosure. Below we provide more discussion of different climate risks and their role for pension funds.

### Risk Components and ESG-related Risks

**Systematic risk.** Systematic risk, that is, the risk that a firm has in common with the market, can contain ESG elements. Notably, Bénabou and Tirole (2010) point out that firms with higher ESG characteristics may have different systematic risk exposures, either due to their resilience in periods of crisis or because the firms face a specific ESG risk factor. Given these systematic risk exposures, the firms would be expected to require different risk premia, and consequently, have different expected returns. Albuquerque et al. (2019) develop a theoretical model consistent with this idea. In their model, firms have a choice to engage in ESG activities in order to increase their product differentiation and enhance their profits. The primary prediction arising from the model is that better ESG activities decrease systematic risk and increase firm value. The authors empirically test this model and find support for the predictions.[6] In further empirical tests, they show that the profits for high-ESG-scoring firms are less correlated with the business cycle than the profits for low-ESG-scoring firms.[7]

**Tracking error.** Integrating ESG considerations into a portfolio process does not always reduce all components of portfolio risk as omitting firms or industries because of ESG concerns (e.g., negative screening) can lead to increased tracking error in a portfolio (e.g., Branch et al. 2019). Institutional investors that track an index or are evaluated relative to an index may in turn be concerned about ESG-related track error.

**Downside risk.** For some investors, firms with higher ESG profiles provide a type of protection against downside risk because these firms are considered to be better managed and in turn have lower exposure to ESG risks. Empirical evidence demonstrates that the tail-risk measures are closely linked to ESG risk, as firms with better ESG performance are less vulnerable to firm-specific negative events (e.g., Diemont et al. 2016; Krueger 2015). Because of this, one of the primary arguments for integrating ESG analysis into portfolio investment decisions is the claim that such integration will mitigate risk, particularly downside risk. Among the most potentially devastating risks are risks that arise from controversies. These controversies may arise from the E of ESG (e.g., emissions, toxic wastes, and environmental disasters) or the S (e.g., human rights, labor rights, customer privacy, and product safety) or the G (e.g., bribery, fraud).

Two recent cases where ESG-related downside risks materialized are the PG&E involvement in the California fires, which was primarily an environmental risk but also involved social and governance risk, and the Wells Fargo series of scandals, which were primarily social risks, given the effects on customers, but also include governance risks. Both cases involved more than a single event and *ex post* analyses of the subsequent events indicate that these events had large negative effects on the stock prices of the two firms, even after controlling for stock market movements. These two events provide examples of the ESG-related downside risks that can occur. In both cases, pension funds lost significant amounts of money from their investments in these firms.

### Climate-related Downside Risks

**Importance of climate-related downside risks.** In recent years, there has been an increasing amount of research on the financial effects of climate risk, which should be of particular relevance to pension fund managers and sponsors because of the potential portfolio effects. Researchers have provided theoretical evidence that climate risk should have a large effect on financial markets and may be mispriced (e.g., Daniel et al. 2016; Bansal et al. 2016); empirical evidence that equity markets underprice climate risk and underreact to it (Hong et al. 2017); and empirical evidence that extreme weather uncertainty affects financial markets (e.g., Kruttli et al. 2021). Further, Pankratz et al. (2021) show that firms with increased exposure to high temperatures face reductions in revenues and operating income. With regard to firm value, evidence suggests that increased climate risk disclosure affects firm value (Krueger 2018); that firms' exposures to climate risk predicts their stock returns (Kumar et al. 2019); that investors demand greater compensation from firms with higher carbon emissions (Bolton and Kacperczyk 2021); and that exposure to regulatory climate shocks negatively correlates with firm valuations in recent years (Sautner et al. 2021).

Another possible concern for pension fund portfolio managers and sponsors lies in the evidence that potential sea level rise is already affecting real estate prices (e.g., Bernstein et al. 2019; Baldauf et al. 2020; Keys and Mulder 2020).[8] These potential consequences of climate risk make it even more difficult for pension fund managers, because climate risk is quite difficult to hedge (Andersson et al. 2016).

This broad base of evidence suggests that institutional investors, and pension fund managers in particular, should be worried about climate change and the resulting risks for their portfolio firms. Direct evidence supporting the claim that climate risks are an important concern for investors comes from Krueger et al. (2020) (KSS henceforth). KSS conduct an international survey among institutional investors, with 23 percent identifying as being asset managers, 22 percent banks, 17 percent pension funds, 15 percent insurance companies, and 8 percent mutual funds. There was a range of institution sizes but the majority had assets under management of at least $1 billion, including 11 percent that had assets of more than $100 billion. The sample was global, with 32 percent located in the US, 17 percent in the UK and Ireland, 12 percent in Canada, 11 percent in Germany, 7 percent in Italy, and 5 percent in Spain (the rest are located elsewhere in the world).

In questions regarding the importance of climate risks relative to other risks, as Figure 6.1 shows, most of the survey participants believe financial risk to be the most important, and climate risks, among other risks, to be relatively less important. However, on an absolute basis, the responses reported in KSS suggest that climate risks are deemed to have material financial consequences for portfolio firms. Moreover, in a question about their temperature expectations, the majority of respondents indicated that they expect a rise in global temperatures, and a significant number believe that the temperature rise will exceed the Paris two-degree target.

Further, their responses show that the majority believe that some climate risks, such as regulatory risk, have already been materializing. This is strong evidence, given theoretical evidence regarding the uncertainty of the time horizon over which climate risks would be materializing (e.g., Barnett et al. 2020; Andersson et al. 2016).

*Figure 1 here*

**Pricing of climate-related downside risks.** Consistent with KSS's evidence that investors worry about climate risks, Ilhan et al. (2021) (ISV henceforth) demonstrate that uncertainty about climate-related downside risks began to be priced in financial markets. They argue that regulatory measures to limit carbon emissions, for example, in the form of a carbon tax or limits on emissions, will have a significant financial impact on firms that produce large carbon emissions. Notably, for these types of firms, regulation that limits carbon emissions can lead to substantial increases in the cost of doing business or even to stranded assets. If banks reduce funding to carbon-intense firms, for instance, because of climate-related capital requirements, such firms may also experience constraints when financing future investment activities. At the same time, it is highly uncertain when and to what extent carbon-intense firms will be affected by future regulation. This climate policy uncertainty poses a challenge for investors in terms of adequately assessing how and when climate regulation will affect firms.

ISV address these issues empirically by exploring whether the option market prices climate policy uncertainty. Specifically, for their sample of S&P 500 firms, they test whether protection against downside tail risks through put options is more expensive for firms that emit more carbon. The benefit of examining traded options is that options-based measures reflect market participants' expectations of risk. Their primary measure to capture downside risk, *SlopeD*, reflects the steepness of the implied volatility slope; higher values of *SlopeD* indicate that deeper out-of-the-money put options are more expensive, and this reflects a relatively higher option protection cost against left-tail risks.

ISV provide a series of results documenting that climate policy uncertainty is priced in the option market. ISV's regression estimates, reproduced in Table 6.1, show that an increase in a firm's (log industry) carbon intensity by one-standard deviation increases *SlopeD* by 0.014 (see Column 1). This increase is meaningful as it equals about 10 percent of the standard deviation of *SlopeD*. Overall, ISV's evidence suggests that put options of carbon-intense firms are relatively more expensive, in particular for the far-left tail, as they protect investors against downside risks originating from climate policy uncertainty. ISV also show that the effect of carbon intensities on downside risk is amplified when the public pays relatively high attention to climate change topics. The reason is that public attention to climate change topics increases the likelihood that pro-climate policies are adopted due to public scrutiny.

*Table 1 here*

ISV use President Trump's election in 2016 as an event that reduced short-term climate policy uncertainty. While Trump signaled in his election campaign that climate-related policies would not become stricter, his opponent Hillary Clinton instead promised climate-friendly policies. ISV's tests in turn exploit that President Trump's election meant no change in the status quo of US climate regulation, whereas the election of Clinton would have implied the opposite. These arguments imply that for carbon-intense firms, the cost of insurance against downside risks associated with climate policy uncertainty should have declined after the election of President Trump. Supporting this prediction, Table 6.2 demonstrates ISV's result that *SlopeD* for very carbon-intense firms indeed declined by 0.025 (Column 1) after President Trump's election, relative to less carbon-intense firms—a reduction equal to 12 percent of *SlopeD*'s standard deviation.

*Table 2 here*

**Addressing climate-related downside risks.** Given the uncertainty surrounding climate risk and ISV's evidence that climate-related downside risks are being priced, it is perhaps not surprising that investors started to address climate risks in their investment processes. In their global survey, KSS also asked the institutional investors which approaches, if any, they had taken to incorporate climate risks into their investment processes (they asked about the previous five years). The responses are provided in Table 6.3. As the table indicates, all but 7 percent of the investors have chosen 'some' approach for incorporating climate risk management into their investment process.[9] The most common approach taken by the institutional investors (38%) is to analyze the carbon footprint of their portfolio firms. Further, 29 percent of the respondents attempt to reduce the carbon footprint of their investment portfolios. Another common approach, followed by 35 percent of the investors, is to analyze the stranded asset risks in their portfolios, that is, the risk of having an asset lose economic value earlier than anticipated due to climate change effects. Again, some of the respondents (23%) take this approach a step further by not only analyzing their portfolios' stranded asset risks, but also trying to reduce these risks (23%).

Over a third of the investors (34%) take an indirect approach because they believe that their general portfolio diversification serves as one method to incorporate climate risks into their portfolio process. In contrast, some investors (26%) take a direct approach by employing valuation models that specifically incorporate climate risks. Other direct approaches employed are to submit shareholder proposals to portfolio firms (25%), to hedge against climate risks (25%), or to employ negative screening (24%). It is striking that out of the list of 12 possible approaches offered to the respondents, the least frequently used method of dealing with climate risks is divestment, which is employed by 20 percent. The respondents could select more than one approach, and in further analyses we find that those who employ more approaches are those who are more concerned about the financial costs of climate change, those with longer horizons and who have a larger fraction of their portfolios managed using ESG analysis. Given the wide variety of approaches commonly employed, it appears that the investment industry is still trying to find out how to most effectively manage climate risks; this likely also applies to pension funds.

*Table 3 here*

As we discuss below, Hoepner et al. (2021) provide evidence that shareholder engagement by investors can reduce downside ESG risks, especially those originating from climate change. The survey by KSS thus also asked investors what measures of engagement over climate risk issues they have taken with any of their portfolio firms (during the past five years). Similar to the results in Table 6.3 of the heterogeneity of approaches taken to incorporate climate-related risks into their investment processes, the answers to this question, provided in Table 6.4, show that the respondents do not employ a unique approach to their engagement strategy, but that they employ a number of different methods. Moreover, the survey investors have a generally high level of engagement with their portfolio firms, as only 16 percent did not have any engagements over the period.[10] The most often used channel is to hold discussions with firm management regarding the financial consequences of climate risks for firms, which is used by 43 percent of the respondents. Thirty-two percent of the respondents propose specific actions to management on climate-risk issues. On the other hand, some of the investors choose to abandon the behind-scenes-approach and question management on a conference call about climate-risk issues (30%), publicly criticize management on climate-risk issues (20%), or submit a shareholder proposal on climate issues

(30%). A number of the investors (30%) vote at the annual meeting against management on proposals over climate issues. Smaller fractions vote against the re-election of any individual board directors due to climate-risk issues or take legal action against management over climate-related issues.

*Table 4 here*

The investors reported that they usually received a response to their engagement, although the response could be a simple acknowledgement of the engagement rather than any actions by the firm to respond to the investor's concerns. The investors also indicated that if their engagement efforts were rebuffed, they typically did not escalate the engagement, try to hedge or divest from the firm. This lack of divestment due to failure of an engagement, combined with the lack of divestment for risk management purposes as discussed above, is striking given the ongoing debate regarding whether to divest from fossil fuel firms.

In the survey, the question of stranded asset risks due to climate change was also explored at a deeper level by asking the respondents the following: 'Responses to climate change may cause some assets to become 'stranded'—i.e., unable to recover their investment cost, with a loss of value for investors. How large do you consider this risk in the following areas?' Then a list of industries was provided which included coal producers, unconventional oil production (e.g., tar sands, fracking), conventional oil producers, natural gas producers, iron and steel producers, and conventional electricity producers. The results are provided in Table 6.5. The two industry sectors for which the largest percentage of respondents considered the risks to be very high were coal producers (25.1% of respondents) and unconventional oil producers (21.1%). In addition, 16.7 percent of the investors thought that conventional oil producers have a very high risk of stranded assets and the responses for the other types of producers were lower, but significant. Although it might be surprising that only 25.1 percent of the investors thought that the stranded asset risk was high in the coal industry, it should also be noted that the average response to the question is 2.73 (out of 4). This magnitude provides a stronger possibility that investors think stranded asset risk is high in the coal sector. There were also significant relations regarding the types of investor institutions who believe that the stranded asset risks are high in these sectors. For example, the investors more concerned about the financial effects of climate risks are the ones who believe that stranded asset risks are higher among oil and natural gas producers. In addition, for most of the sectors, investors who engage portfolio firms more over climate-risk topics, those with a higher share of investments under ESG principles, and those with a higher passive investment share, view stranded asset risks to be higher.

*Table 5 here*

The survey evidence by KSS shows that a number of investors engage with their portfolio firms on climate issues. To understand whether such engagement can reduce downside risks, Hoepner et al. (2021) employ proprietary data regarding the activities of a large investor, who specializes in engagements with firms on ESG issues for both its own account and those of others. Through an analysis of 1,712 engagements across 573 targets worldwide over the 2005-18 period, the authors find that a successful engagement typically takes about three years.

The authors employ two measures to examine whether a shareholder engagement appears to affect the downside risk of the target firms. The first measure is the lower partial moment of the second order (LPM) using a zero percent-return-threshold, that is, the negative part of the return distribution of returns. The second measure is the investment’s value at risk (VaR). Using these measures in two different empirical approaches (difference-in-differences and factor model), the authors provide evidence that a successful ESG engagement by the investor is followed by reductions in the target firms' downside risk. They further find that engagement over environmental topics delivers the highest benefits in terms of downside risk reduction, and environmental engagements primarily feature the theme of climate change. This finding is consistent with the survey evidence in KSS, which indicates as discussed above that engagement over climate change is an important channel through which some institutions attempt to tackle climate-related risks. The results by Hoepner et al. (2021) suggests that such engagements have the potential to deliver substantial benefits for investors. Using the factor model approach, Hoepner et al. (2021) also find that the downside risk factor associated with a firm tends to decrease after at least partially successful engagements. Similar evidence is obtained by Dyck et al. (2019) who demonstrate that institutional investors are able to improve the ESG profiles of portfolio firms.

**Conclusions**

In this paper, we discuss the implications of ESG risks for pension fund portfolios. We argue that the long-term horizons of pension funds exposes them to the long-lived effects of many ESG risks, especially those related to climate change. The potential consequences of being underfunded also leaves pension funds particularly exposed to ESG-related downside risks. We demonstrate how downside risks may affect pension funds in the face of climate change. We provide evidence showing that institutional investors think that climate risks are imminent today and have important financial implications for their portfolio firms. We also show that these risks are priced in financial markets. Finally, we present evidence on whether and how institutional investors address climate-related risks in the investment process. We show that the investors tend to prefer to employ risk management and engagement strategies, rather than divestment, to address the climate risk in their portfolios. Overall, our evidence implies that pension funds should develop processes to identify, measure, and manage ESG-related downside risks, especially those related to climate change.

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**Endnotes**

[1] Some of the other authors cited in this paper use the terminology CSR (corporate social responsibility) rather than ESG. We use the term ESG throughout this paper rather than alternating between ESG and CSR.

[2] The composition of firms in the S&P 500, particularly the largest firms, has changed during the period. The top five firms in 1975 were IBM, Exxon, Procter & Gamble, General Electric and 3M. The top five firms in 2020 were Apple, Microsoft, Amazon, Alphabet, and Facebook. Obviously, the latter have significantly more of their assets in intangible assets.

[3] The agencies the EU cites as providing the controversy information are RepRisk, Bloomberg Environmental & Social News Sentiment Scores, MSCI ESG Controversies, Sustainalytics Controversies Research and Reports, ISS Country Controversy Assessment, and Vigeo Eiris Controversy Risk Assessment.

[4] See Gilbert and Kent (2015) and Gold (2019).

[5] See Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability-related disclosures in the financial services sector.

[6] In other tests on the relation between ESG scores and systematic risk, Oikonomou, Brooks, and Pavelin (2012) provide evidence that ESG/CSR performance is negatively but weakly related to systematic firm risk. They conclude that corporate social irresponsibility is positively and strongly related to financial risk.

[7] Some practitioners have a similar view on the systematic element of ESG risks. These practitioners maintain that since ESG are systematic risk factors, investing according to ESG risks would then be a form of smart beta. The implication of this view is that these risk factors are

mispriced and consequently, an investor could take advantage of this fact by constructing a portfolio with specific exposure to ESG risks.

[8] It should be noted that Murfin and Spiegel (2020) provide contrasting evidence.

[9] It should be noted that respondents with more sophisticated tools would have been more likely to participate in the survey.

[10] In a survey of institutional investors regarding their shareholder engagements, McCahery et al. (2016) find that 19 percent of the respondents did not engage with their portfolio firms.

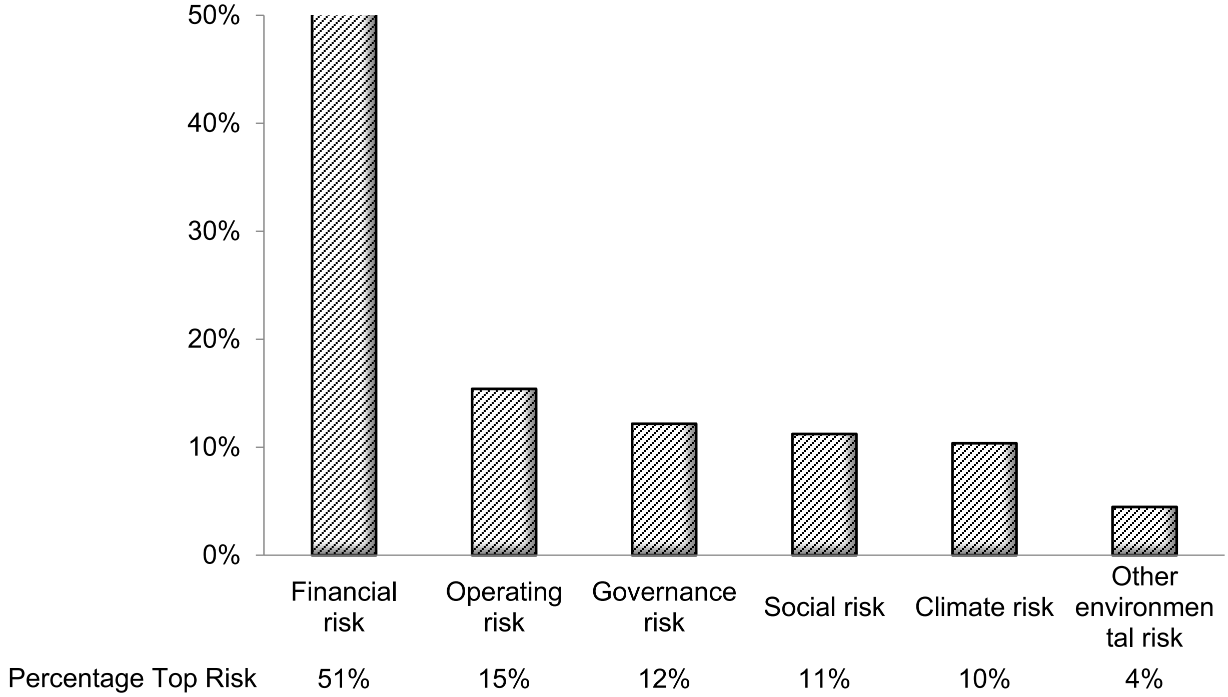


**Figure 1.** Comparative importance of climate risks.

*Note:* This figure reports the respondents' rankings of six major investment risks. Respondents were asked to rank the six risks from one to six, where one is the most important risk and six the least important risk. The figure reports the percentages of respondents that rank a risk as the most important risk.

*Source:* Krueger et al. (2020), Table 2.

**Table 1.** Effects of carbon emission on downside risk

| Dependent variable: | *SlopeD* | *SlopeD* | *SlopeD* |
|---|---|---|---|
| | (1) | (2) | (3) |
| *log(Scope 1/MV firm)* | 0.006*** | | |
| | (3.39) | | |
| *Residual log(Scope 1/MV firm)* | | 0.003 | 0.005 |
| | | (0.81) | (1.06) |
| *log(Scope 1/MV industry)* | | | 0.006*** |
| | | | (3.76) |
| Model | Heckman | Heckman | Heckman |
| Controls | Yes | Yes | Yes |
| Year-by-quarter fixed effects | Yes | Yes | Yes |
| Level | Firm | Firm | Firm |
| Frequency | Monthly | Monthly | Monthly |
| Obs. | 18,664 | 18,664 | 18,664 |
| Adj. $R^2$ | n/a | n/a | n/a |

*Note:* This table reports regressions estimated at the firm-month level. *SlopeD* measures the steepness of the function that relates implied volatility to moneyness (measured by an option's Black-Scholes delta) for OTM put options with 30 days maturity. *Scope 1/MV firm* are a firm's Scope 1 carbon emissions (in metric tons of $CO_2$) divided by the firm's equity market value (in millions $). *Scope 1/MV industry* is the Scope 1 carbon intensity of all firms in the same industry (SIC4) and year. It is defined as total Scope 1 carbon emissions (metric tons of $CO_2$) of all reporting firms in the industry divided by the total market capitalization of all reporting firms in the industry (in millions $). *Residual log(Scope 1 MV/firm)* is the residual of an OLS regression with *log(Scope 1/MV firm)* as the dependent variable and *log(Scope 1/MV industry)* as the independent variable. The regressions in the table control for *log(Assets), Dividends/net income, Debt/assets, EBIT/assets, CapEx/assets, Book-to-market, Returns, Institutional ownership, CAPM beta, Volatility, Oil beta,* and a time trend (not reported). The sample includes all firms in the S&P 500 with data on carbon emissions disclosed to CDP. The table estimates the effect of emissions generated between 2009 and 2016 on option market variables measured between November 2010 and December 2017. *t*-statistics, based on standard errors clustered by industry (SIC4) and year, are in parentheses. n/a, not applicable. **p*<0.1; ***p*<0.05; ****p*<0.01.

*Source:* Ilhan et al. (2021), Table 4.

**Table 2.** Effect of 2016 Trump election on climate-related downside risk

| Dependent variable: | *SlopeD* | *SlopeD* | *SlopeD* | *SlopeD* |
|---|---|---|---|---|
| Event window: | [-250; +250] | [-250; +250] | [-250; +250] | [-250; +250] |
| | (1) | (2) | (3) | (4) |
| *Post Trump election x High Scope 1/MV Industry* | -0.025** | -0.029** | -0.025*** | -0.020** |
| | (-2.18) | (-2.43) | (-2.88) | (-2.20) |
| *Scope 1/MV industry high* | 0.041* | 0.043* | | |
| | (1.67) | (1.77) | | |
| *Post Trump election* | -0.025*** | | | -0.022*** |
| | (-4.63) | | | (-4.33) |
| Model | DiD | DiD | DiD | DiD |
| Controls | Yes | Yes | Yes | Yes |
| Day fixed effects | No | Yes | Yes | No |
| Firm fixed effects | No | No | Yes | No |
| Industry fixed effects | No | No | No | Yes |
| Level | Firm | Firm | Firm | Firm |
| Frequency | Daily | Daily | Daily | Daily |
| Obs. | 200,897 | 200,897 | 200,897 | 200,897 |
| Adj. R-sq. | 0.062 | 0.091 | 0.294 | 0.184 |

*Note:* This table reports regressions estimated at the firm-day level. Results are from difference-in-differences regressions around the date of President Trump's election on November 9, 2016. *SlopeD* measures the steepness of the function that relates implied volatility to moneyness (measured by an option's Black-Scholes delta) for OTM put options with 30 days maturity. *Post-Trump election* equals one for all days after President Trump's election, and zero for all days before the election. *Scope 1/MV industry high* equals one for firms that operate in the top-10 industries based on *Scope 1/MV industry*, and zero otherwise. The regressions control for *Effective tax rate*, *Effective tax rate x Post-Trump election*, *log(Assets), Dividends/net income, Debt/assets, EBIT/assets, CapEx/assets, Book-to-market, Returns, Institutional ownership, CAPM beta, Volatility,* and *Oil beta* (not reported). The sample includes all firms in the S&P 500 with data on carbon emissions disclosed to CDP. *t*-statistics, based on standard errors double clustered by firm and day, are in parentheses. *$p$<0.1; **$p$<0.05; ***$p$<0.01.

*Source:* Ilhan et al. (2021), Table 7.

**Table 3.** Climate-risk-management approaches

| Climate-risk-management approaches taken in the past five years | | Percentage that took this measure (%) | Significant differences in mean response vs. rows |
|---|---|---|---|
| | | (1) | (2) |
| (1) | Analyzing carbon footprint of portfolio firms | 38.0 | 4-14 |
| (2) | Analyzing stranded asset risk | 34.6 | 5-14 |
| (3) | General portfolio diversification | 33.9 | 6-14 |
| (4) | ESG integration | 31.7 | 6-14 |
| (5) | Reducing carbon footprint of portfolio firms | 29.3 | 1-2, 10-14 |
| (6) | Firm valuation models that incorporate climate risk | 25.9 | 1-4, 12-14 |
| (7) | Use of third-party ESG ratings | 25.6 | 1-4, 12-14 |
| (8) | Shareholder proposals | 25.1 | 1-4, 12-14 |
| (9) | Hedging against climate risk | 24.6 | 1-4, 13-14 |
| (10) | Negative/exclusionary screening | 23.7 | 1-5, 13-14 |
| (11) | Reducing stranded asset risk | 22.9 | 1-5, 13-14 |
| (12) | Divestment | 20.2 | 1-8, 12-14 |
| (13) | None | 7.1 | 1-12, 14 |
| (14) | Other | 3.7 | 1-13 |

*Note:* This table reports the percentage of 410 respondents that in the previous five years took a given approach to incorporate climate risks into the investment process. Responses were not mutually exclusive. The table ranks results based on their relative frequency. Column (1) presents the percentage of respondents that took a certain measure. Column (2) reports the results of a *t*-test of the null hypothesis that the percentage for a given approach is equal to the percentage for each of the other approaches, where only differences significant at the 10% level are reported.

*Source:* Krueger et al. (2020), Table 4.

**Table 4.** Climate-risk engagement

| Direct engagement over climate-risk issues in the past five years | | Percentage that used this approach (%) | Significant difference in mean response vs. rows |
|---|---|---|---|
| | | (1) | (2) |
| (1) | Holding discussions with management regarding financial implications of climate risks | 43 | 2-10 |
| (2) | Proposing specific actions to management on climate-risk issues | 32 | 1, 6-10 |
| (3) | Voting against management on proposals over climate-risk issues at annual meeting | 30 | 1, 6-10 |
| (4) | Submitting shareholder proposals on climate-risk issues | 30 | 1, 6-10 |
| (5) | Questioning management on a conference call about climate-risk issues | 30 | 1, 6-10 |
| (6) | Publicly criticizing management on climate-risk issues | 20 | 1-5, 9 |
| (7) | Voting against re-election of any board directors due to climate-risk issues | 19 | 1-5, 9 |
| (8) | Legal action against management on climate-risk issues | 18 | 1-5, 9 |
| (9) | Other | 1 | 1-8, 10 |
| (10) | None | 16 | 1-9 |

*Note:* This table reports the percentage of 406 respondents that haven taken a particular approach of direct engagement over climate-risk issues in the previous five years. The table ranks results based on their relative frequency. Responses were not mutually exclusive. Column (1) presents the percentage of respondents that took a certain approach. Column (2) reports the results of a *t*-test of the null hypothesis that the percentage for a given approach is equal to the percentage for each of the other approaches, where significant differences at the 10% level are reported.

*Source:* Krueger et al. (2020), Table 6.

**Table 5**. Stranded asset risk

| Stranded asset risk | % with 4 ('very high') score (1) | Mean score (2) | % with 'Do not know' (3) | N (4) | H0: Mean Score = 1 (4) | Significant differences in mean score vs. rows (6) |
|---|---|---|---|---|---|---|
| (1) Coal producers | 25.1 | 2.78 | 3 | 371 | *** | 2-6 |
| (2) Unconventional oil producers | 21.3 | 2.69 | 3 | 371 | *** | 1, 4-6 |
| (3) Conventional oil producers | 16.7 | 2.64 | 4 | 371 | *** | 1, 4-6 |
| (4) Natural gas producers | 11.9 | 2.46 | 3 | 370 | *** | 1-3, 5 |
| (5) Iron and steel producers | 11.7 | 2.40 | 5 | 369 | *** | 1-4 |
| (6) Conventional electricity producers | 10.5 | 2.42 | 4 | 371 | *** | 1-3 |

*Note:* This table reports the investors' responses to the question of how large they consider the risk that climate change causes some assets to become stranded, that is, unable to recover their investment cost, with a loss of value for investors. The survey listed six industries for which the respondents were asked to evaluate this risk. Respondents could indicate their views on a scale of one ('low') through four ('very high'). They could also indicate 'Do not know'. Column (1) presents the percentage of respondents indicating that stranded asset risk is 'very high'. The table ranks results based on this measure. Column (2) reports the mean score, where higher values correspond to higher stranded asset risk. Column (3) presents the percentage of respondents indicating 'Do not know.' Column (4) reports the number of respondents. Column (5) reports the results of a *t*-test of the null hypothesis that each mean score is equal to 1 (low stranded asset risk). Column (6) reports the results of a *t*-test of the null hypothesis that the mean score for a given reason is equal to the mean score for each of the other reasons, where significant differences at the 10% level are reported. *t*-statistics (reported in parentheses) are based on standard errors that are clustered at the investor-country level. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

*Source:* Krueger et al. (2020), Table 10.