Global Carbon Divestment and Firms' Actions*

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Abstract

We examine the actions of financial institutions and firms regarding greenhouse gas emissions. We find that financial institutions around the world reduce their exposure to stocks of high-emission industries after 2015, especially for those located in high-climate-awareness countries, suggesting that institutions are concerned about climate risks in recent years. In the presence of divestment, public high-emission firms in the same countries tend to experience lower price valuation ratios, but they increase capital expenditure, research and development (R&D) expenses, and green innovation activities, and reduce emissions resulting from their operations. We do not obtain the same results using private firms. Our results support the notion that divestment campaigns by financial institutions exert pressure on public firms to adopt climate-friendly policies and decrease carbon footprints.

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1 Introduction

As the world experienced more extreme weather events in recent years, public concerns over climate risks have raised and the urge to combat climate change has become stronger. In the financial market, investors and financial institutions are also taking more responsibilities. Some of the largest investors, including sovereign wealth funds, asset managers, and university endowments, express concerns about sustainability issues and plan to divest from the fossil fuel industry. As of March 2020, over 3,000 organizations (with a collective assets under management of US$103.4 trillion) have become signatories of the Principles for Responsible Investment (PRI), a United Nations-supported initiative.

Limiting future global temperature increase requires international coordination among scientists, governments, companies, and the general public. The empirical evidence on the role of investors so far focuses on shareholder engagement: A survey of institutional investors (Krueger, Sautner, and Starks, 2020) finds that 43% of the respondents held discussions with portfolio companies' management regarding climate risks in the past five years. Azar et al. (2021) show that the largest institutional investors focus their engagement effort on large firms with high emissions. The effect of divestment campaigns is, however, less clear; in a recent *Wall Street Journal* article (Power (2021)), Tariq Fancy, formerly chief of sustainable investing at BlackRock, and Alex Edmans of London Business School claim that divestment has negligible effect on company behavior. David Swensen, then-Chief Investment Officer of Yale University's $30 billion endowment, stated that he "differ[ed] with divestment proponents about the means to transition to a greener economy" after a faculty senate meeting that discussed divestment (Kristoffersen and Pavilonis (2020) of *The Yale Daily News*).

In this paper, we check whether financial institutions divest from high emission firms and whether divestment affects firm policies. Using institutional holdings data from 23 countries, we first measure financial institutions' exposure to stocks in high-emission industries. Following Choi, Gao, and Jiang (2020a), we adopt the definition provided by the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, which lists five major industry categories of carbon dioxide and other greenhouse gas emission sources: Energy; Transport; Buildings; Industry (such as chemicals and metals); and Agriculture, Forestry, and Other Land Use (AFOLU). Each sector is further divided into subcategories (see Krey et al., 2014 for a full list). We hand match these subcategories with the industry classifications of stocks provided by DataStream. Stocks of firms in the matched industries are labeled as high-emission firms.

We calculate a carbon ratio, defined as the total weight of high-emission stocks in an institution's equity portfolio. For every country, we construct a time series of the aggregate carbon ratio, which averages across institutions (weighted by their sizes) and is adjusted for market weights. Consistent with prior evidence from the U.S. and other countries (Bolton and Kacperczyk, 2020a; Choi, Gao, and Jiang, 2020b; Gibson and Krueger, 2018), the aggregate carbon ratio is generally lower over time. However, there is substantial variation across different markets and many markets see a sharp drop in the end of 2015. The downward trend coincides with fossil fuel divestment campaigns that grew rapidly in 2015 and the adoption of the Paris Agreement.[1] We link the cross-country differences to climate perceptions estimated by Gallup, which surveyed individuals from 111 countries in a comprehensive study of global opinions on climate change in 2010. We find that countries where individuals were more aware of climate risks experience a larger decrease in the aggregate carbon ratio after 2015.[2]

Although the goal of the divestment campaigns is to exert pressure on firms' management to impose climate policies, firms do not necessarily respond if their stocks earn higher returns (as shown by Bolten and Kacpercyzk, 2020b and Hsu, Li, and Tsou, 2019) and are held by

[1]In the early 2010s, student groups began to push university endowments to divest from fossil fuels. The assets tied to institutions committed to fossil fuel divestment had a 70-fold increase from 2014 to 2015, as reported by Hirji (2015), who claims that the campaign "went mainstream in 2015." The Paris Agreement, which aims to limit global temperature rise in this century, was drafted in 2015 and signed by 195 participating member states and the European Union.

[2]Throughout the paper, we refer to the reduction in carbon ratio as carbon divestment, interpreting the term "divestment" in a broad sense—that is, the opposite of investment.

other investors who are not committed to divestment, or if managers' wealth is unaffected (Davies and Van Wesep, 2018).

We attempt to document the effects of institutional investors' reduced carbon exposure on companies by studying stock price valuation and firms' real decisions. First, we find that valuation ratios (price-to-earnings and price-to-book) of a high-emission firm tends to be lower after 2015 if it is located in high-awareness countries. Increasing the awareness measure by one standard deviation is associated with a 6% decrease in high-emission firms' P/E ratio after 2015, raising external financing equity costs for these firms. Chava (2014) also finds that U.S. firms with environmental concerns face higher costs of capital.

We further show that high-emission firms located in high-awareness countries reduce their emissions in 2016–2018. Using international firm-level estimates provided by the CDP (formerly the Carbon Disclosure Project), we find evidence that companies reduce Scopes 1 and 2 CO_2 emissions (divided by total assets) under divestment pressure in the country. Scope 1 emissions are direct emissions from firms' activities, while Scope 2 captures indirect emissions from consumption of purchased electricity, heat, or steam; both are a result of firms' operations. If the awareness measure increases by one standard deviation, Scopes 1 and 2 emissions divided by total assets for high-emission firms decrease by 5.5% in 2016–2018.

High-emission firms in high-awareness countries also increase their capital expenditure and research and development (R&D) expenses, as well as the proportion and the number of green patents in 2016–2018. These changes suggest that high-emission firms invest in methods to reduce their carbon footprints. Our results are robust to using the change in aggregate carbon ratio or a structural break estimate of the divestment trend in each country instead of the Gallup survey.

While we do not observe the channel through which investors affect firms' real decisions and cannot claim causality, our triple difference (difference-in-difference-in-differences) approach links firms' actions to institutional divestment. Divestment from publicly traded stocks of high-emission firms is more prevalent in high-awareness countries after 2015. We see corresponding changes in public firms' valuation, emissions, expenses, and green innovation activities under the same conditions. In contrast, we do not obtain any significant results using *private* high-emission firms, which do not face the same divestment pressure from institutions.

Although it is still possible that some omitted variables simultaneously drive financial institutions' and public firms' activities, variables affecting both public and private high-emission firms (such as environmental regulations or an increase in climate awareness) cannot explain our findings. At the very least, we observe that financial decisions made by institutions and real decisions made by public firms go in the same direction, the direction that lowers carbon emissions and helps combat climate change.

The reduction in a country's aggregate carbon ratio is a result of institutions' disposal of stocks of high-emission firms and/or investors' increased allocation to institutions with cleaner portfolios. Our documented effects on stock prices and firms' actions support the theoretical predictions made by Pastor, Stambaugh, and Taylor (2021). In particular, the sharp drop in aggregate carbon ratio in 2015 corresponds to a positive shock in their ESG (Environmental, Social, and Governance) factor, when ESG concerns strengthen. Pastor, Stambaugh, and Taylor (2021) show that strong investor ESG preferences create a large valuation gap between green and brown firms, which incentivizes firms to become greener.

Our findings that financial institutions and investors avoid high-emission stocks are also similar to the case of "sin" stocks, which are shunned by some investors because the addictive properties of these companies' products are viewed as sinful (Hong and Kacperczyk, 2009). We present evidence that such avoidance can affect firms' behavior. This is consistent with Dyck, Lins, Roth, and Wagner (2019), who show that institutional investors transplant their norms into their portfolio firms by improving firms' environmental and social performance.

The remainder of the paper is structured as follows. Section 2 describes the data. Sections 3 and 4 present the results of institutional carbon divestment and firms' real decisions, respectively. Section 5 concludes.

2 Data

In this paper, we combine several data sources and implement our analysis.

2.1 The Gallup survey

In 2007–2008, The Gallup Organization surveyed individuals from 128 countries in the first comprehensive study of global opinions on climate change (the Gallup survey hereafter). Before that, surveys of this kind were restricted to only one or two countries or focused on only one region. The Gallup survey aggregated opinion from the adult population fifteen years of age and older in both rural and urban areas. Among other questions, the survey focuses on people's awareness of climate change by asking "how much do you know about global warming or climate change?" The survey shows that 61% of individuals worldwide were aware of global warming, i.e., they know a great deal or something about it, in 2007–2008. There is sizeable heterogeneity among different countries. For example, developed countries are more aware than developing countries, with countries in Africa the least aware.

The Gallup survey are conducted repeatedly in the following years. We use the survey result in 2010 as it is the starting year of our sample. We define the variable, *Awareness*, as the percentage population in the country who believe they know a great deal or something about global warming or climate change. Then, we merge countries' score with our FactSet data and end up with 20 markets in our sample.[3] Countries such as Japan and Australia exhibit extremely high level of awareness, i.e., 98%, while India and South Africa have awareness of lower than 40%; see Table 1. *Awareness* will be used as our survey-based measure on the intention of divestment, as a complement to our portfolio based measures. The empirical premise is that investors in the high awareness countries are likely to take collective actions, such as fossil divestment, to fight against climate change.

[3] France, Norway, and Switzerland are missing in the Gallup survey of 2011. Data are from `https://news.gallup.com/poll/147203/Fewer-Americans-Europeans-View-Global-Warming-Threat.aspx`.

2.2 Equity holdings of institutional investors

Quarterly holdings by institutional investors and their locations (at the country level) are obtained from FactSet, which covers institutions from 57 countries. Holdings of U.S.-based institutional investors are from 13F filings provided by Thomson Reuters.[4] Both FactSet and 13F are primarily sourced from regulatory filings of each market and cover stock holdings. While it varies across different markets, most of institutional investors update their holding information on a quarterly or even monthly basis. We use quarterly holdings for our analysis.

We focus on the domestic portfolio of institutional investors. To limit the impact from institutions whose major investment strategy is international stocks, fixed income, or commodities, we drop the institutions with less than 30 domestic stocks in the reported portfolio. We also delete the countries with less than 10 institutions in the data. Our sample includes 26,165 unique funds and 502,602 fund-quarter observations from 23 countries from 2010 to 2018, and the total value of their domestic equity holdings is 13.71 trillion USD at the end of 2018.[5] See Table 1 for the list of markets in our sample.

2.3 Stock and public company information

Stock price, market capitalization, and industry information are available from Thomson Reuters DataStream. For U.S. stocks, we use return and market capitalization data from CRSP (we obtain a list of U.S. stocks from DataStream and match them to CRSP using ISIN and CUSIP). DataStream covers more than 100,000 equities in nearly 200 countries from 1980 onward. We can observe the firms' countries of domicile (from the NATION variable). The literature notes that DataStream may suffer from data errors. Following Hou, Karolyi, and Kho (2011) and Ince and Porter (2006), we remove all monthly returns that are above 300% and reversed within 1 month, as well as zero monthly returns (DataStream repeats the last valid data point for delisted firms).

[4]We use institutional investor, institution, and fund interchangeably hereafter.

[5]We start our sample in 2010 because the carbon emission data from CDP is available from then.

We merge stock information with the holdings data via ISIN for non-US sample and via CUSIP for US data. For measures on holding size and fund AUM, we transform the local currency into USD using real-time currency rates.

Annual accounting information are from Thomson Reuters Worldscope for the non-US sample and from Compustat for US companies. We obtain total earnings, book equity, and total assets. Price-to-earnings (PE) and Price-to-Book (PB) ratios are calculated using the end-of-year market capitalization divided by total earnings and book equity in the previous year, respectively, and take natural log of one plus PE or PB (i.e., Ln_PE and Ln_PB) in regressions. For, company-year observations with negative earnings or book equity, the ratio is missing. Companies' capital expenditure (*Capex*) and research and development expenditure (*R&D*) are scaled by lagged total assets. Note that *Capex* and *R&D* data are missing for a significant fraction of firm-year observations in our sample. PB and PE ratios are winsorized within country-year at the 2.5th and 97.5th percentiles, and *Capex* and *R&D* are winsorized at the 97.5th percentile.

2.4 Carbon emission measures

To identify high-emission firms, we follow the measure in Choi, Gao, and Jiang (2020a). That is, we adopt the industry definitions provided by the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change. Five major industry sectors are identified as major emission sources: Energy; Transport; Buildings; Industry (such as chemicals and metals); and Agriculture, Forestry, and Other Land Use (AFOLU). Each sector is further divided into subcategories (Krey et al. 2014 offers a full list). We hand-match the IPCC subcategories with DataStream Industry Classification Benchmark (ICB) codes. To be consistent across firms in different countries, we use the industry categorization from DataStream for both US and non-US firms. Since this IPCC measure is based on industries, it covers all the firms in our sample, a clear advantage for international studies. By comparison, other rating-based measures such as MSCI ESG ratings are only available for a subset of firms in our sample and may be subject to selection issues.[6] Firms that are matched with the IPCC emission industries are classified as high-emission firms, i.e., the indicator $High\_Emission = 1$; the rest of firms have $High\_Emission = 0$.

The firm-level emission data is from CDP. The dataset provides an estimation of companies' CO2 emission (in tons) on an annual basis. CDP categorizes emissions into the three "Scopes" following the GHG Protocol Corporate Standard: Scope 1 emissions are direct emissions from owned or controlled sources; Scope 2 emissions are indirect emissions from the generation of purchased energy; and Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions. [7] Bolton and Kacperczyk (2020b) find that institutional investors apply exclusionary screens based on Scopes 1 & 2 emissions, but not on Scope 3 emissions. Since our study focuses on institutional investors, we use the summation of Scopes 1 & 2 emissions as our emission measure.

The CDP data is available from 2010. We merge it with the DataStream/CRSP sample via ISIN or company name if/when ISIN is missing in CDP. The coverage is small–only 6,654 firm-year observations have non-missing CDP data, but it does cover firms in more than 20 countries. We define our firm-year level emission measure, $Emission$, as the summation of Scopes 1 and 2 emission divided by lagged total assets. The unit is tons per million USD. $Emission$ is winsorized within country-year at the 97.5th percentile.

2.5 Company patent information

The patent information is from Bureau van Dijk's (BvD) Orbis IP database. The database covers both public and private firms around the world. We retrieve patent priority date and their IPC code. Priority date specifies the earliest filing date of patent applications. We use IPC code to classify each patent into green patent or non-green patent based on the guidelines from the Organization for Economic Co-operation and Development (OECD) and

[6] See page 1120 of Choi, Gao, and Jiang (2020a).
[7] See `https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf`

the procedure in (Cohen et al., 2020).[8] According to OECD's guideline, patents that are environment-related belong to several types such as environmental management, water adoption, biodiversity protection, climate change mitigation, and greenhouse gas management. Haščič and Migotto (2015) offer a detailed description on how to identify environmental-related patents. We calculate the number of green patents and the ratio of green to all patents that a firm files for each year, and merge with other databases via firms' ISIN code or country location.

2.6 Private firm information

The accounting information for private firms are from BvD Orbis Global database. We obtain total assets, capital expenditure, and research and development. *Capx* and *R&D* are scaled by lagged total assets. Such data for private firms are missing for a significant fraction of markets in our sample. We winsorize *Capex* and *R&D* at the 97.5th percentile.

To match public firms with comparable private firms, we create a propensity matching score for each listed firm based on country, industry, and firm total assets. The matched private firm has to be in the same country and industry with total assets closest to the public firm. For public firms and the matching private firms, we require that they have at least one patent filing during 2010–2018.

3 Carbon divestment

3.1 A portfolio-based measure: carbon ratio

We first measure the carbon emission intensities of institutional investors' stock holdings. Our measure builds on the industry definitions provided by IPCC, which lists five sectors as major emission sources: Energy; Transport; Buildings; Industry (such as chemicals and metals); and Agriculture, Forestry, and Other Land Use (AFOLU). Based its industry code

[8] See this link for OECD's identifications of environment-related technologies.

provided by DataStream, all firms in the matched industries are defined as high-emission firms and are assigned a value of one to the indicator $High\_Emission$; all other firms are given a value of zero.

From the firm-level indicator of high emission and the equity positions reported in FactSet or 13F, we calculate the portfolio-average carbon exposure ($Carbon\_Ratio$) for institutional investor i in quarter t:

$$Carbon\_Ratio_{i,t} = \sum_j w_{i,j,t} * High\_Emission_{j,t} - \sum_j w_{j,t}^{mkt} * High\_Emission_{j,t} \qquad (1)$$

where stock j for $j = 1, 2, ..., J$ represent all stocks in the domestic market where investor i is located, and $w_{i,j,t}$ is the portfolio weight of stock j in the domestic equity holdings of investor i at quarter t . The first term of Eq.(1) is the total portfolio weight on emission firms for investor i, while the second term is the market weight of all emission firms. $Carbon\_Ratio_{i,t}$ measures how much a fund's portfolio deviates from the market benchmark. Note that here we do not count investors' non-domestic holdings as it is not clear what the most appropriate benchmark is.

Then, for country m, we calculate the market-level $Carbon\_Ratio_{m,t}$ by taking the value weighted average of the fund-level $Carbon\_Ratio_{i,t}$ by each institution's size of holdings.[9] For each country, we have a time-series that describes the institutional investors' average emission intensities relative to the market portfolio, and its trend reflects the tendency of carbon divestment.

In Figure I, we calculate a simple average of $Carbon\_Ratio_{m,t}$ across all countries and plot it over the time. It shows that around 2015 the global $Carbon\_Ratio$ started to decrease from overweighting on emission (i.e., $Carbon\_Ratio > 0$) before to underweighting afterwards. This structure change in $Carbon\_Ratio$ is coincided with the passage of the Paris Agreement at the end of 2015, which is arguably the most important global planning to combat climate change.

[9]We also use equal-weighted average as an alternative specification, and the result is similar.

We define the post-event period from 2016 to 2018 ($LATE = 1$), while the pre-event period as 2010–2015 ($LATE = 0$). Our reduced-from measure of carbon divestment, $\Delta Carbon\_Ratio_m$, is the average $Carbon\_Ratio_{m,t}$ between 2016–2018 minus the average between 2010–2015. Table 1 lists the value of $\Delta Carbon\_Ratio_m$ for each country.

First, note that the global average is -1.04%, which translating into dollar amount implies approximately 140 billion USD sell-off of carbon intensive firms. There is cross-country heterogeneity. For example, Scandinavian countries exhibit strong tendency of divestment, such as Finland (-3.55%) and Norwey (-4.54%). India and South Africa, which are shown to have low awareness in survey, do not appear to divest carbon industries with $\Delta Carbon\_Ratio$ of 1.65% and 0.89%, respectively.

To examine if such change in $Carbon\_Ratio$ is statistically significantly across countries, we run the following country-quarter level regression,

$$Carbon\_Ratio_{m,t} = \alpha + \beta_1 LATE + \epsilon_{m,t}. \tag{2}$$

The results are reported in Table II. In column (1), the coefficient of $LATE$ is -1.0% (with t-stat of 1.92). We add country fixed effect in column (2), and the result is very similar. Furthermore, we check if the divestment tends to be stronger for countries with high awareness of climate change. We add $Awareness$ and an interaction term between $Awareness$ and $LATE$ into Eq.(2). Columns (3) and (4) report the result: the coefficients of the interaction term are around -4.6% (with t-stat above 3.8). The effect is economically meaningful: a one standard deviation increase in $Awareness$—or 17.6% more population know about climate change—is associated with 0.81% more carbon divestment after 2015.

3.2 Structure break

In this subsection, we try to measure the change in the *trend* of divestment using a standard structure break test. Notice that the variable $\Delta Carbon\_Ratio_m$ we define above, by comparison, measures the absolute change in portfolio weights. This approach does not take into account any possible changes in the trend. In other words, if such divestment trend is well expected by investors or companies in 2010, one should not see significant changes in corporate reactions. However, if it is the case that the divestment trend is accelerated after 2015, then corporations should react even more strongly.

We first run the structure break regression using the global average $Carbon\_Ratio$ (i.e., the time series plot in Figure 1),

$$Carbon\_Ratio_t = \alpha + \beta_1 t + \beta_2 (t - t^*) \mathrm{I}\{t > t^*\} + \epsilon_t \tag{3}$$

where t refers to the time trend and t^* is the quarter when a structure breaker is identified. $\mathrm{I}\{t > t^*\}$ is an indicator function. The program will try each of the possible values of t^* over the sample period, and the value of t^* is determined as the quarter where the regression of Eq.(3) has the highest R^2. The sample period from 2010Q1 to 2018Q4, and we limit t^* to be chosen from 2011 to 2017. β_1 measures the trend, and β_2 the change in the trend after the breaker quarter t^*. t^* tells the timing of the occurrence of the structural change.

Table II reports the results. The point estimate of β_1 is 0.06%, which is economically small. The value of β_2 appears to be -0.22% (with t-stat of 7.4), implying that a quarterly divestment of 0.9% per year relative to the pre-trend as estimated by β_1. This number is larger than the reduced-form estimation based on $\Delta Carbon\_Ratio$. The R^2 equals 64.3%. Furthermore, the estimation of t^* shows that the structural breaker happens around the first quarter of 2015, which is again close to the passage of the Paris Agreement.

Then, we run the regression of Eq.(3) for each country and allow t^* to vary by country. The point estimate of β_2 is our second portfolio-based measure on the tendency of carbon divestment, and we denote it as $\Delta Divest\_Slope_m$. Table II lists the estimation for each country. First, there is a strong pattern of increased divestment: 19 out of 23 markets in our sample exhibit a negative number of $\Delta Divest\_Slope_m$. Also, the cross-section heterogeneity remains. For some countries, the measures are aligned with $\Delta Carbon\_Ratio$. For example, Finland still appears to be a high divestment country ($\beta_2 = -1.88\%$), while India to be low divestment ($\beta_2 = 0.75\%$).

3.3 Compare portfolio- and survey-based measures

Last, we compare the two portfolio-based measures with the survey-based measure, *Awareness*. In Figures III, we first plot $\Delta Carbon\_Ratio_m$ against $Awareness_m$. The slope is -0.046 (with t-stat of 3.71), and the R^2 is 0.084. The result is similar in Figure IV, where we plot $\Delta Divest\_Slope_m$ against $Awareness_m$ with a linear fitted line. The slope is -0.132 (with t-stat of 1.56), and the R^2 is 0.11. The result suggests that the portfolio-based measures are strongly correlated with the survey-based measure, albeit different in some dimensions. We use all three measures in our analysis on the consequences.

4 Consequences of carbon divestment

In this section, we examine the impact of investors' carbon divestment on firm actions. We primarily use the survey-based measure, *Awareness*, as it covers more countries, and use the other two portfolio-based divestment measures in the robustness tests.

4.1 Price impact

One direct impact of the world-wide divestment on carbon intensive firms is on the valuation level of these firms. This can be driven by the change in investors' preference, similar to the findings in Hong and Kacperczyk (2009) that the prices of sin stocks are relatively lower. Or, it can be the case that investors expect higher operating costs—due to more strict regulations—for carbon intensive firms and offer lower valuation. Since such divestment trend is of long horizon, the price impact (if any) is hardly to reverse and can sustain for longer periods. This is different from the case of fire sales where the price pressure fades away after a few quarters (e.g., Coval and Stafford 2007).

To examine such long-term effect on stock prices, we adopt a difference-in-difference-difference identification strategy. That is, we examine whether the valuation ratio, such as PB and PE, of carbon intensive firms relative to clean firms tend to be lower in the high divestment countries in the late sample period. In this way, we can rule out the potential effect of time-series factors that may drive the valuation difference between emission and clean firms. For example, the sharp decrease in the crude oil price may lower the valuation of energy intensive industries, but this effect cannot explain the difference between emission and clean firms varies with the countries' tendency of long-term carbon divestment. We also control for firm fixed effects, which rules out the possibility that the composition of emission and clean firms is correlated with countries' divestment.

Specifically, we run the following the firm-year level regression with all countries from 2010 to 2018,

$$Ln\_PE_{i,t} = \beta_1 High\_Emission_i * LATE_t * Divestment_m + v_t + u_i + \epsilon_{i,t} \quad (4)$$

where $Divestment_{m,t}$ is one of three carbon divestment measures for country m where company i is located at year t. $LATE$ equals one for years of 2016, 2017, and 2018, and zero otherwise. We also use Ln_PB as the alternative measure of valuation. Firm and year fixed effects are included, and so are the interaction terms between $High\_Emission$ and $LATE$ and between $LATE$ and $Divestment$. Standard errors are clustered by country.

Table IV reports the summary statistics of main variables, and the regression results are reported in Table V. Here, we use the survey-based measure, $Awareness$. Since high investor awareness indicates more divestment on carbon-intensive firms, we expect β_1 to be negative. In column (1), we only include year fixed effect, the point estimate of β_1 is -0.305 (with t-stat of 3.3). After adding firm fixed effects in column (2), the coefficient changes to -0.330 (with t-stat of 2.0). In terms of economic magnitude, a one standard deviation decrease in

Awareness (i.e., 19.2% more population knows) is associated with a 5.8% to 6.3% decline in P/E ratio for high emission firms in late sample years. In columns (3) and (4), we repeat the regressions using Ln_PB in the left-hand side. The sample size is larger as firm-year observations with negative earnings are included here. The results are similar: β_1 are both negative.

4.2 Real actions

A natural question that follows is whether such price pressure can push companies to upgrade cleaner technology and lower emissions. These actions can be driven by the clientele channel, that is, socially responsible investors may continue to sell off their holdings if the company does not plan to improve the carbon footprint. The management of the companies who care about their stock price will react and improve carbon footprint. Our hypothesis is that carbon intensive firms in high-divestment countries are likely to take actions after 2015. Although we cannot identify the action, if any, is caused by the domestic divestment, the evidence can nonetheless shed light on the ongoing debate.

4.2.1 The impact on capital expenditure, R&D, and emission

To test our hypothesis, we develop two sets of measures on firm actions. The first set is based on firms' financial report. We examine whether carbon intensive firms tend to increase capital expenditure and R&D in high divestment countries in later years. The caveat is obvious in that we do not know whether those increased expenditures (if any) are environment-related. To address this issue, we use the second measure, the amount of CO2 emissions (scaled by firm size). But the downside lies in its very small coverage of firms. To further address this issue, we examine firm's filling for green patents in the next subsection.

To eliminate the potential noises in firms' year-by-year investment, we focus on the average level over a longer period. For all three measures, *Capex*, *R&D*, and *Emission*, we calculate the average before the structural change, 2010 to 2015 (or $LATE = 0$), and compare it to the average after, 2016 to 2018 (or $LATE = 1$). Then, we take the log change (after minus before), which can be thought of as the percentage change in the ratio, and run a cross-sectional regression,

$$\Delta Capex_i = \alpha + \beta_1 High\_Emission_i + \beta_2 Divestment_m + \beta_3 High\_Emission_i * Divestment_m + \epsilon_i \tag{5}$$

Our focus lies in the interaction term, that is, whether high emission firms tend to take more actions in high divestment countries. In Table VI, we use $Awareness$ as the divestment measure. In column (1), the left-hand side variable is $\Delta Capex$. We expect high emission firms to increase capital expenditure when divestment pressure is high, i.e., β_3 to be negative. The results are consistent and significant (with t-stat of 2.2). Economically, a one standard deviation increase in $Awareness$ (19.2%) is associated with a 3.49% rise in the capex ratio, while the average of $\Delta Capex$ during this period is -37.1%.

In column (2), we examine expenditure on research and development. Note that only about 40% of our sample has a non-missing value of $\Delta R\&D$. The point estimate of β_3 is -0.338 (with t-stat of 2.5), which implies that a one standard deviation increase in $Awareness$ (19.2%) is associated with a 6.49% rise in R&D ratio, while the average of $\Delta R\&D$ during this period is -8.0%.

In column (3), we use CO2 emission ratio as the dependant variable in Eq.(5). Due to the limited data availability, the sample size of this regression is approximately 1100 firms. Since we expect firms under high divestment pressure to lower their CO2 emission, β_3 should be negative. The estimated β_3 appears to be -0.288 (with t-stat of 2.6). A one standard deviation increase in $Awareness$ (19.2%) is associated with a 5.51% decline in CO2 emission ratio, while the average of $\Delta Emission$ during this period is -3.9%.

To further pin down the underlying mechanism, we conduct the same analysis on a set of matched private firms. That is, if the carbon divestment measure is correlated other country-level confounding events, such as more environment-friendly regulatory policies, we should find simliar results for private firms in those countries. If this not the case in data, it would support our hypothesis that the pressure of divestment campian makes effect through the public stock market. Indeed, the insignificant results reported in Columns (4)–(6) are consistent with our conjecture.

4.2.2 The Impact on green innovation

For each firm, either public or private, we count the total numebr of patents filed every year, and also the number of patents are classified as green patent based on the classification in Cohen, Gurun, and Nguyen (2019). Then, we calculate $Green\_Ratio$ as the number of green patents to that of all patents, and $\Delta Green\_Ratio$ equals one if the average $Green\_Ratio$ between 2016 to 2018 increases from the average between 2010 to 2015, and zero otherwise. Alternatively, we also look at the number of green patents, $Green\_Number$, and define $\Delta Green\_Number$, which equals one if the average $Green\_Number$ between 2016 to 2018 increases from the average between 2010 to 2015, and zero otherwise. Then, we run the following Logit regression,

$$\Delta Green\_Ratio_i = \alpha + \beta_1 High\_Emission_i + \beta_2 Divestment_m + \beta_3 High\_Emission_i * Divestment_m + \epsilon_i \quad (6)$$

Similarly, we focus on the interaction term, that is, whether high emission firms tend to increase green patenting in high divestment countries in late years. To support our hypothesis, we expect β_3 to be positive for public firms but insignificant for private firms. Table VII presents the results. Columns (1)–(2) show that publicly traded high emission firms tend to file more green patents, as a fraction of total patents or in absolute numbers, than clean firms in high awareness countries after 2015. In terms of economic magnitude, relative the mean value of $\Delta Green\_Ratio$ (8.0%), a one standard deviation increase in $Awareness$ is associated with a 2.4% rise in $\Delta Green\_Ratio$. Columns (3)–(4) present the results for matched private firms. The coefficients of the interaction term appear to be insignificant from zero, suggesting the country-level divestment does not generates significant pressure and impact on non-listed firms.

4.3 Robustness: Using portfolio-based divestment measures

In Tables VIII and IX, we use the two alternative portfolio-based divestment measures, introduced in Sections 3.1 and 3.2, to repeat the analysis in Tables V and VI. While the portfolio-based measures, $\Delta Divestment\_Slope$ and $\Delta Carbon\_Ratio$, can accurately capture the magitude of divestment, they are only avaiable to 23 markets where the insitutional holding data are available.

We first focus on price impact. In Panel A of Table VIII, the divestment measure is $\Delta Divestment\_Slope$. Since a negative value of $\Delta Divestment\_Slope$ means stronger divestment, we expect β_1 to be positive. In column (1), we only include year fixed effect, the point estimate of β_1 is 15.01 (with t-stat of 4.2). After adding firm fixed effects in column (2), the coefficient increases to 21.41 (with t-stat of 5.2). The economic magnitude is also meaningful: a one standard deviation decrease in $\Delta Divestment\_Slope$ (-0.54%) is associated with an 8.10 to 11.56% drop in prices relative to earnings for high emission firms after 2015 (the standard deviation of Ln_PE is about one). In columns (3) and (4), we repeat the regressions using Ln_PB in the left-hand side. The estimations are similar: β_1 are both positive with t-stats above two.

In Panel B, the divestment measure is $\Delta Carbon\_Ratio$, and we expect β_1 to be positive. For all the four columns, the coefficient of the triple interaction term appears to be significantly positive with t-stats from 2.2 to 3.2. The point estimates imply that a one standard deviation decrease in $\Delta Carbon\_Ratio$ (-2.58%) is associated with a 7.89 to 14.65% drop in pricing ratios for high emission firms after 2015. Panel C repeats the regressions using *Awareness* but with the smaller sample, and we find the results are very similar.

In Panel A of Table XI, we use $\Delta Divestment\_Slope$ as the divestment measure to examine firm actions. In column (1), the left-hand side variable is $\Delta Capex$. We expect high emission firms to increase capital expenditure when divestment pressure is high, i.e., β_3 to be negative. The results are consistent and significant (with t-stat of 2.5). Economically, a one standard deviation increase in $\Delta Divestment\_Slope$ (-0.54%) is associated with a 5.04% rise in the capex ratio. In column (2), we examine expenditure on research and development. Note that only about one third of our sample has a non-missing value of $\Delta R\&D$. The point estimate of β_3 is -8.6 (with t-stat of 1.6), which implies that a one standard deviation increase in $\Delta Divestment\_Slope$ (-0.54%) is associated with a 4.64% rise in R&D ratio. In column (3), we use CO2 emission ratio as the dependant variable in Eq.(5). Since we expect firms under high divestment pressure to lower their CO2 emission, β_3 should be positive. The estimated β_3 tends to be 8.82 (with t-stat of 2.0). A one standard deviation increase in $\Delta Divestment\_Slope$ (-0.54%) is associated with a 4.76% decline in CO2 emission ratio. In columns (4)–(6), we repeat the regressions using the sample of matched private firms, but we do not find similar patterns. Taken together, the findings suggest that the pressure is likely driven by the pressure from the public stock market. In Panel B of Table XI, we use $\Delta Carbon\_Ratio$ as the divestment measure. The sign of the interaction term in columns (1)–(3) are insignificant but qualitatively consistent. Panel C repeats the regressions using *Awareness* but with the smaller sample, and we find the results are highly similar.

5 Conclusion

In this paper, we examine whether financial institutions and public firms take actions to reduce carbon exposure. Even though the scientific consensus is that humans cause climate change (Cook et al., 2016, 2013; Anderegg et al., 2010; Oreskes, 2004), many climate deniers disagree and oppose measures to curb emissions. It is possible that financial institutions' and firms' climate efforts vary across countries and across time, depending on their climate awareness. We show that after 2015, institutional investors in countries where people are more aware of climate risks divest from carbon-intensive industries to a larger extent. Such divestment trends are associated with lower price valuation, higher capital expenditures, R&D expenses, and green innovation activities, as well as lower CO_2 emissions for public firms (but not private firms) in these countries.

Our paper presents evidence that divestment campaigns can affect firms' real decisions. As there are more socially responsible funds and growing concerns over climate change, it is important to understand how funds can push companies to become more socially responsible. Future research with better data can study the channel through which institutions exert pressure on firms and how firms change their operation functions to reduce emissions.

References

Anderegg, William RL, James W Prall, Jacob Harold, and Stephen H Schneider, "Expert credibility in climate change," *Proceedings of the National Academy of Sciences*, 2010, *107* (27), 12107–12109.

Bolton, Patrick and Marcin Kacperczyk, "Carbon Premium around the World," *Available at SSRN 3550233*, 2020.

_ and _ , "Do investors care about carbon risk?," Technical Report, National Bureau of Economic Research 2020.

Chava, Sudheer, "Environmental Externalities and Cost of Capital," *Management Science*, 2014, *60* (9), 2223–2247.

Choi, Darwin, Zhenyu Gao, and Wenxi Jiang, "Attention to global warming," *The Review of Financial Studies*, 2020, *33* (3), 1112–1145.

_ , _ , and _ , "Measuring the Carbon Exposure of Institutional Investors," *The Journal of Alternative Investments*, 2020.

Clarke, Leon, K Jiang, K Akimoto, M Babiker, G Blanford, K Fisher-Vanden, JC Hourcade, V Krey, E Kriegler, A Löschel et al., "Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change ed O Edenhofer et al," 2014.

Cohen, Lauren, Umit G Gurun, Quoc H Nguyen et al., "The ESG-Innovation Disconnect: Evidence from Green Patenting," Technical Report, National Bureau of Economic Research, Inc 2020.

Cook, John, Naomi Oreskes, Peter T Doran, William RL Anderegg, Bart Verheggen, Ed W Maibach, J Stuart Carlton, Stephan Lewandowsky, Andrew G

Skuce, Sarah A Green et al., "Consensus on consensus: a synthesis of consensus estimates on human-caused global warming," *Environmental Research Letters*, 2016, *11* (4), 048002.

Coval, Joshua and Erik Stafford, "Asset fire sales (and purchases) in equity markets," *Journal of Financial Economics*, 2007, *86* (2), 479–512.

Davies, Shaun William and Edward Dickersin Van Wesep, "The unintended consequences of divestment," *Journal of Financial Economics*, 2018, *128* (3), 558–575.

Dyck, Alexander, Karl V Lins, Lukas Roth, and Hannes F Wagner, "Do institutional investors drive corporate social responsibility? International evidence," *Journal of Financial Economics*, 2019, *131* (3), 693–714.

Gibson, Rajna and Philipp Krueger, "The sustainability footprint of institutional investors," *Swiss Finance Institute Research Paper*, 2018, (17-05).

Haščič, Ivan and Mauro Migotto, "Measuring environmental innovation using patent data," 2015.

Hong, Harrison and Marcin Kacperczyk, "The price of sin: The effects of social norms on markets," *Journal of Financial Economics*, 2009, *93* (1), 15–36.

Hou, Kewei, G Andrew Karolyi, and Bong-Chan Kho, "What factors drive global stock returns?," *The Review of Financial Studies*, 2011, *24* (8), 2527–2574.

Hsu, Po-Hsuan, Kai Li, and Chi-Yang Tsou, "The pollution premium," *Working paper*, 2019.

Ince, Ozgur S and R Burt Porter, "Individual equity return data from Thomson Datastream: Handle with care!," *Journal of Financial Research*, 2006, *29* (4), 463–479.

Kristoffersen, Matt and Valerie Pavilonis, "FAS Senate to Discuss Divestment," https://yaledailynews.com/blog/2020/02/09/fas-senate-to-discuss-divestment-2/ 2020.

Krueger, Philipp, Zacharias Sautner, and Laura T Starks, "The importance of climate risks for institutional investors," *The Review of Financial Studies*, 2020, *33* (3), 1067–1111.

Oreskes, Naomi, "The scientific consensus on climate change," *Science*, 2004, *306* (5702), 1686–1686.

Pastor, Lubos, Robert F Stambaugh, and Lucian A Taylor, "Sustainable Investing in Equilibrium," *Journal of Financial Economics, forthcoming*, 2021.

Power, William, "Does Sustainable Investing Really Help the Environment?," https://www.wsj.com/articles/sustainable-investing-good-for-environment-11636056370 2021.

Skuce, Andrew G, John Cook, Mark Richardson, Bärbel Winkler, Ken Rice, Sarah A Green, Peter Jacobs, and Dana Nuccitelli, "Does it matter if the consensus on anthropogenic global warming is 97% or 99.99%?," *Bulletin of Science, Technology & Society*, 2016, *36* (3), 150–156.

Table I. Summary Statistics

This table lists the countries/areas in our sample, and the sample period is from 2010Q1 to 2018Q4. It reports the average of the number of institutions and their total equity holdings (in billion USD) of each quarter. $\Delta Carbon\_Ratio$ is the difference between the average country-level $Carbon\_Ratio$ in 2016–2018 and that in 2010–2015. The country-level $Carbon\_Ratio$ is calculated as the value-weighted average of each institution's portfolio weight on high emission firms net of the market weight. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010.

	ΔCarbon_Ratio	Awareness	Total holdings ($billion)	No. of institutions
Australia	0.58%	0.98	46.77	204.47
Austria	-2.66%	0.92	1.38	118.17
Belgium	0.17%	0.8	3.52	135.69
Canada	0.89%	0.96	269.43	1284.44
Denmark	-1.01%	0.97	9.13	143.94
Finland	-3.55%	0.97	14.87	103.33
France	5.01%		89.66	854.31
Germany	-3.97%	0.97	52.16	612.03
Hong Kong	-4.51%	0.94	15.93	89.36
India	1.65%	0.37	75.52	825.75
Italy	-1.59%	0.76	3.41	130.64
Japan	-1.62%	0.98	103.30	137.42
Netherlands	4.37%	0.91	12.67	113.67
Norway	-4.54%		17.25	115.17
Poland	-3.45%	0.85	24.28	158.97
Portugal	0.36%	0.8	0.35	75.42
Singapore	-2.59%	0.9	2.52	54.53
South Africa	0.89%	0.4	23.40	312.25
Spain	-3.92%	0.85	10.78	3000.03
Sweden	-1.64%	0.96	110.41	293.06
Switzerland	-0.77%		52.95	307.17
United Kingdom	-1.04%	0.97	309.33	1202.64
United States	-0.94%	0.96	11149.35	3709.42
Global Average	-1.04%	0.86	539.06	607.91

Table II. Regression of *Carbon_Ratio* on *LATE* and *Awareness*

This table presents the result of regressions of *Carbon_Ratio* on *LATE* and *Awareness*. *LATE* equals one for years of 2016–2018, and zero otherwise. *Carbon_Ratio* is calculated as the value-weighted average of each institution's portfolio weight on high emission firms net of the market weight in the country/area. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010. Standard error are clustered by country, and the corresponding t-statistics are reported in parentheses. The sample includes the 23 markets listed in Table I from 2010Q1 to 2018Q4.

	(1)	(2)	(3)	(4)
	Carbon_Ratio	Carbon_Ratio	Carbon_Ratio	Carbon_Ratio
LATE	-0.010	-0.010	0.028	0.028
	(-1.92)	(-1.86)	(3.07)	(3.14)
Awareness			0.005	
			(0.10)	
LATE×Awareness			-0.044	-0.044
			(-3.09)	(-3.09)
Country Fixed Effect	No	Yes	No	Yes
N	825	825	789	789
Adj. R^2	0.006	0.807	0.008	0.812

Table III. Structural Break Test

This table reports the result of structural break test by regressing quarterly $Carbon\_Ratio$ on time trend and a break indicator. For the global average or each country/area, the following regression is conducted: $Carbon\_Ratio_t = \alpha + \beta_1 t + \beta_2 (t - t^*) \mathrm{I}\{t > t^*\} + \epsilon_t$, where t refers to the time trend, t^* is the quarter where a structure breaker is identified, and $\mathrm{I}\{t > t^*\}$ is an indicator function. t^* is determined as the specification that gives the highest R^2. $\Delta Divest\_Slope$ equals the point estimate of β_2. T-statistics of β_1 and β_2 based on robust standard errors are reported in parentheses.

	β_1	$t(\beta_1)$	β_2 (ΔDivest_Slope)	$t(\beta_2)$	t^*	R^2
Global Average	0.0006	(4.58)	-0.0022	(-7.37)	2015Q1	0.6428
Finland	0.0163	(8.00)	-0.0188	(-8.53)	2011Q3	0.7077
Austria	0.0107	(3.73)	-0.0133	(-3.80)	2012Q3	0.2624
Denmark	0.0093	(4.33)	-0.0098	(-4.32)	2011Q2	0.3236
Netherlands	0.0053	(8.19)	-0.0093	(-4.52)	2016Q1	0.6737
Portugal	0.0005	(1.01)	-0.0092	(-1.68)	2017Q4	0.0239
Sweden	0.0012	(4.62)	-0.0084	(-8.88)	2016Q2	0.7083
Poland	0.0053	(1.94)	-0.0076	(-2.62)	2011Q1	0.6735
Australia	0.0040	(13.68)	-0.0064	(-10.97)	2014Q4	0.8435
France	0.0036	(11.04)	-0.0064	(-2.79)	2017Q2	0.8034
Singapore	0.0045	(3.70)	-0.0062	(-4.69)	2011Q3	0.6835
Hong Kong	0.0030	(1.07)	-0.0059	(-2.05)	2011Q1	0.8289
Japan	0.0039	(2.13)	-0.0056	(-2.57)	2012Q2	0.1928
South Africa	0.0032	(9.71)	-0.0056	(-7.12)	2015Q2	0.7317
Spain	0.0023	(1.81)	-0.0052	(-3.20)	2012Q4	0.4833
Switzerland	0.0031	(1.98)	-0.0037	(-1.96)	2012Q3	0.0527
Germany	-0.0006	(-1.67)	-0.0034	(-3.96)	2015Q2	0.7297
Italy	-0.0009	(-1.87)	-0.0025	(-1.29)	2016Q3	0.3023
United Kingdom	0.0004	(1.84)	-0.0022	(-3.72)	2015Q3	0.3136
Norway	-0.0006	(-0.85)	-0.0022	(-2.31)	2013Q2	0.7339
United States	-0.0006	(-11.16)	0.0010	(2.71)	2017Q2	0.8084
Belgium	-0.0011	(-1.18)	0.0014	(1.28)	2012Q1	-0.0034
Canada	-0.0025	(-1.25)	0.0033	(1.58)	2011Q1	0.3639
India	-0.0060	(-3.53)	0.0075	(4.11)	2011Q3	0.4980

Table IV. Summary Statistics of Key Variables

Price-to-earnings (*PE*) and Price-to-Book (*PB*) ratios are calculated using the end-of-year market capitalization divided by total earnings and book equity in the previous year, respectively. *Ln_PE* and *Ln_PB* are the log of one plus *PE* or *PB*, respectively. *Capex* is capital expenditure scaled by lagged total asset, and *R&D* is the expenditure on research and development scaled by lagged total assets. *Emission* is the company's total CO_2 emissions (Scopes 1 and 2) divided by lagged total assets. *PB* and *PE* ratios are winsorized within country-year at the 2.5th and 97.5th percentiles, and *Capex*, *R&D*, and *Emission* are winsorized at the 97.5th percentile. The operator Δ refers to the log difference in average between 2016–2018 and 2010–2015. Δ*Green Ratio* and Δ*Green Number* are dummy variables in that Δ*Green Ratio* equals 1 if the firm's average proportion of green patents increases from 2010–2015 to 2016–2018, Δ*Green Number* equals 1 if the firm's average number of green patents increases from 2010–2015 to 2016–2018. Δ*Carbon_Ratio* and Δ*Divest_Slope* are defined in Tables I and III. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010. The sample includes stocks from 67 countries from 2010 and 2018.

Variable	Mean	Std. Dev.	P1	P25	P50	P75	P99	N
				Firm-year level variables				
Public firms:								
Ln_PE	2.954	1.156	0.134	2.317	2.855	3.483	6.498	178792
Ln_PB	0.983	0.688	0.012	0.509	0.828	1.301	3.297	236824
Capx	0.215	1.884	0.000	0.021	0.064	0.174	2.539	194808
R&D	0.149	4.739	0.000	0.005	0.027	0.073	1.246	89496
Emission	1619	16054	0	37	130	645	22675	9495
				Firm-year level variables				
Public firms:								
ΔPE	-0.014	1.240	-3.510	-0.533	0.012	0.528	3.260	22968
ΔPB	-0.034	0.997	-2.860	-0.435	-0.014	0.384	2.550	27490
ΔCapex	-0.371	1.280	-4.780	-0.886	-0.225	0.282	2.700	22532
ΔR&D	-0.033	0.845	-2.670	-0.332	-0.023	0.283	2.370	9599
ΔEmission	-0.039	0.598	-1.830	-0.244	-0.020	0.179	1.680	1156
ΔGreen Ratio	0.080	0.272	0	0	0	0	1	23527
ΔGreen Number	0.075	0.264	0	0	0	0	1	23527
Private firms:								
ΔCapex	0.072	1.380	-3.450	-0.653	0.070	0.792	4.170	1599
ΔR&D	-0.041	1.030	-3.330	-0.322	0.006	0.343	2.900	678
ΔEmission	0.033	1.607	-5.358	-0.150	0.018	0.271	3.806	108
ΔGreen Ratio	0.033	0.179	0	0	0	0	1	26605
ΔGreen Number	0.032	0.176	0	0	0	0	1	26605
				Country level variables				
ΔDivest_Slope	-0.005	0.006	-0.019	-0.008	-0.006	-0.002	0.008	23
ΔCarbon_Ratio	-0.010	0.026	-0.045	-0.035	-0.010	0.006	0.050	23
Awareness	0.769	0.192	0.270	0.660	0.810	0.940	0.980	67

Table V. Regressions of Price Ratios on Awareness

This table presents the regression result of price ratios on awareness. Price-to-earnings (PE) and Price-to-Book (PB) ratios are calculated using the end-of-year market capitalization divided by total earnings and book equity in the previous year, respectively. Ln_PE and Ln_PB are the log of one plus PE or PB, respectively. PB and PE ratios are winsorized within country-year at the 2.5th and 97.5th percentiles. $LATE$ equals one for years of 2016–2018, and zero otherwise. $High\_Emission$ is an indicator of high emission industries based on IPCC's categorization. $\Delta Carbon\_Ratio$ and $\Delta Divest\_Slope$ are defined in Tables I and III. $Awareness$ is the fraction of population who know about climate change in Gallup survey in 2010. The sample includes stocks from 67 countries from 2010 and 2018. Standard error are clustered by country, and the corresponding t-statistics are reported in parentheses.

	(1)	(2)	(3)	(4)
	Ln_PE	Ln_PE	Ln_PB	Ln_PB
High_Emission	0.108		0.186	
	(0.26)		(1.35)	
Awareness	-0.403		0.057	
	(-1.41)		(0.22)	
High_Emission×Awareness	-0.240		-0.374	
	(-0.54)		(-2.55)	
LATE×High_Emission	0.259	0.305	0.162	0.100
	(3.58)	(2.20)	(2.25)	(1.10)
LATE×Awareness	-0.102	0.034	0.244	0.207
	(-0.46)	(0.23)	(1.52)	(1.34)
LATE×High_Emission×Awareness	-0.305	-0.330	-0.201	-0.093
	(-3.31)	(-2.04)	(-2.32)	(-0.86)
Firm Fixed Effect	No	Yes	No	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
N	178792	178792	236824	236824
Adj. R^2	0.035	0.533	0.026	0.624

Table VI. Regressions of Action Measures on Awareness

This table shows the result of regressions of action measures on awareness for public and private firms. *Capex* is capital expenditure scaled by lagged total asset, and *R&D* is the expenditure on research and development scaled by lagged total assets. *Emission* is the company's total CO2 emissions (Scopes 1 and 2) divided by lagged total assets. *Capex*, *R&D*, and *Emission* are winsorized at the 97.5th percentile. The operator Δ refers to the log difference in average between 2016–2018 and 2010–2015. *High_Emission* is an indicator of high emission industries based on IPCC's categorization. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010. Private firms are matched to public firms with the same country, industry and similar total assets. Public and private firms in the sample have at least one patent in 2010–2018. The sample includes firms from 39 countries. Standard error are clustered by country, and the corresponding *t*-statistics are reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Public Firms			Private Firms		
	ΔCapex	ΔR&D	ΔEmission	ΔCapex	ΔR&D	ΔEmission
High_Emissionin	-0.150	-0.191	0.322	0.108	0.226	0.367
	(-2.50)	(-2.09)	(3.40)	(0.46)	(0.62)	(0.23)
Awareness	0.651	-0.496	0.318	0.328	-0.753	1.526
	(5.33)	(-4.44)	(2.36)	(1.02)	(-3.22)	(1.52)
High_Emissionin×Awareness	0.182	0.338	-0.287	-0.175	-0.306	-0.600
	(2.16)	(2.47)	(-2.62)	(-0.59)	(-0.66)	(-0.39)
N	22532	9599	1156	1599	678	108
Adj. R^2	0.016	0.007	0.002	0.001	0.016	-0.015

Table VII. Regressions of Green Patent on Awareness

This table presents the result of logit regressions of green patent on awareness for public and matched private firms. Δ*Green Ratio* and Δ*Green Number* are dummy variables in that Δ*Green Ratio* equals 1 if the firm's average proportion of green patents increases from 2010–2015 to 2016–2018, Δ*Green Number* equals 1 if the firm's average number of green patents increases from 2010–2015 to 2016–2018. *High_Emission* is an indicator of high emission industries based on IPCC's categorization. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010. Private firms are matched to public firms with the same country, industry and similar total assets. Public and private firms in the sample have at least one patent in 2010–2018. The sample includes firms from 39 countries. Standard error are clustered by country, and the corresponding z-values are reported in parentheses.

	(1)	(2)	(3)	(4)
	Public Firms		Private Firms	
	ΔGreen Ratio	ΔGreen Number	ΔGreen Ratio	ΔGreen Number
High_Emission	-0.503	-0.273	0.284	0.538
	(-1.14)	(-0.79)	(0.36)	(0.74)
Awareness	-3.906	-4.147	-2.402	-2.466
	(-3.42)	(-3.44)	(-1.75)	(-1.76)
High_Emission×Awareness	2.026	1.626	0.828	0.450
	(3.22)	(3.20)	(0.67)	(0.40)
N	23527	23527	26605	26605
Pseudo R^2	0.048	0.052	0.025	0.027

Table VIII. Robustness: Regressions of Price Ratios on Divestment Measures

This table presents the result of robustness checks of price ratios on divestment measures. Price-to-earnings (PE) and Price-to-Book (PB) ratios are calculated using the end-of-year market capitalization divided by total earnings and book equity in the previous year, respectively. Ln_PE and Ln_PB are the log of one plus PE or PB, respectively. PB and PE ratios are winsorized within country-year at the 2.5th and 97.5th percentiles. $LATE$ equals one for years of 2016–2018, and zero otherwise. $High\_Emission$ is an indicator of high emission industries based on IPCC's categorization. $\Delta Carbon\_Ratio$ and $\Delta Divest\_Slope$ are defined in Tables I and III. $Awareness$ is the fraction of population who know about climate change in Gallup survey in 2010. Panels A, B, and C use $\Delta Divest\_Slope$, $\Delta Carbon\_Ratio$, and $Awareness$ as the divestment measure, respectively. The sample includes stocks from 23 countries from 2010 and 2018. Standard error are clustered by country, and the corresponding t-statistics are reported in parentheses.

Panel A: Using $\Delta Divest\_Slope$

	(1) Ln_PE	(2) Ln_PE	(3) Ln_PB	(4) Ln_PB
High_Emission	-0.239		-0.156	
	(-6.25)		(-5.52)	
High_Emission×LATE	0.069	0.121	0.036	0.067
	(3.96)	(5.60)	(1.63)	(3.34)
ΔDivest_Slope	29.048		4.410	
	(2.68)		(0.34)	
High_Emission×ΔDivest_Slope	-8.910		6.193	
	(-1.79)		(1.40)	
LATE×ΔDivest_Slope	14.082	4.073	-2.564	-2.620
	(1.90)	(0.77)	(-0.54)	(-0.59)
High_Emission×LATE×ΔDivest_Slope	15.007	21.406	9.368	7.078
	(4.16)	(5.19)	(2.63)	(2.08)
Firm Fixed Effect	No	Yes	No	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
N	100843	100843	140443	140443
Adj. R^2	0.061	0.556	0.043	0.624

Panel B: Using ΔCarbon_Ratio

	(1) Ln_PE	(2) Ln_PE	(3) Ln_PB	(4) Ln_PB
High_Emission	-0.211		-0.156	
	(-3.48)		(-4.19)	
High_Emission×LATE	0.099	0.144	0.051	0.085
	(2.99)	(3.26)	(2.47)	(4.90)
ΔCarbon_Ratio	9.324		1.947	
	(1.91)		(0.66)	
High_Emission×ΔCarbon_Ratio	0.189		1.724	
	(0.08)		(1.33)	
LATE×ΔCarbon_Ratio	4.407	0.903	0.937	0.540
	(2.70)	(0.91)	(0.56)	(0.40)
High_Emission×LATE×ΔCarbon_Ratio	4.370	5.680	3.058	3.078
	(3.16)	(3.01)	(2.23)	(3.00)
Firm Fixed Effect	No	Yes	No	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
N	100843	100843	140443	140443
Adj. R^2	0.079	0.556	0.052	0.625

Panel C: Using Awareness (23 Countries)

	(1)	(2)	(3)	(4)
	Ln_PE	Ln_PE	Ln_PB	Ln_PB
High_Emission	-0.400		0.026	
	(-7.12)		(0.52)	
High_Emission×LATE	0.360	0.509	0.233	0.201
	(8.48)	(18.16)	(9.46)	(6.03)
Awareness	-0.332		0.232	
	(-1.56)		(1.19)	
High_Emission×Awareness	0.208		-0.241	
	(1.82)		(-3.73)	
LATE×Awareness	-0.330	-0.054	0.124	0.103
	(-1.96)	(-0.41)	(1.13)	(1.00)
High_Emission×LATE×Awareness	-0.401	-0.528	-0.260	-0.178
	(-6.16)	(-8.82)	(-5.71)	(-3.11)
Firm Fixed Effect	No	Yes	No	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
N	99830	99830	138820	138820
Adj. R^2	0.043	0.557	0.043	0.624

Table IX. Robustness: Regressions of Action Measures on Divestment

The table shows the result of robustness checks of action measures on divestment. *Capex* is capital expenditure scaled by lagged total asset, and *R&D* is the expenditure on research and development scaled by lagged total assets. *Emission* is the company's total CO2 emissions (Scopes 1 and 2) divided by lagged total assets. *Capex*, *R&D*, and *Emission* are winsorized at the 97.5th percentile. The operator Δ refers to the log difference in average between 2016–2018 and 2010–2015. *High_Emission* is an indicator of high emission industries based on IPCC's categorization. Δ*Carbon_Ratio* and Δ*Divest_Slope* are defined in Tables I and III. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010. Panels A, B, and C use Δ*Divest_Slope*, Δ*Carbon_Ratio*, and *Awareness* as the divestment measure, respectively. Private firms are matched to public firms with the same country, industry and similar total assets. Both public and private firms are required to have at least one patent in 2010–2018 in the sample. The sample includes firms from 23 countries. Standard error are clustered by country, and the corresponding t-statistics are reported in parentheses.

Panel A: Using ΔDivest_Slope

	(1)	(2)	(3)	(4)	(5)	(6)
	Public Firms			Private Firms		
	ΔCapex	ΔR&D	ΔEmission	ΔCapex	ΔR&D	ΔEmission
High_Emission	-0.032	0.009	0.040	-0.010	-0.158	-0.791
	(-1.26)	(0.32)	(1.08)	(-0.16)	(-0.74)	(-6.88)
ΔDivest_Slope	-18.681	18.062	-14.261	-26.441	-5.542	87.242
	(-1.51)	(3.94)	(-3.31)	(-2.93)	(-0.21)	(1.19)
High_Emission×ΔDivest_Slope	-9.341	-8.612	8.819	16.236	-3.592	-192.576
	(-2.55)	(-1.64)	(2.01)	(1.41)	(-0.08)	(-1.92)
N	13828	4666	897	1100	319	108
Adj. R^2	0.011	0.006	0.005	0.007	0.004	0.008

Panel B: Using ΔCarbon_Ratio

	(1)	(2)	(3)	(4)	(5)	(6)
	Public Firms			Private Firms		
	ΔCapex	ΔR&D	ΔEmission	ΔCapex	ΔR&D	ΔEmission
High_Emission	-0.011	0.044	0.046	-0.060	0.076	-0.411
	(-0.32)	(0.95)	(1.65)	(-0.59)	(0.41)	(-1.88)
ΔCarbon_Ratio	-3.740	1.465	-1.809	-0.259	-16.130	-1.341
	(-0.91)	(0.56)	(-1.29)	(-0.07)	(-2.83)	(-0.13)
High_Emission× ΔCarbon_Ratio	-0.674	1.092	2.111	-5.128	17.687	-15.028
	(-0.43)	(0.46)	(0.86)	(-1.10)	(1.95)	(-0.77)
N	13828	4666	897	1071	319	108
Adj. R^2	0.004	0.002	-0.002	0.004	0.017	0.001

Panel C: Using Awareness (23 Countries)

	(1)	(2)	(3)	(4)	(5)	(6)
	Public Firms			Private Firms		
	ΔCapex	ΔR&D	ΔEmission	ΔCapex	ΔR&D	ΔEmission
High_Emission	-0.122	-0.236	0.201	0.257	-12.299	0.367
	(-4.25)	(-3.08)	(1.60)	(1.71)	(-4.93)	(0.23)
Awareness	0.717	-0.444	0.169	0.394	-15.429	1.526
	(6.35)	(-3.67)	(1.03)	(1.38)	(-5.86)	(1.52)
High_Emission × Awareness	0.154	0.280	-0.196	-0.365	12.640	-0.600
	(2.20)	(3.49)	(-1.41)	(-1.51)	(4.83)	(-0.39)
N	13828	4666	897	1100	319	108
Adj. R^2	0.021	0.003	-0.002	0.002	0.041	-0.015

Figure I. Global Average *Carbon_Ratio*

This figure plots the average *Carbon_Ratio* of all countries from 2010Q1 to 2018Q4. For each country/area, *Carbon_Ratio* is calculated as the value-weighted average of institution's portfolio weight on high emission firms net of the market weight. The vertical line represents 2015Q4.

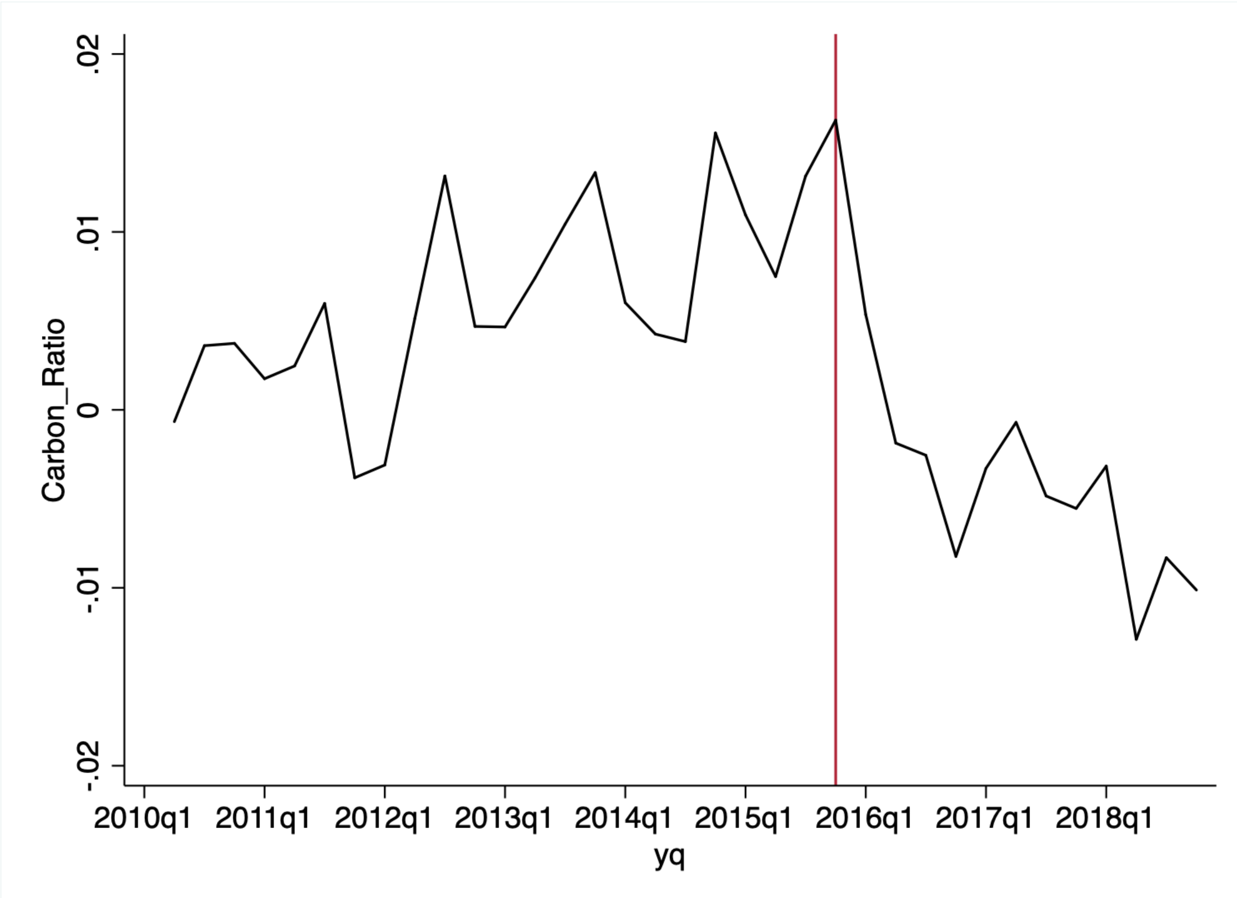

Figure II. *Carbon_Ratio* by *Awareness*

This figure plots the average *Carbon_Ratio* of high and low awareness groups from 2010Q1 to 2018Q4. Countries are equally sorted into high and low awareness groups. *Awareness* is the fraction of population who know about climate change in Gallup survey in 2010. The figure plots the average *Carbon_Ratio* of each group from 2010Q1 to 2018Q4. For each country/area, *Carbon_Ratio* is calculated as the value-weighted average of institution's portfolio weight on high emission firms net of the market weight. The vertical line represents 2015Q4.

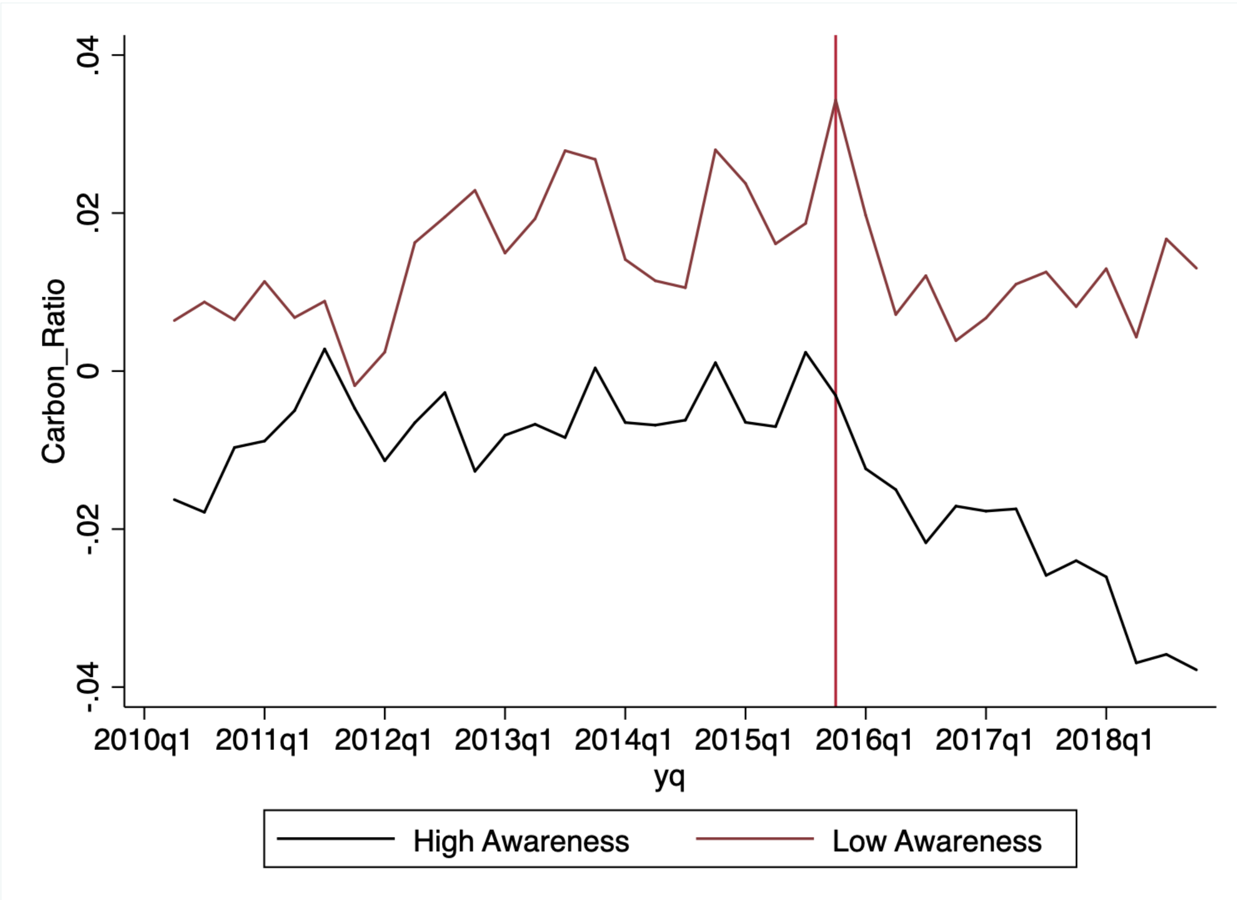

Figure III. $\Delta Carbon\_Ratio$ and $Awareness$

This scatter plots the relationship between $\Delta Carbon\_Ratio$ and $Awareness$ with a linear fitted line and 95% confidence intervals. For each country/area, $Carbon\_Ratio$ is calculated as the value-weighted average of institution's portfolio weight on high emission firms net of the market weight. $Awareness$ is the fraction of population who know about climate change in Gallup survey in 2010.

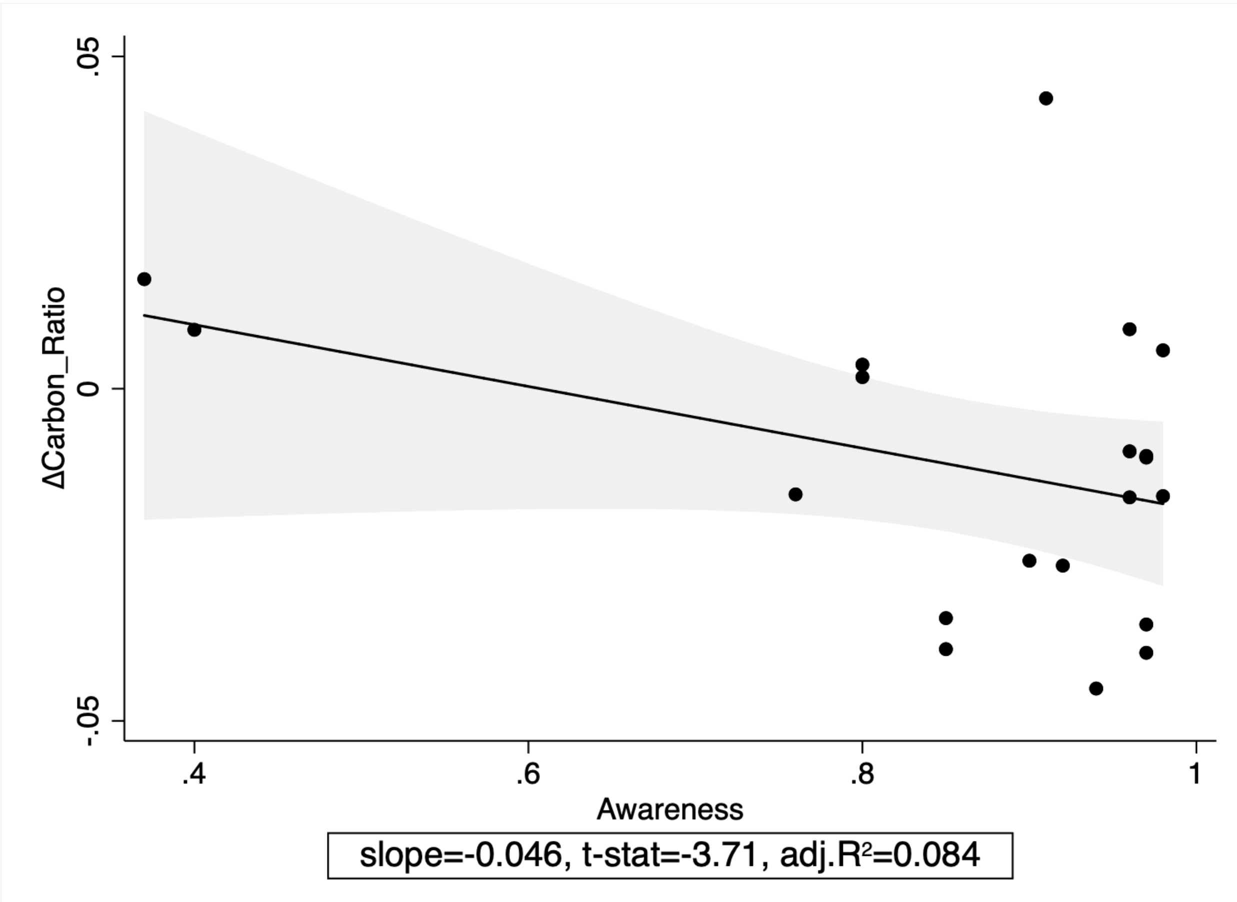

Figure IV. $\Delta Divest\_Slope$ and $Awareness$

This scatter plots the relationship between $\Delta Divest\_Slope$ and $Awareness$ with a linear fitted line and 95% confidence intervals. $\Delta Divest\_Slope$ is the point estimate of β_2 in Eq.(3). $Awareness$ is the fraction of population who know about climate change in Gallup survey in 2010.