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GLOBAL PRICING OF CARBON-TRANSITION RISK

Patrick Bolton
Marcin Kacperczyk

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ABSTRACT

Companies are exposed to carbon-transition risk as the global economy transitions away from fossil fuels to renewable energy. We estimate the market-based premium associated with this transition risk at the firm level in a cross-section of over 14,400 firms in 77 countries. We find a widespread carbon premium—higher stock returns for companies with higher levels of carbon emissions (and higher annual changes)—in all sectors over three continents, Asia, Europe, and North America. Short-term transition risk is greater for firms located in countries with lower economic development, greater reliance on fossil energy, and less inclusive political systems. Long-term transition risk is higher in countries with stricter domestic, but not international, climate policies. However, transition risk cannot be explained by greater exposure to physical (or headline) risk. Yet, raising investor awareness about climate change amplifies the level of transition risk.

Patrick Bolton
Columbia Business School
804 Uris Hall
New York, NY 10027
and NBER
pb2208@columbia.edu

Marcin Kacperczyk
Imperial College Business School
Tanaka Building
South Kensington Campus
London SW7 2AZ
United Kingdom
m.kacperczyk@imperial.ac.uk

1 Introduction

Public opinion, governments, business leaders, and institutional investors all over the world are awakening to the urgency of combatting climate change.[2] This growing concern about climate change may crystalize into a faster and perhaps more disorderly transition away from fossil fuels to renewable energy. By now over 100 countries have committed to carbon net neutrality targets, representing nearly 50% of world GDP. In addition, a number of multilateral agreements and other commitments to reduce carbon emissions have been made.[3] This, in turn, means greater carbon-transition risk for companies, especially those that rely more on fossil fuel production or consumption. Ultimately, of course, this transition may also affect the speed with which the physical climate changes.

In this paper we take a (forward-looking) global financial-market perspective to evaluate the economic importance investors attach to this transition risk, by looking at stock prices of a large set of companies with different degrees of exposure to this risk. From an individual firm's perspective, transition risk reflects the uncertain rate of adjustment towards carbon neutrality. From investors' perspective, the risk also embodies evolving beliefs about the transition to cleaner energy. Transition risk is the amalgamation of a wide range of shocks, including changes in climate policy, reputational impacts, shifts in market preferences and norms, and technological innovation.

Much of the economics literature on climate risk relies on country-level measures. This country-level focus unfortunately creates empirical identification challenges, as country-level variation could be driven by sources other than carbon transition at the country level. In this study, we can to some extent overcome this challenge by exploiting the rich cross-sectional firm-level variation in carbon emissions, within each country. This granularity of firm-specific confounders can be combined with various fixed effects to capture unobservable variation driving transition risk. To our knowledge, this is the first study in economics on transition risk with such a large panel data structure.

The economics literature on climate change following Nordhaus (1991) has framed the issue as a global public goods problem that requires a global Pigouvian carbon tax to internalize the externality. The tax should be set equal to the social cost of carbon to achieve efficiency, where the social cost is given by the discounted, expected, physical harm from a warming climate caused by the accumulation of carbon particles in the atmosphere. This literature does not address the transition risk that firms relying on fossil energy face as the economy adjusts to renewable energy. In contrast, the finance literature on climate change is more directly concerned with the pricing of climate change

[2] Some of the most notable actions include the national and pan-national initiatives, such as Conference of the Parties (COP), Nationally Declared Contributions (NDCs) supported by the United Nations, or the G20 Taskforce for Climate-related Financial Disclosure (TCFD).
[3] Some of the prominent examples include China's commitment of carbon net neutrality by 2060, and Japan's and U.K.'s commitments by 2050.

risk, in particular transition risk. But this literature is still in its infancy and we currently only have patchy evidence on the pricing of carbon-transition risk. Accordingly, in this study we attempt a more systematic, more wide-ranging, analysis than has been done to date on the pricing of transition risk, focusing on how stock returns reflect investor concerns about carbon transition risk, both short-term and long-term. Specifically, we explore how corporate carbon emissions together with country characteristics that reflect the country's likely progress in the energy transition affect stock returns for over 14,400 listed companies in 77 countries over a period ranging from 2005 to 2018. This is essentially the universe of all listed companies globally for which it is possible to obtain carbon emissions data. We exploit a rich country, industry, and firm-level variation to identify some of the more nuanced elements of transition risk as it relates to technological shifts, social norms, and policies.

A first contribution of our paper is to shed light on the distribution of corporate carbon emissions across the 77 countries in our sample. In most studies on global carbon emissions the unit of analysis is the country and little information is provided about the breakdown of emissions across companies within each country. According to Fortune magazine, in 2017 the 500 largest companies in the world generated $30 trillion in revenues[4]. This represents 37.5% of World GDP, which was around $80 trillion in 2017 according to the CIA's World Factbook. It is thus natural to view climate change mitigation not just through the lens of the largest emitting countries, but also through the lens of the largest emitting companies. As a by-product of our analysis, we provide an overview of how carbon emissions are distributed across the listed companies around the world.

Our study is the first comprehensive exploration of carbon transition risk around the world at the firm level, and we were uncertain as to what we might find. There are, however, a number of general considerations that led us to expect particular results. First, a plausible null hypothesis is that we would not find higher stock returns for companies with higher carbon emissions on the grounds that investor awareness about climate change has not yet become salient in many countries during our sample period, with the exception perhaps of Europe (and to some extent in the United States, Japan, and a few other OECD countries).

Another reasonable hypothesis is that the carbon premium is to be found in the parts of the world responsible for the highest fraction of carbon emissions, that is, in the largest and most developed economies. An important reason is that this is where emission reductions are most urgent and therefore where transition risks are highest. All the more so that the more developed economies also have greater capabilities to innovate in renewable energy technologies. A further plausible conjecture is that in countries with large commodity export sectors (Australia, Brazil) there would be

[4] https://fortune.com/global500/2018/

more political opposition to the introduction of policies limiting carbon emissions, and therefore that investors would perceive a lower transition risk in these countries.

Public opinion clearly matters more in more democratic countries and climate activists may have greater success in the courts of countries with a stronger rule of law. Yet, greater political "voice" or stronger rule of law can cut both ways. It can empower green public opinion, but it can also entrench opposition to climate change mitigation. How the carbon premium should be expected to vary with countries' political and legal traditions is thus largely an open question.

A somewhat less plausible but nevertheless important hypothesis is that cross-country differences may not matter so much in a world of globally integrated stock markets. To the extent that the same representative investors hold all the public companies around the world, there should be a uniform treatment by these investors of firm-level carbon risk around the world. By this hypothesis, differences in carbon premia across countries would then mostly reflect different expected policy risk.

We are able to explore all of these hypotheses and to partly confirm some or reject others. A few general striking results emerge from our analysis, but the overall picture is relatively nuanced. A first striking general finding is that there is actually a positive and significant carbon premium in most areas of the world. It is present in North America, Europe, and Asia. The only exception is Africa, Australia, and South America, where we do not find a significant premium. Moreover, this premium is related to both direct emissions from production, and indirect emissions from firms in the supply chain. Importantly, firms associated with higher emissions offer higher stock returns after controlling for characteristics that predict returns, such as size, book-to-market, momentum, the value of property, plant & equipment (PPE), profitability, and investment over assets.

Surprisingly, we find a similar carbon premium in China and in the U.S. These two economies are the largest carbon emitters in the world, but they are very different in many respects: their level of economic development, the relative size of their manufacturing and energy sectors, the size of their financial markets and asset management sectors, their political systems, their demographics, and their public opinions on the environment and climate change. Despite all these differences, we find that the carbon premium is similar in both economies. A related surprise is that differences in level of development more generally do not explain the variation in carbon premium across countries.

A second general finding is that the carbon premium is related to both the level of emissions and percentage changes in the level of emissions. Our findings bring out the fact that a firm's exposure to transition risk is proportional to the level of its emissions. This is a very robust finding that underscores the importance of the level of emissions to apprehend transition risk; it goes against the near exclusive focus of attention on emission intensity by practitioners and other climate finance studies. Carbon emissions must be significantly curbed in the next two decades, whether or not companies are wasteful in their fossil energy consumption. Interestingly, both levels and changes in emissions affect the carbon premium, which we interpret as reflecting that transition risk involves both a long-run and short-run component. Given that emissions are highly persistent over time, the level of emissions picks up the long-run exposure to transition risk, whereas changes reflect a company's short-run drift away from (or into) greater future emissions. Changes in emissions could also reflect changes in earnings, but we control for this effect by adding the company's return on equity and sales growth among our independent variables.

Subsequently, we delve into cross-country variation to shed light on the sources of the carbon premium. The main premise of our tests is that in partially segmented markets, the local country environment can amplify or mitigate the average premium. Since country-level evidence is possibly subject to omitted variables bias (or correlated confounding economic variables), we exploit firm-level variation in carbon emissions in conjunction with a variety of firm-level controls and fixed effects to better identify each economic channel. Our identification approach is similar to the one effectively used by Rajan and Zingales (1998) in their study of the link between financial development and economic growth.

As a starting point, we consider differences in the level of economic development. We find that the short-term carbon premium is generally higher among firms that are headquartered in countries with more modest economic development. In particular, it is higher in countries with lower GDP per capita, countries whose economic output relies more on manufacturing sector, and in countries with less developed healthcare system. Yet, the same characteristics cannot explain the cross-country variation in the long-term carbon premium. These results stand in contrast to the common view that the carbon risk is a problem of developed countries.

We further identify several other country characteristics that matter significantly. We group these characteristics into two broad categories, respectively political or social factors, and energy factors. Regarding political factors, we find that both "voice" and "rule of law" significantly affect the short-run carbon premium associated with changes in emissions. More democratic countries (with stronger rule of law) tend to have lower carbon premia, other things equal. Further, we find that long-term carbon premium is larger in countries with tighter climate policy. The significance of long-term effects suggests that investors may perceive any policy change as more permanent. Notably, among two types of policies, domestic and international, we find that only the former is economically significant whereas the effect of the latter is very small. This result underscores the importance of political coordination costs associated with climate policies, a problem that the global communities have witnessed in recent years.

When we consider the country-level variation in energy mix, we find that the carbon premium is lower in countries with a higher share of renewable energy, and higher in countries with greater dependence on the energy sector. The energy mix effect is reflected in the short-term premium, which suggests that any technological progress is perceived as transitory or otherwise as a factor that is hard to estimate in the long run. Somewhat surprisingly, we find that a country's energy consumption is not a significant predictor of the carbon premium.

Finally, we also find that in the countries that have been exposed to greater damages from climate disasters (floods, wild-fires, droughts, etc.) there is no significantly different carbon premium. This result suggests that the carbon premium does not reflect physical climate risks, nor that physical risk is positively correlated with transition risk, or that (consistent with the findings of Hong, Li, and Xu, 2019) transition risk may be more salient to investors than rising physical risk.

Given that climate change has become a major issue for investors only recently we also explore how the carbon premium has changed in recent years. We do this by comparing the estimated premia for the two years leading up to the Paris agreement in 2015 and following the agreement. A number of striking results emerge from this analysis. First, when we pool all countries together, we find that there was no significant premium before the Paris agreement, but a highly significant and large premium in the years after the agreement. This general result is consistent with the view that investors have only recently become aware of the urgency of climate change. Second, the change in carbon premium is mostly related to long-term risks, which given our previous results suggests that Paris agreement led investors to update their beliefs about long-term impact of climate policy tightness rather than the short-term impact of technology or political environment. Finally, when we break down the change in the carbon premium around the Paris agreement by continent, we find that the premium has sharply risen in Asia, and less so in North America and Europe. In effect, Asia is entirely responsible for the rise in the global carbon premium around the Paris agreement.

A difficult question to answer is how transition risk gets impounded into asset prices. From an equilibrium perspective, our results imply the existence of a transition stage during which prices of assets with low emissions are bid up while prices of assets with high emissions are bid down in response to changing investor beliefs. The different repricing phases are difficult to pin down empirically since individual asset prices may transition at different times and at different speeds. Still, we provide some suggestive evidence that such repricing has indeed taken place. In particular, we show that the rise in the use of renewable technology coincides with the decrease in stock prices of oil majors. These repricing effects are economically large and underscore the importance of the energy transition to a new equilibrium.

Overall, our analysis paints a nuanced picture of the pricing of carbon transition risk around the world. The pricing is uneven across countries but widespread in North America, Asia, and Europe. From a short-term perspective, it is related to the energy mix of the country and to politico-socio-economic characteristics of the country. In turn, climate policy tightness is reflected in long-term carbon-transition pricing. The carbon premium is also rising, with a significant increase post Paris agreement, a fact consistent with the rise in investor awareness.

Related Literature: We are obviously not the first to undertake a cross-country analysis. As informative as such analyses can be, and as suggestive as the results are, it is important to underline the important limitation that we cannot draw any causal inferences from this analysis. The closest analysis to ours is by Görgen, Jacob, Nerlinger, Riordan, Rohleder, and Wilkens (2020), who estimate stock return differences between a group of "brown" and "green" firms around the world. Also, related in terms of general subject matter are the studies by Dyck, Lins, Roth, and Wagner (2019) and by Gibson, Glossner, Krueger, Matos, and Steffen (2019), who both explore how environmental, social, and governance (ESG) motivated investing varies around the world.

Next to this cross-country literature there is, of course, a growing country-level climate finance literature, mostly focused on the U.S. In an early theoretical contribution, Heinkel, Kraus, and Zechner (2001) have shown how divestment from companies with high emissions can give rise to higher stock returns. Another relevant analysis for transition risk by Shapiro and Walker (2018) finds that air pollution by U.S. manufacturers has declined significantly as a result of tightening pollution regulations between 1990 and 2008. An early study by Matsumura, Prakash, and Vera-Munoz (2014) finds that higher emissions are associated with lower firm values. Relatedly, Chava (2014) finds that firms with higher carbon emissions have a higher cost of capital. More recently, Ilhan, Sautner, and Vilkov (2020) have found that carbon emission risk is reflected in out-of-the-money put option prices. Hsu, Li, and Tsou (2019) find that highly polluting firms are more exposed to environmental regulation risk and command higher average returns. Engle, Giglio, Lee, Kelly, and Stroebel (2020) have constructed an index of climate news through textual analysis of the Wall Street Journal and other media and show how a dynamic portfolio strategy can be implemented that hedges risk with respect to climate change news. Monasterolo and De Angelis (2019) explore whether investors demand higher risk premia for carbon-intensive assets following the COP 21 agreement. Garvey, Iyer, and Nash (2018) study the effect of changes in direct emissions on stock returns, and Bolton and Kacperczyk (2020) find that there is a significantly positive effect of carbon emissions on U.S. firms' stock returns for both direct and indirect carbon emissions.

Other related studies have explored the asset pricing consequences of greater material risks linked to climate events and global warming. Bansal, Kiku, and Ochoa (2016) reveal the asset pricing implications of rising temperatures using an equilibrium framework with an endogenous temperature process embodied in a standard long-run risk model. Hong, Li, and Xu (2019) have found that the rising drought risk caused by climate change is not efficiently priced by stock markets. Several studies have looked at climate change and real estate prices. Baldauf, Garlappi, and Yannelis (2020) find little evidence of declining prices as a result of greater flood risk due to sea level rise. Bakkensen and Barrage (2017) find that climate risk beliefs in coastal areas are highly heterogeneous and that rising flood risk due to climate change is not fully reflected in coastal house prices. Bernstein, Gustafson, and Lewis (2019) find that coastal homes vulnerable to sea-level rise are priced at a 6.6% discount relative to similar homes at higher elevations. However, in a related study Murfin and Spiegel (2020) find no evidence that sea-level-rise risk is reflected in residential real estate prices. Finally, Giglio, Maggiori, Rao, Stroebel, and Weber (2018) use real estate pricing data to infer long-run discount rates for valuing investments in climate change abatement.

The remainder of the paper is organized as follows. Section 2 describes the data and provides summary statistics. Section 3 discusses the results. Section 4 concludes.

2 Data and Sample

Our primary database matches two data sets by respectively Trucost, which provides annual information on firm-level carbon and other greenhouse gas emissions, and FactSet, which assembles data on stock returns and corporate balance sheets. We performed the matching using ISIN as a main identifier. In some instances, in which ISIN was not available to create a perfect match, we relied on matching based on company names.[5] Finally, when there are multiple subsidiaries of a given company, we used the primary location as a matching entity. The ultimate matching produced 14,468 unique companies out of 16,222 companies available in Trucost. They represent 77 countries. Among the companies we were not able to match, more than two thirds are not exchange listed and the remaining ones are small and are not available through Factset. The top three countries in terms of missing data are China, Japan, and the United States. In sum, our sample essentially covers more than 98% of publicly listed companies in terms of their market capitalization, for which we have emissions data. We augment this data with country-level variables from the World Bank, Germanwatch, the provider of the global climate policy index and the climate risk index (CRI), and Morgan Stanley for the MSCI world index data.

[5] After standardizing the company names in FactSet and Trucost, respectively, we choose companies whose names have a similarity score of one based on the standardized company names.

2.1 Data on Corporate Carbon Emissions

Trucost firm-level carbon emissions data follows the Greenhouse Gas Protocol that sets the standards for measuring corporate emissions.[6] The Greenhouse Gas Protocol distinguishes between three different sources of emissions: scope 1 emissions, which cover direct emissions over one year from establishments that are owned or controlled by the company; these include all emissions from fossil fuel used in production. Scope 2 emissions come from the generation of purchased heat, steam, and electricity consumed by the company. Scope 3 emissions are caused by the operations and products of the company but occur from sources not owned or controlled by the company. These include emissions from the production of purchased materials, product use, waste disposal, and outsourced activities. The Greenhouse Gas Protocol provides detailed guidance on how to identify a company's most important sources of scope 3 emissions and how to calculate them. For purchased goods and services, this basically involves measuring inputs, or "activity data", and applying emission factors to these purchased inputs that convert activity data into emissions data. Trucost upstream scope 3 data is constructed using an input-output model that provides the fraction of expenditures from one sector across all other sectors of the economy. This model is extended to include sector-level emission factors, so that an upstream scope 3 emission estimates can be determined from each firm's expenditures across all sectors from which it obtains its inputs (see Trucost, 2019).[7]

The Trucost EDX database reports all three scopes of carbon emissions in units of tons of CO2 emitted in a year. We first provide basic summary statistics on carbon emissions across our 77 countries aggregated up from the firm-level emissions reported by Trucost. Table 1 reports the country-level distribution of firms in our sample and various measures of emissions broken down into scope 1, scope 2, and scope 3. We consider the average total yearly emissions in tons of CO2 equivalent per firm in each country (*S1TOT*, *S2TOT*, and *S3TOT*), the (winsorized) yearly percentage rate of change in emissions (*S1CHG*, *S2CHG*, and *S3CHG*), and the total yearly emissions by country (*TOTS1*, *TOTS2*, and *TOTS3*).

The largest country by number of observations is obviously the United States, but remarkably it only represents around 19.8% of total observations, with Japan a close second with 14% of observations, and China third with around 8.2% of observations. Importantly for our analysis, Table 1 highlights that the majority of listed firms in our sample is not concentrated in these three large economies. In aggregate, the entire population of countries in our sample produces a staggering 11.81

[6] See https://ghgprotocol.org.

[7] Downstream scope 3 emissions, caused by the use of sold products, can also be estimated and are increasingly reported by companies. Trucost has recently started assembling this data (see Trucost, 2019); however, we do not include this data in our study.

billion tons of scope 1, 1.62 billion tons of scope 2, and 7.99 billion tons of scope 3 emissions per year. The three biggest contributors in terms of total carbon emissions produced are China producing 2.91 billion tons of scope 1 emissions per year, followed by the U.S. with 2.33 billion, and Japan contributing 980 million. The same three countries also dominate scope 2 and scope 3-emissions, except that the ranking changes with U.S producing 2.1 billion of scope 3 emissions, followed up by Japan with 1.25 billion, and China with 841 million tons of CO2.

The global production of emissions does not necessarily reflect the contribution of each firm to the total, as the relative sizes of countries vary. In fact, the top three countries in terms of scope 1 emissions per firm are Russia, the Netherlands, and Greece, with their respective emission levels of 10.1 million, 5.6 million, and 4.2 million tons of CO2 per year. An average Russian firm also leads the rankings in terms of scope 3 emissions with 6.1 million tons of CO2, followed by Germany and France, with respective numbers of 3.4 and 2.9 million tons of CO2. A slightly different picture can be painted when we compare firm-level emission intensities. The most intense countries in terms of scope 1 emissions include Estonia, Morocco, and Peru. Among the largest countries, Russia, India, and China score relatively high, while France, Japan, and the United Kingdom score relatively low.

Another striking observation is that carbon emissions are growing in most countries throughout our sample period. The country with the highest growth rate in scope 1 emissions is Mauritius, with an average yearly growth rate of 45%. The second largest is Bulgaria with a 35% growth rate, and the third, fourth, and fifth largest are, respectively, Iceland, Kenya, and Lithuania. All these five countries have witnessed rapid GDP growth over our ample period. Among the largest economies, the ones with the highest growth rate in emissions are China with nearly 18%, the Russian Federation with 16%, the United States with 7.9%, and Germany with 7.1% growth rates. Among the countries with the lowest growth rates in scope 1 emissions are, remarkably, Saudi Arabia, with a negative 10.5% growth rate (this may reflect the fact that a lot of companies have gone public over our sample period, lowering the average per-company scope 1 emissions), Luxembourg with a negative 33% growth rate, and Jordan with a minus 7.5% growth rate. When it comes to the growth rate in scope 3 emissions, some of these rankings are reversed, reflecting the fact that some countries increasingly rely on imports whose production generates high emissions. Thus, Saudi Arabia has a 4.3% growth rate in scope 3 emissions.

In Figures 1 and 2, we further represent the detailed cross-country variation in total emissions over two equal-length time periods, which classify countries into four categories by their performance in these metrics. The left panel of each figure represents scope 1 emissions, the middle panel scope 2 emissions, and the right panel scope 3 emissions. As can be seen in Figure 1, the countries with the highest total average yearly emissions are first, the countries with the highest GDP, second the countries with the largest populations, and third the largest commodity exporting countries. Important exceptions are Sweden, which has the lowest emissions among developed countries, Iceland, and the Czech Republic. Importantly for our analysis, there is considerable cross-country variation in total emissions. To the extent that the carbon premium reflects concerns about the level of emissions, we expect to see considerable variation in the premium across countries.

We further show how the performance of countries has changed from the first half period of our sample, from 2005 to 2011, to the second half period, from 2012 to 2018. The most noteworthy changes are the deterioration in total emission performance of Latin America, the Russian Federation, Turkey, and Australia.

Interestingly, however, there is little correlation between a country's levels of total emissions and average per-firm emissions, as can be seen in Figure 2, which represents the cross-country variation in average per-firm emissions. Among the worst performers in the world in per-firm emissions are the United States, Saudi Arabia, Argentina, Colombia, China, the Russian Federation, India, Japan and the European Union (excluding the U.K.).

In Table 2, Panel A we report summary statistics on per-firm carbon emissions in units of tons of CO2 emitted in a year, normalized using the natural log scale. Thus, the log of total scope 1 emissions of the average firm in our sample (*LOGS1TOT*) is 10.32, with a standard deviation of 2.95. Note that the median number is the largest for scope 3 emissions (*LOGS3TOT*), indicating that most companies in our sample are significantly exposed to indirect emissions. To mitigate the impact of outliers we have winsorized all growth and intensity measures at the 2.5% level. In Panel B, we report the correlations between the total emissions variable and the emission percentage change variable for the three different categories of emissions. Interestingly, the correlation coefficients are quite low, indicating that the emission change variable reflects a different type of variation in the data.

Finally, Panel C provides summary statistics on stock returns and several control variables we use in our subsequent tests. The dependent variable, $RET_{i,t}$, in our cross-sectional return regressions is the monthly return of an individual stock *i* in month *t*. The average return in our sample is 1.08% with a standard deviation of 10.23%. We use the following control variables in our cross-sectional regressions: $LOGSIZE_{i,t}$, which is given by the natural logarithm of firm *i*'s market capitalization (price times shares outstanding) at the end of year *t*; $B/M_{i,t}$, which is firm *i*'s book value divided by its market cap at the end of year *t*; *LEVERAGE*, which is the ratio of debt to book value of assets; momentum, $MOM_{i,t}$, which is given by the average of the most recent 12 months' returns on stock *i*, leading up to and including month *t-1*; capital expenditures $INVEST/A$, which we measure as the firm's capital expenditures divided by the book value of its assets; a measure of the firm's specialization, HHI , which is the Herfindahl concentration index of the firm with respect to its different business segments, based on each segment's revenues; the firm's stock of physical capital, *LOGPPE*, which is given by the natural logarithm, of the firm's property, plant, and equipment; the firm's earnings performance $ROE_{i,t}$, which is given by the ratio of firm i's net yearly income divided by the value of its equity; the firm's idiosyncratic risk, $VOLAT_{i,t}$, which is the standard deviation of returns based on the past 12 monthly returns; and, $MSCI_{i,t}$, which is an indicator variable equal to one if a stock *i* is part of the MSCI World index in year *t*, and zero otherwise. To mitigate the impact of outliers we winsorize *B/M, LEVERAGE, INVEST/A*, and *ROE* at the 2.5% level, and *MOM* and *VOLAT* at the 0.5% level.

The average firm's monthly stock return equals 1.08%, with a standard deviation of 10.23%. The average firm has a market capitalization of $66 billion, significantly larger than the size of the median firm in our sample, which is $15 billion. The average book-to-market ratio is 0.57, and average book leverage is 23%. The average return on equity equals 11.1%, slightly more than the median of 10.87%.

Table 3 provides summary statistics by year for the total number of firms in our sample in any given year and for total emissions, the level and percentage change in emission intensity, for all three *SCOPE* categories. Note in particular the large increase in coverage after 2015, when the number of firms jumps from 5427 in 2015 to 11961 in 2016. This is due to the fact that Trucost has been able to expand the set of firms worldwide for which it was able to collect data on carbon emissions.

We also report the distribution of firms by industry in Table A.1, using the six-digit Global Industry Classification (GIC 6). Our global database should reflect a greater proportion of firms in manufacturing and agriculture than is the case in developed economies. This is indeed what is reflected in Table 4, with 580 companies in the machinery industry, 530 in the chemicals industry, 520 in the electronic equipment, instruments and components industry, 506 in metals and mining, and 440 food products companies. In the services sector the largest represented industries are banking with 679 banks and real estate, with 619 companies (some of which are also engaged in construction and development).

Finally, we report summary statistics on the main determinants of carbon emissions in Table 4. We regress in turn the log of total firm-level emissions, the percentage change in total emissions, and the levels of emission intensity on the following firm-level characteristics: *LOGSIZE, B/M, ROE, LEVERAGE, INVEST/A, HHI, LOGPPE*, and *MSCI.* To allow for systematic differences in correlations across countries and over time, we include year/month fixed effects and country fixed effects. In this regard, our identification comes from within-country variation in a given year. In columns (4)-(6), we further include industry fixed effects to account for possible differences across industries. Finally, in columns (7)-(9), we include firm fixed effects. In Panel A, we show considerable variation across industries in the effect of these variables on emissions (for example, the R-square increases from 0.696 to 0.779 when we add industry fixed effects to the regression for *LOGS1TOT*). Accordingly, we focus on the regressions with industry fixed effects and note that total emissions significantly increase with the size of the firm (in particular if it is a constituent of the MSCI World index), its book to market ratio, its leverage, and its tangible capital stock (*PPE*). This is altogether not surprising, to the extent that emissions are generated by economic activity, which is proportional to the size of the firm. Somewhat surprising is the strong effect of leverage. One possible explanation is that firms with higher emissions may anticipate future drop in profitability due to transition risk and as a result take more leverage. Interestingly, investment has a strong negative effect on emissions, suggesting that new capital vintages are more carbon efficient. Industry specialization (a high HHI) also has a negative effect on emissions, perhaps because non-specialized conglomerates tend to be larger. Alternatively, conglomeration can reflect a firm's response to potential costs of high emissions in a particular sector.

Finally, we also note a strong explanatory power of firm attributes as the coefficient increases to 0.960 when we add firm fixed effects. Nonetheless, the coefficients of the firm-level characteristics do not change markedly in this specification relative to the one with industry fixed effects.

3 Results

We organize our discussion into two subsections. The first one reports results on the overall pricing of transition risk and the second reports results related to specific components of the risk.

3.1 Pricing Carbon-Transition Risk throughout the World

The transition to a carbon net neutral world generates risk for shareholders through both cash-flow and discount rate risk. Firms with high emissions may incur greater costs from emission abatement, renewable energy production, policy compliance, and possible litigation. When these costs materialize firms may respond by increasing leverage, which increases default risk, or in extreme cases may have to cease operating. But, transition risk also involves uncertainty with respect to the dynamics of changes in investors' beliefs about climate change risk. Both types of shocks increase equity risk.[8] Firms with high emissions are also exposed to reputational risk, social backlash, and stakeholder activism, shareholder pressure to divest, and generally headline risk. Using the logic of Merton (1987), these factors could increase the discount rates of high carbon emission firms. In this section we present results in support of such transition risk effects. In our unconditional tests we do not aim to separate the cash flow from the discount rate effects. In the following section, where we provide

[8] But the energy transition may also open up new opportunities, giving firms access to higher profit streams. In this case one could observe a reduction in risk premia (e.g., Kogan and Papanikolaou, 2014).

additional evidence regarding the specific transmission mechanism driving stock returns, we attempt to separate out individual sources of transition risk.

3.1.1 Empirical Specification

Our analysis of carbon-transition risk centers on two different cross-sectional regression models relating individual companies' stock returns to carbon emissions. Rather than a factor-based model we take a firm characteristic-based approach along the lines of Daniel and Titman (1997). This approach is particularly well suited given the rich cross-sectional variation in firm characteristics in our sample.[9] As shown in Bolton and Kacperczyk (2020), these characteristics are particularly relevant when using carbon emissions as the main sorting variable. This approach also allows us to take full advantage of fixed effects along time, country, industry, and firm dimensions. Further, we can better account for potential dependence of residuals by using a clustering methodology. Finally, the advantage of taking a characteristics-based approach is that we do not need to take a stance on the underlying asset pricing model. One basic conceptual difficulty with the choice of asset pricing model in the context of a complex pricing problem such as climate change risk, is that such a model has not yet been formulated. However, since we do not take a risk-factor approach, we cannot explore the presence of a "carbon alpha" or of any mispricing of carbon-transition risk. Our aim is more limited: to provide a comprehensive picture of the cross-sectional variation in stock-level returns throughout the world.

We begin by linking companies' *total* emissions in a given year to their corresponding monthly stock returns in the cross-section. This regression reflects the long-run, structural, firm-level impact of emissions on stock returns. Taking absolute carbon neutrality as a benchmark, one can think of this measure as a rough proxy for the quantity of risk a firm is exposed to at a given point in time. Specifically, we estimate the following model:

$$RET_{i,t} = a_0 + a_1(TOT\ Emissions)_{i,t} + a_2 Controls_{i,t-1} + \mu_t + \varepsilon_{i,t} \quad (1)$$

where $RET_{i,t}$ measures the stock return of company *i* in month *t* and *TOT Emissions* is a generic term standing for respectively *LOGS1TOT*, *LOGS2TOT*, and *LOGS3TOT*. The vector of firm-level controls includes the firm-specific variables *LOGSIZE, B/M, LEVERAGE, MOM, INVEST/ASSETS, HHI, LOGPPE, ROE,* and *VOLAT.*

[9] The risk factor-based approach has been a popular method to measure risk premia in a single-country, but in a fully global study, such as this one, this approach is problematic because of the difficulties in specifying appropriate factor-mimicking portfolios for a large number of countries with limited data, and because of cross-country comparability issues.

Second, we relate companies' *percentage changes* in annual total emissions to their monthly stock returns by estimating the following cross-sectional regression model:

$$RET_{i,t} = a_0 + a_1\Delta(Total\ Emissions)_{i,t} + a_2 Controls_{i,t-1} + \mu_t + \varepsilon_{i,t} \quad (2)$$

The percentage change in total emissions (*S1CHG*, *S2CHG*, and *S3CHG*) captures the short run impact of emissions on stock returns. In particular, changes in total emissions reflect the extent to which companies load up on, or decrease, their material risk with respect to carbon emissions. From a transition perspective, this measure captures the position of a firm on a long-term path towards carbon neutrality. In this respect, it is complementary to the long-term objective captured by the level of emissions.

We estimate these two cross-sectional regressions using pooled OLS. In both models we also include country fixed effects, as well as year/month fixed effects. Hence, our identification is cross-sectional in nature. In some tests, we additionally include industry fixed effects to capture within-industry variation across firms. Finally, we include firm fixed effects which allows us to exploit within-firm variations and thus absorb any time-invariant, firm-level, characteristics correlated with emissions and stock returns. In all the model specifications, we cluster standard errors at the firm and year levels, which allows us to account for any serial correlation in the residuals as well as capture the fact that some control variables, including emissions, are measured at an annual frequency. Our coefficient of interest is a_1.

3.1.2 Evidence from the United States and China

We begin our analysis by comparing the results for our regression models in the two economies with the largest emissions, China and the U.S. We report the results in Table 5. These two economies differ in fundamental ways and one would expect the carbon premium to reflect fundamental differences in the level of economic and financial development, and in the legal and political regimes. Yet, we find that the results for scope 1 emissions are surprisingly similar, which suggests that firm-level variation in emissions may be more relevant for transition risk than are the differences between the two countries. Specifically, once one controls for industry and time period, as well as a battery of firm characteristics, firm-level differences in *LOGS1TOT* generate a highly significant carbon premium of similar size both in China (.067) and in the U.S. (.083), or equivalently 2.39% and 2.85% per one-standard-deviation change in total emission levels in each country. Using a slightly shorter time period (2005-2017), Bolton and Kacperczyk (2020) find that the premium for U.S. companies is slightly lower (.060). Here we find a higher premium estimated over the time interval 2005-2018. This higher premium is in line with the findings Bolton and Kacperczyk (2020) that the carbon premium is rising over time, especially after the Paris agreement of 2015.

The finding of a firm-level carbon premium for listed Chinese companies is novel and surprising. Although China in many ways has been a pioneer in the promotion of renewable energy, it does not stand out for its *ESG* institutional investor constituency, nor for its institutional investors' focus on carbon emissions. Yet, financial markets in China do price in a carbon premium at the firm level, at least when it comes to direct emissions (as reported in Panel A, the carbon premium associated with scope 2 and 3 emissions is only significant at the 10% level in China, while it is significant at the 1% level in the U.S). The similarities in the results across the two economies are even more striking for the carbon premium associated with percentage changes in emissions, as can be seen in Panel B. For both countries, the premium is highly significant and of similar size, except for changes in scope 2 emissions, for which the premium is nearly double in China.

3.1.3 Unconditional Results

We next turn to the estimation of the model for the full sample of 77 countries. Relative to our previous specification, we also include country-fixed effects to account for country-specific variation in the data. We report the results in Table 6. In columns (1)-(3), we use our baseline regression; in column (4)-(6), we include industry fixed effects, and in columns (7)-(9) we include firm fixed effects. In Panel A, we report the results for the level of carbon emissions. Throughout all specifications, we find a positive and statistically significant effect of total emissions on individual stock returns, consistent with the hypothesis that higher-emission firms are riskier. Interestingly, when we do not control for industry there is no significant carbon premium at the firm level for total scope 1 emissions. One possibility is that some firms (or industries) with high emissions experience unexpectedly low returns. The example of that could be a recent devaluation in the energy sector. For that reason, it seems natural to exploit within-industry variation in the data. Indeed, when we add an industry fixed effect, the premium is large and highly significant. A one-standard-deviation increase in *LOGS1TOT* is associated with a return premium of 2.34% per year. These results indicate that variations in stock returns across industries swamp variations in firm-level emissions within a given industry. Put differently, while we find a global carbon premium at the firm level once we control for country and industry, this premium explains only a small fraction of stock returns as reflected in the small differences in R-squares between the regressions without and with industry fixed effects.

Note that the coefficient of *LOGS3TOT* is highly significant in the regressions without and with industry fixed effects. It is also economically significant, as a one-standard-deviation increase in *LOGS3TOT* is associated with a return premium of 3.08% for the specification without industry fixed effects, and 4.54% with the fixed effects. This is to be expected given that total scope 3 emissions are determined using an input-output matrix.

The results become even more significant and robustly estimated when we include firm fixed effects. The coefficients of both scope1 and scope3 emissions more than double compared to the specification that includes industry fixed effects.[10] These results suggest that most of the variation in the data comes from within-firm rather than between-firm variation in emissions.

The results with respect to percentage changes in carbon emissions are all highly significant and are not affected at all by the inclusion of industry fixed effects or firm fixed effects, as can be seen in Panel B. Per one-standard-deviation change in scope 1 and scope 3, the corresponding return premia amount to 2.5% and 4.1% per year, similar in magnitude to the effects we observed for the levels of emissions. Of course, statistically speaking, taking differences in emissions is very close to including firm fixed effects in the model with levels of emissions.

The overarching conclusion from this part of our analysis is that firm-level global stock returns reflect firm-level variation in both *total emissions* and *percentage changes in total emissions*, which indicates that investors price carbon-transition risk both from a short-term and long-term perspective.

3.1.4 Geographic Distribution

Another informative representation of the transition risk is its distribution across different geographic regions. The economics literature on climate change has emphasized the importance of the spatial distribution of climate policies (e.g., Nordhaus and Yang, 1996) and physical impacts (Cruz and Rossi-Hansberg, 2020). Different regions have different exposures to climate change as well as different capacities to adapt. With respect to transition risk, one might expect that a country's economic development, social norms, or headline risk may be equally important. At the same time, in the context of financial markets, greater global market integration may offset some of the country-level heterogeneities. We evaluate the geographic distribution of transition risk pricing by separately looking at four different regions: North America, Europe, Asia, and Southern Hemisphere countries (defined as "Others").

We report the results in Table 7, Panel A for total emissions, and Panel B for percentage changes. For brevity, we focus on scope 1 and scope 3 emissions. The effects of total emissions on stock returns for North America are very similar to those obtained when we pool all countries together. In contrast, in the EU the level of scope 1 emissions has a somewhat weaker effect on stock returns, even when we add industry fixed effects. This is surprising given that the EU has arguably

[10] A model with emission levels and firm fixed effects implicitly captures both long-term as well short-term effects of transition risk. Hence, the economic magnitude can be roughly understood as a total of the two effects in the data.

put in place some of the strictest regulations limiting carbon emissions. One possible explanation might be that as a result of the EU's "single-market" regulations there is a much smaller variation in emissions across firms, once we control for other firm characteristics. As it turns out, this single-market effect for the EU is consistent with the other results obtained for Europe as a whole, where the carbon premium is much more in line with the premium obtained when we pool all countries together. The results for Asia are quite similar to those in North America for scope 1 emissions, but they are visibly larger for scope 3 emissions, especially when we factor in industry fixed effects. When it comes to percentage changes in emissions, the magnitudes of the effects for Europe are visibly smaller than those in North America and Asia. The regions of the world that stand out are Africa, Australia, and South America, where the coefficient of *S1CHG* is insignificant when we add industry fixed effects. This result is quite interesting as these countries are least aligned with the principle of carbon neutrality.

An important robustness question is which matters more, where the company is headquartered (which is the determinant of classification in our data) or where emissions are generated? This distinction may be particularly relevant for firms with global operations, which are subject to different social pressures, policies, or headline risk. While the granularity of our data does not allow us to attribute total firm emissions to individual plants, we can evaluate whether the impact of firm emissions differs in a sample of multinational companies vs. those operated in a single country. Empirically, we define an indicator variable, *FORDUM,* equal to one for firms that have at least some sales generated abroad and zero for firms whose sales are entirely from a single country. Next, we estimate the models in equations (1) and (2) with an additional interaction term between measures of emissions and *FORDUM*.

We present the results in Table A.2. Across all empirical specifications, we find only weak evidence that firms with multinational operations exhibit different sensitivities of their stock returns with respect to total firm emissions. For the specifications with the level of emissions, the interaction terms are small and statistically insignificant and for the specifications with the percentage changes, the interaction term is significant at the 10% level for scope 3 emissions. Overall, it does not seem that the geographic source of firm-level emissions is a primary driver of the carbon premium in our data.

In sum, the similarities in firm-level carbon premia between the U.S. and China notwithstanding, our continent-level results reveal that there is substantial variation in the carbon premium throughout the world. Consequently, we turn next to an investigation of which country and industry characteristics are likely to affect transition risk.

3.1.5 Economic Development

The level of a country's economic development is an important consideration when it comes to climate policy. Typically, richer countries are expected to, and have for the most part, made stronger commitments to combat climate change. Rich countries have a greater responsibility to combat climate change as they are the source of the largest cumulative emissions over the past two centuries by far. Another reason to expect a lower carbon premium in developing countries is simply that currently these countries have low levels of emissions. In addition, these countries' economies are not as deeply founded on fossil fuel energy consumption and may therefore be able to transition more easily to a renewable energy development path. On the other hand, if these countries depend a lot on fossil fuels their willingness to adjust in the short run may be smaller.

In this section, we explore the empirical relevance of these arguments. A remarkable general finding, as we show in Table A.3, is that the carbon premium does not seem to be related to countries' overall level of development. We first broadly categorize developed countries to be the G20 countries and the remaining group of countries to be developing countries.[11] When we add industry fixed effects, we observe from Table A.3 (Panel A) that the G20 group of countries have highly significant carbon premia related to the level of emissions for all three scope categories. But this is also the case for the most part for the group of developing countries (scope 2 emissions are only significant at the 10% level for this group of countries). Moreover, the size of the coefficients is similar. As for the short-run effects of carbon emissions on stock returns, we observe that they are again highly significant for both the G20 countries (controlling for industry) and the group of developing countries. Also, the size of the coefficients is again broadly similar.

Admittedly, the above classification of countries into two groups, developing and developed is rather coarse, and there is substantial heterogeneity in country characteristics within each group. Accordingly, we also investigate the effect of interacting GDP per capita, and other development variables such as the share of the manufacturing sector in GDP and health expenditure per capita, with the level and changes in emissions. As we show in Panel A of Table 8, the interaction of per capita GDP and the level of emissions is insignificant. The same is true for the interaction of the share of manufacturing and the level of emissions, and for the interaction of per capita health expenditures and the level of emissions. Overall, these results indicate that differences in development do not appear to explain much of the variation in long-run carbon premia across countries. On the other hand, when we interact the same variables with the percentage change in emission, as a measure of short-term risk, a slightly different picture emerges. Now, firms located in countries with higher

[11] The results are qualitatively very similar, reported in Panel B, if we define developed countries based on OECD membership.

GDP per capita and a more developed health system have statistically smaller stock returns. Further, firms located in countries with a higher dependence on the manufacturing sector in their output creation have higher stock returns.

3.2 Carbon-Transition Risk Drivers

We explore a number of channels through which carbon-transition risk could manifest itself. Specifically, we study the role of heterogeneity across technological, socio-economic, regulatory policy, and reputation dimensions. The main empirical challenge of identifying each of the channels empirically is that to a large extent we can only measure the transition risk drivers at the country level. Hence, in a regression that relates stock returns to country-level characteristics, our estimates could potentially be biased due to omitted country-level variables. To mitigate this concern we add the firm-level variation in carbon emissions, and estimate the role of the different mechanisms by interacting the country variables with firm-level emissions. This estimation approach follows closely the identification strategy of Rajan and Zignales (1998), which also interacts country-level financial development variables with industry-level financial constraints. In our tests, we are also able to sharpen our empirical identification by absorbing additional firm-level, industry-level, and country-level variation through a mix of observable characteristics and fixed effects.

3.2.1 Technological Mix

An important source of carbon-transition risk is technological change in energy production and carbon capture. As they transition to carbon neutrality, firms may find themselves at different points in their energy mix, carbon intensity, and outside demand for energy. The more distant the firms are from their target technology profile in a new green equilibrium, the more they are exposed to potential aggregate technology shocks. The resulting risk may come from unexpectedly high costs of green energy production as well as uncertainty about such costs.[12]

In this section, we explore the importance of these factors for stock prices. First, we investigate whether firms located in countries with a higher share of renewable energy have lower carbon premia. Second, we explore whether the size of the fossil fuel production sector affects the carbon premium. We hypothesize that firms located in countries in which the share of the energy sector is large would have a larger carbon premium. Finally, consumption of energy per capita may indicate how far the transition to a low-emission economy has progressed. It may also indicate the

[12] A separate issue that we do not explore formally in the paper is the uncertainty about the depreciation of any stranded assets and their impact on firm value. Atanasova and Schwartz (2020) analyze the empirical importance of this issue in the oil& gas industry.

expected demand for fossil-dependent energy going forward. We expect that firms in countries with high energy consumption are exposed to higher transition risk.

The results of this analysis are reported in Table 9. Our results present a few interesting patterns. First, we find that the green and brown energy variables do not matter much for how stock returns react to emission levels. Across all specifications, the coefficients of the interaction terms are small and statistically insignificant. The exception is the interaction term between scope 3 emissions and the reliance on renewable energy. This effect, however, is only marginally significant. Second, the hypothesis that a more renewable-energy based economy is associated with lower carbon premia is broadly borne out in the data when it comes to the short-run impact of changes in emissions. Firms located in countries with a larger fraction of renewable energy production have lower carbon premia with respect to changes in emissions, as indicated by the negative highly significant coefficients for the interaction terms. Similarly, we find that the coefficients of the interaction terms between the share of the energy sector and changes in emissions are highly significant and positive, indicating that investors perceive the risk with respect to carbon emissions to be greater in countries with large fossil fuel energy sectors. Finally, we find that energy use is not significantly related to stock returns irrespective of the risk measure we focus on. One reason may be that the energy source being consumed may be green. Also, the place of consumed energy need not be the same as the country in which it is sourced. In sum, the distinction between short-term and long-term reactions to technological mix suggests that such environment is transitory in nature, at least when assessed from the capital markets perspective.

Overall, we find strong evidence that a country's energy production mix is an important predictor of how investors price short-term changes in emissions. The direction of the results is broadly consistent with our hypothesis that uncertainty about technological change increases transition risk.

3.2.2 Socio-political Environment

Changing social norms and investor preferences have played a major role in the rise of the responsible investment movement. We may find a higher return premium in countries with stronger social norms, other things equal. We explore this channel by looking at whether a country's "rule of law" and "voice" affects its carbon premium. Another indirect measure of social and political stability we look at is the country's income inequality as measured by the Gini coefficient. As before, we interact each of the variables with the level and percentage changes of emissions. We report the results in Table 10.

We do not find a significant effect of these variables on the premium associated with the level of emissions and conclude from these results that social factors do not appear to affect the long run risk associated with carbon emissions. All coefficients of the interaction terms in Panel A are small and statistically insignificant. In contrast, we find that social factors do matter for investors' carbon risk perceptions in the short run. As reported in Panel B, the coefficients of the interaction terms between respectively "rule of law" and changes in emissions, and between "voice" and changes in emissions, are both highly significant and negative, indicating that the carbon premium is lower in countries with better rule of law and more democratic political institutions. Similarly, the coefficient of the interaction term between the Gini coefficient and changes in emissions is significant and positive, meaning that in countries with higher inequality the carbon premium is likely to be larger. Overall, the results on social inclusion point to a transitory role such factor plays in pricing of carbon-transition risk.

3.2.3 Climate Policy Tightness

Transition risk is often associated with expected regulatory changes dictating the adjustment to a green economy. Investor expectations of future climate-related policies can be an important risk component. Firms located in countries in which the government has made the most ambitious pledges to reduce carbon emissions may therefore be associated with a higher carbon premium. This is particularly true when local regulations are reinforced by pan-governmental policy actions, such as the UN-led COP initiative.

Climate change mitigation policies may originate from two sources: domestic regulators or international pan-governmental agreements. In this section, we evaluate the importance of each of the channels separately using unique data on country-specific regulatory tightness. Our policy data come from *Germanwatch*. To our knowledge, ours is the first large-sample study that evaluates the direct importance of both types of policies for global stock returns. Each year, *Germanwatch* collects information on all climate-related policies and converts this information into a numerical score, where a higher number means a stricter regulatory regime. We define two variables that we interact with firm-level carbon emissions. *INTPOLICY* is a normalized measure of international policy tightness; *DOMPOLICY* is a normalized measure of domestic policy tightness. We interact each of the two variables with the level and percentage changes in firm emissions.

We report the results in Table 11. We find two interesting results. First, in Panel A, we show that climate policy is generally more important for the sensitivity of carbon emission *levels* on stock returns. The effect is positive and economically significant for both scope 1 and scope 3 emissions, and statistically significant for scope 3 emissions. On the other hand, both types of climate policy tightness are broadly unrelated to the short-term effect of emissions on stock returns, as shown in Panel B. These results support the view that carbon policies are seen by investors as permanent shocks to carbon risk. To the extent that such policies may be costly to firms and investors, the investor perspective is that they are largely irreversible. Second, and perhaps more unexpectedly, we find that between the two types of climate policies, domestic ones have a bigger effect on the carbon premium. This result sheds light on analysts concerns about the commitments made by countries in Paris could be empty promises, perhaps because the coordination costs are either too high or the objective functions across countries are too diverse. It is only when these commitments are likely to lead to domestic policy implementation that investors start paying attention.

3.2.4 Reputation Risk

An important component of transition risk is reputation risk. A few fossil-fuel intensive industries that we define as 'salient' are known to attract negative media coverage, which can further amplify transition risk. Is it the case that the carbon premium is mostly concentrated in the oil & gas, utilities, and motor sectors that are the focus of much headline risk? The underlying economic reason behind such cross-sector variation could be differences in possible negative reputation effects in "brown" versus "green" sectors. Given that the media focus is largely on the salient brown industries, one would expect that investors in companies in these sectors price-in an additional risk compensation for their exposure to the negative stigma of holding these stocks.

To explore this hypothesis, we estimate the same regression specification for our 77 countries as in Table 6, excluding the salient industries mentioned above. We report the results in Table 12. Remarkably, when we exclude these industries, we find that the premium, if anything, is larger and statistically more significant for the level of emissions. It also remains highly significant for the premium associated with the changes in emissions. This could mean that transition risk has mostly been "baked in" in these salient sectors, but not yet in the other sectors that face less analyst scrutiny. These findings are also consistent with the results in Table 6 that variations in stock returns across industries swamp within-industry effects of carbon emissions on stock returns.

3.2.5 Physical Risk

Much of the economics literature on climate risk has sought to estimate the expected damages due to climate change. The materialization of such damages through climate disaster events introduces what is called a physical risk. A natural hypothesis is that transition risk is positively correlated with physical risk. As countries are exposed to more severe weather events caused by climate change one would expect that there will be greater support for policies combatting climate change in these countries. In other words, the extent to which a country has been exposed to climate disasters may shape investors' beliefs about the cost of long-term damage due to climate change. To test this hypothesis, we use a country-level, year-by-year index measuring physical risk (CRI) from *Germanwatch*. This index is based on the frequency of climate-related damages. Countries with higher values of the CRI index are considered as having higher physical risk. We estimate the coefficients of the interaction terms between CRI and firm-level emission measures, both their levels and percentage changes. The results are reported in Table 13. Columns (1)-(4) show the results based on total emissions, and columns (5)-(8) the results based on percentage changes. Consistent with the hypothesis that physical risk amplifies the risk premium associated with transition risk we find positive values for the interaction terms with emission changes. However, all of these coefficients are statistically insignificant. Also, contrary to our prediction, the coefficients of the interactions with emission levels are negative (again, however, these coefficients are statistically and economically small). Overall, we conclude that transition risk does not appear to be linked to different exposures to physical risk.

3.2.6 Changes in Investor Awareness

Our analysis so far has explored the carbon premium, pooling all observations from 2005 to 2018 together. Arguably, however, awareness about risks tied to carbon emissions has been increasing in recent years. By pooling the effect on stock returns for later years with the earlier years, our cross-sectional results may not adequately capture the true impact of carbon emissions on stock returns now that the world is mobilizing to combat climate change. We therefore also explore how the carbon premium reacts to salient events that reshape public reaction to climate changes. In particular, one such defining event is the landmark Paris climate agreement at the COP 21 in December 2015. This event has enhanced the salience of the climate debate worldwide and underscored the importance of possible transition risk going forward. It is therefore to be expected that the event has likely changed investors' perception of risk along multiple dimensions, including future energy costs, social preferences, or policy changes. Our empirical analysis around this event captures the aggregate effect, encompassing all of the above possibilities, of investors' response to this event.

Specifically, we regress stock returns on carbon emissions by pooling the observations together for respectively the two years (2014-2015) preceding and the two years (2016-2017) following the Paris agreement. We report the results in a series of tables, starting with Table 14, which provides the estimates for the levels and changes in emissions for our aggregate sample of 77 countries. Panel A presents the results for the pre-Paris period, both for the levels and changes in emissions, while Panel B presents corresponding results for the post-Paris period. Notably, there is no significant premium associated with the level of emissions right before Paris (even with industry fixed effects), whereas there is a highly significant and large positive premium after Paris. In turn, the results for changes in emissions are significant in both periods and show no visible difference. One way to interpret these contrasting results is that as a result of COP 21, investors significantly updated their beliefs about long-term transition risk. Consistent with our previous findings, the result may also suggest that Paris agreement has been particularly relevant for the market update about forthcoming climate-related policies. In fact, this narrative has been pretty popular among practitioners and policy makers.

In which parts of the world did the Paris agreement have the biggest effect? To explore this question, we estimate the same model as in Table 14 for each continent. We report the results for measures related to the level of carbon emissions in Table 15 (Panel A contains the results for the pre-Paris period and Panel B for the post-Paris period). Remarkably, there is no apparent change for North America. Both before and after the Paris agreement there is no significant carbon premium associated with the level of emissions. In Europe, both before and after Paris there is a significant carbon premium (except that the premium for scope 1 emissions becomes insignificant after Paris). Hence, there does not seem to be a significant change in the value of the premium around the Paris event for Europe. The biggest change is in Asia, where the carbon premium was insignificant before Paris, but became highly significant after Paris. This is true, whether we exclude China or not. Finally, in the other continents (Africa, Australia, and South America) there is also no apparent change before and after Paris.

Another relevant breakdown is between the group of G20 countries and the group of other countries. The results are reported in Table A.4. Again, the difference in the carbon premium before and after Paris is dramatic for the group of G20 countries. Before the agreement there was no significant carbon premium, but after the agreement there is a highly significant positive premium, whether we include industry fixed effects or not. In contrast, the changes in the other group of countries are much smaller. While there is a shift towards a significant premium, it is mostly for scope 3 emissions.

We also undertake this analysis after excluding the salient industries associated with fossil fuels. Recall that our cross-sectional analysis when we pool all years together established that the carbon premium is present even beyond these industries. The results reported in Table A.5 reveal similar robustness in carbon premium around the Paris shock. Indeed, there is a highly significant and positive premium associated with the level of emissions in other industries as well post Paris.

All in all, these results paint a rather striking picture of the pricing of transition risk across countries. On average across all 77 countries there is a significant carbon premium with respect to the level of emissions, reflecting firms' long-run exposure to transition risk. There is also a perceived transition risk with respect to changes in emissions, which capture the risk associated with the short-run drift away or into higher future emissions. The carbon premium, however, is far from uniformly distributed across these countries, across sectors, and over time. Interestingly, the long-term carbon premium does not appear to be tied to a country's level of development, a country's reliance on renewable energy, or its socio-political openness. These factors matter more when investors evaluate the short-term adjustment towards a long-term green economy.

In turn, the expectation of significant policy risk seems to matter more for the long-term assessment of transition risk and not so much its short-term path. The expectation of a significant long-term change seems to be reflected in salient events, such as the Paris agreement. The striking and surprising finding here is that awareness about carbon risk, as reflected in the carbon premium, has changed the most in Asia, where investor awareness has jumped after the Paris agreements, whereas it has remained basically unchanged in Europe and North America, either because these regions already had greater awareness of climate change (Europe) or had less awareness and did not revise their beliefs (North America).

3.3 Transitioning to a Green Equilibrium

Our results are broadly consistent with the existence of a return premium compensating investors for the carbon-transition risk they face. But at what point did investors begin to demand compensation for this risk? Basic logic suggests that the period when carbon transition risk is compensated should be preceded by a period during which assets are repriced to reflect the new risk. This repricing can in principle be a protracted process that parallels the economic shift from a brown to a green equilibrium. Moreover, the repricing is driven by changes in investor awareness about climate change risk. During this transition phase, one would expect to see increased demand (and therefore higher prices) for assets with low levels of emissions, and decreased demand (and lower prices) for assets with high levels of emissions. Although this adjustment mechanism is straightforward, testing for such asset price adjustments is challenging, especially in the context of heterogenous global financial markets, in which individual assets may transition at different times and at different speeds.

In the absence of a clear large-scale empirical setting, we fall back on suggestive evidence from one individual sector, the tobacco industry, where such a repricing process accompanied the rebranding of tobacco companies as "sin stocks". As Hong and Kacperczyk (2009) show, the reclassification of the tobacco industry as a sin asset class meant that tobacco companies were added to the divestment lists of many investors. This divestment movement resulted in higher expected returns (Merton, 1987). Prior to 1950s the negative health effects of tobacco consumption were not known; in fact, many considered tobacco a cure. This perception changed following the reports of the General Surgeon, which resulted in a massive change in beliefs about the industry. Consequently, the 1950-1970 period saw a massive revaluation of the industry, with tobacco companies being valued at much lower multiples. Following this repricing, however, tobacco companies over the subsequent four decades delivered very large returns.

We believe that a similar process is underway in the energy industry, with green energy companies being valued at much higher multiples and some "brown" companies already being valued with lower multiples. We can infer some of these repricing effects from some of our tests. As highlighted in Table 12, when we exclude salient industries from our sample the effect of scope 1 emission levels on stock returns increases relative to the unconditional value in Table 6, which means that the salient industries, on average, underperformed other sectors (with lower emissions) over our sample period. Interestingly however, this difference only appears in regressions without industry fixed effects, which suggests that the repricing has been a broad categorical repricing of the whole industry rather than individual firms in these industries. Of course, this repricing need not be a once-and-for-all revaluation as it appears to have been for the tobacco industry. In fact, it seems to us that investors' attitudes to carbon emissions are much more dynamic, and thus it is quite possible that one could witness multiple waves of repricing followed by periods with high returns. This is in fact what we think our data captures. Because the carbon transition process is ongoing this can only be a speculative inference, which we expect a future out-of-sample test of the carbon transition will confirm.

4 Conclusion

If global warming is to be checked, the global economy will have to wean itself off fossil fuels and reduce carbon emissions to zero by 2050 or 2060. This translates into a year-to-year rate in emissions reductions equal to the drop we have witnessed in 2020 as a result of the COVID-19 pandemic. Whether the global economy will be able to stick to such a rate of transition away from fossil fuels, whether the reduction in emissions will be smooth or highly non-linear and abrupt is impossible to say. But was is certain is that in the coming years and decades investors will be exposed to substantial transition risk. Given that stock markets are fundamentally forward-looking it is natural to ask whether and to what extent this transition risk is by now reflected in stock returns.

We have taken the broadest possible look at this question by analyzing the pricing of carbon-transition risk at the firm level in a cross-section of over 14,400 listed companies in 77 countries. To date very little is known about how carbon emissions affect stock returns around the world. Our wide-ranging exploratory study provides a first insight into this question. We have found evidence of a widespread, significant, rising, carbon premium—higher stock returns for companies with higher carbon emissions. This premium is not just present in a few countries (U.S., EU) or in a few sectors tied to fossil fuels. It is ubiquitous, affecting firms in all sectors over three continents, Asia, Europe, and North America. Moreover, stock returns are related not just to firms' direct emissions but also to their indirect emissions through the supply chain. Finally, we have found that this carbon premium has been rising after the landmark Paris accord of 2015, in line with the growing awareness about the urgency of combatting climate change and the rise of the sustainable investment movement.

At a broad level, our study is relevant for the discussions centered on carbon tax as a means to achieve reduction in emissions. While the idea of carbon tax is ex ante appealing clearly it does not come without costs. A clear impediment to successful global carbon taxation are coordination costs resulting from the bargaining process involving political parties with diverse interests and economic capacities. Our study offers an alternative to pass on the problem to financial markets. In fact, the increasing cost of equity for companies with higher emissions can be regarded as an alternative system of decentralized taxation. While this solution is not free of all problems it is clearly mitigating to a great extent the political risk of global taxation.

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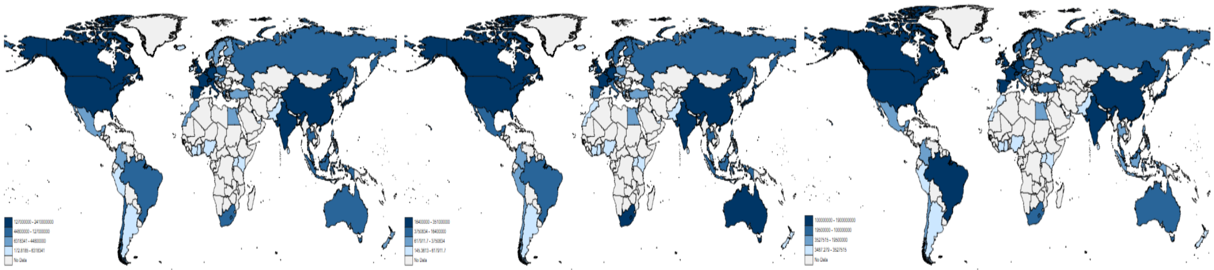
2005-2011



2012-2018

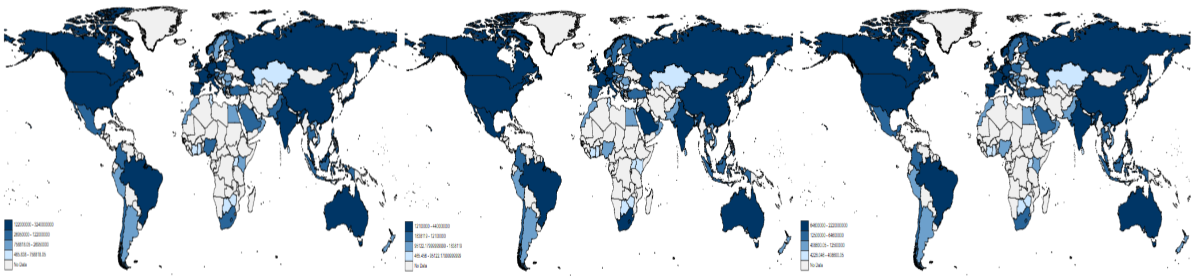
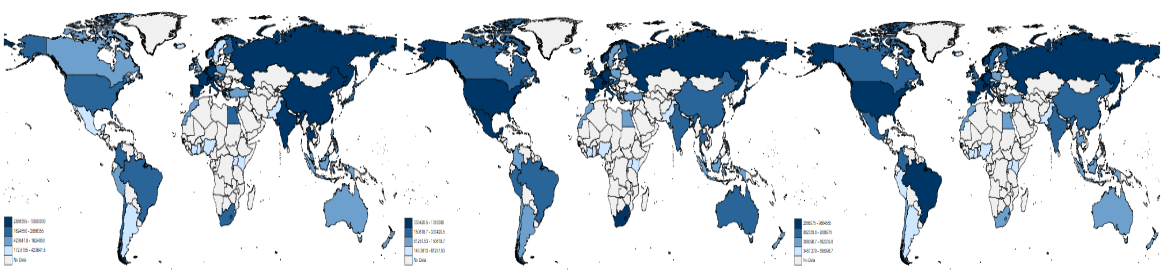


Figure 1: Total Annual Carbon Emissions by Country

2005-2011



2012-2018

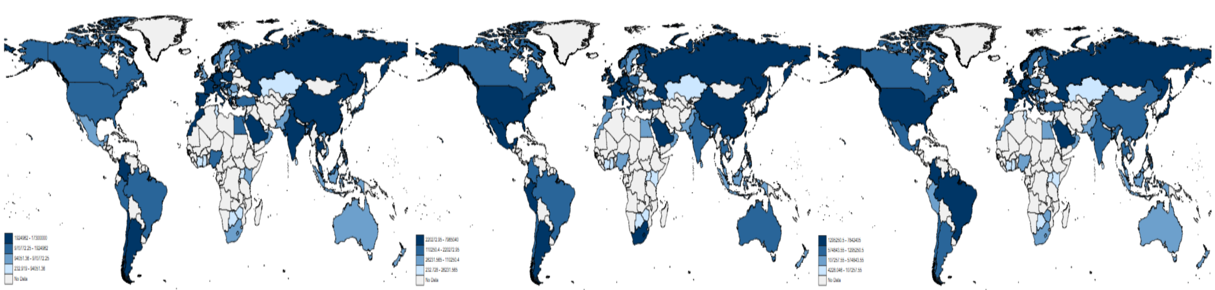


Figure 2: Average Annual Total Carbon Emissions per Firm

Table 1: Carbon Emissions by Country: 2005-2018

S1TOT (S2TOT ; S3TOT) measures the firm-level average (by country) of scope 1(scope 2; scope 3) carbon emissions measured in tons of CO2e. S1CHG (S2CHG; S3CHG) measures the percentage growth rate in carbon emissions of scope 1 (scope 2; scope 3) (winsorized at 2.5%). TOTS1 (TOTS2; TOTS3) is a sum of S1TOT (S2TOT; S3TOT) within a country in a given year (averaged across all years).

CODE	COUNTRY	Freq.	Perc.	# co.	S1TOT	S2TOT	S3TOT	S1CHG	S2CHG	S3CHG	TOTS1	TOTS2	TOTS3
AE	UAE	1,748	0.2	34	382822	45424	133220	10.93%	16.32%	11.05%	13000000	1106904	3338979
AR	ARGENTINA	550	0.06	6	1977235	259067	1032782	11.18%	38.18%	10.24%	9816885	1137898	4831946
AT	AUSTRIA	3,741	0.42	42	1543117	175280	1478427	10.00%	16.37%	7.56%	34500000	4073719	33900000
AU	AUSTRALIA	37,405	4.21	471	580313	225151	390624	14.38%	20.19%	11.88%	141000000	51700000	91500000
BD	BANGLADESH	254	0.03	5	112458	23661	145789	16.66%	25.97%	14.83%	490572	106452	624504
BE	BELGIUM	3,883	0.44	52	1611505	398625	1586838	5.88%	11.12%	6.28%	35200000	9368517	39000000
BG	BULGARIA	123	0.01	3	49815	11011	44659	34.85%	6.04%	14.60%	1010125	85163	303958
BH	BAHRAIN	198	0.02	3	1986	5858	28640	7.04%	8.84%	9.21%	5696	16924	83299
BR	BRAZIL	10,249	1.15	126	1846871	200604	2147921	11.05%	16.74%	9.09%	119000000	12700000	145000000
BW	BOTSWANA	68	0.01	2	3986	16534	38093	12.15%	21.45%	21.82%	6650	28041	64964
CA	CANADA	25,479	2.87	399	1179827	194523	794471	13.80%	18.99%	11.30%	226000000	35700000	147000000
CH	SWITZERLAND	12,638	1.42	172	1751558	219020	1848782	5.40%	9.95%	5.63%	142000000	18500000	144000000
CI	CÔTE D'IVOIRE	154	0.02	2	10867	13642	102418	5.46%	6.50%	6.45%	18779	25697	181503
CL	CHILE	3,991	0.45	37	2520658	150335	526513	9.99%	17.85%	9.09%	61800000	3816032	13500000
CN	CHINA	73,490	8.28	1660	4009318	258028	1121424	17.16%	24.86%	16.47%	2910000000	232000000	841000000
CO	COLOMBIA	1,141	0.13	13	2638497	153165	1602004	16.65%	23.03%	13.89%	24900000	1460375	14600000
CZ	CZECH REP.	446	0.05	5	80966	84133	106096	3.29%	8.69%	-2.05%	298304	276486	311847
DE	GERMANY	19,023	2.14	253	4126920	584281	3403940	7.12%	13.69%	7.24%	458000000	70800000	397000000
DK	DENMARK	4,310	0.49	48	1830641	81427	715844	6.29%	8.37%	5.98%	48000000	2101215	19200000
EE	ESTONIA	116	0.01	2	1324801	23427	72707	10.45%	18.91%	5.49%	2649601	46855	145415
EG	EGYPT	2,855	0.32	30	1300763	71534	347754	4.98%	10.42%	5.58%	22200000	1285661	6255982
ES	SPAIN	7,140	0.8	84	3733641	254727	2095625	9.14%	15.39%	6.55%	153000000	11100000	89400000
FI	FINLAND	4,049	0.46	42	1401658	320239	1548562	2.96%	10.18%	3.74%	34300000	7964368	37800000
FR	FRANCE	20,256	2.28	248	3537015	457697	2902571	7.12%	11.09%	6.26%	411000000	57400000	355000000
GB	UK	68,153	7.68	660	1037499	263688	1350755	7.47%	8.86%	6.25%	436000000	110000000	560000000
GH	GHANA	235	0.03	2	3583	3103	68338	0.63%	3.23%	2.96%	6882	5945	133928
GR	GREECE	1,929	0.22	23	4208318	155010	938891	13.98%	18.93%	7.11%	47800000	2284545	11200000
HK	HONG KONG	28,827	3.25	830	1963473	177584	524083	14.95%	28.14%	14.69%	383000000	45200000	119000000
HR	CROATIA	128	0.01	2	839807	101136	745120	-6.99%	-1.29%	12.21%	1503091	194606	1321002
HU	HUNGARY	474	0.05	3	2033690	348850	2292191	8.91%	22.72%	0.16%	6100691	1046018	6871986
ID	INDONESIA	8,865	1	130	982778	88318	416476	12.58%	14.81%	10.12%	62100000	5377655	28000000
IE	IRELAND	1,749	0.2	20	1013523	88576	854927	5.99%	9.48%	5.64%	12700000	1108046	10300000
IL	ISRAEL	5,688	0.64	92	207414	49185	289135	12.32%	15.74%	9.46%	9144490	1943727	10900000
IN	INDIA	33,514	3.78	518	3452714	141930	1006817	13.04%	19.06%	12.24%	831000000	34700000	248000000
IS	ICELAND	81	0.01	3	1257	1412	26849	32.91%	28.11%	28.32%	3156	3806	67937
IT	ITALY	6,656	0.75	107	4129000	307340	2549945	6.26%	11.40%	5.64%	169000000	14300000	118000000
JM	JAMAICA	68	0.01	2	335	1422	11711	1.05%	16.31%	12.74%	671	2843	23423
JO	JORDAN	196	0.02	4	1325	6190	30871	-7.52%	0.47%	6.09%	4338	17295	102857
JP	JAPAN	124,903	14.07	2258	1312299	231427	1511355	4.90%	10.72%	5.22%	980000000	204000000	1250000000
KE	KENYA	524	0.06	8	103831	8819	75464	24.97%	27.08%	14.38%	799872	58883	458581
KW	KOREA	51,738	5.83	843	1243235	166251	1001098	10.34%	14.19%	9.15%	397000000	60700000	344000000
KZ	KAZAKHSTAN	45	0.01	1	1153	1005	21863	19.74%	18.64%	13.32%	1153	1005	21863
LB	LEBANON	85	0.01	2	3788	11484	34112	10.68%	13.73%	19.42%	5696	17485	54787
LK	SRI LANKA	452	0.05	4	11715	29408	42644	10.17%	23.04%	6.94%	28522	89216	136662
LT	LITHUANIA	58	0.01	1	1590	4595	18366	23.73%	20.36%	21.61%	1590	4595	18366
LU	LUXEMBOURG	54	0.01	3	1035	1368	8149	-33.03%	-36.01%	-24.82%	2263	2823	17197

MA	MOROCCO	1,352	0.15	13	1690454	67664	307399	6.16%	8.18%	5.86%	15400000	582425	2563349
MU	MAURITIUS	114	0.01	3	925	1368	9340	45.24%	67.68%	27.90%	2115	3259	22106
MX	MEXICO	4,157	0.47	65	630508	322220	1146013	10.20%	15.58%	9.50%	23000000	10100000	36900000
MY	MALAYSIA	12,596	1.42	188	1289048	58716	364614	12.85%	18.36%	9.32%	108000000	6093201	32100000
NG	NIGERIA	1,182	0.13	16	1556752	68555	299827	1.31%	5.69%	0.65%	23600000	1024925	4236235
NL	NETHERLANDS	5,579	0.63	63	5563867	702550	2898875	5.06%	7.38%	4.50%	188000000	23700000	97700000
NO	NORWAY	5,680	0.64	97	1269294	294583	1627966	10.02%	13.26%	9.33%	49000000	9238739	56700000
NZ	NEW ZEALAND	3,011	0.34	50	393267	32502	239998	5.67%	9.68%	8.79%	8036961	707115	5067580
OM	OMAN	488	0.05	8	369577	60682	106543	6.60%	16.64%	8.10%	2686115	433197	755255
PE	PERU	544	0.06	5	1023906	213257	201341	15.87%	18.77%	10.71%	3617539	755370	721199
PH	PHILIPPINES	5,583	0.63	72	1077980	87818	518201	17.10%	26.63%	12.56%	49100000	4010504	23100000
PK	PAKISTAN	3,169	0.36	51	750597	40021	217645	12.02%	14.41%	9.61%	25900000	1223456	6959005
PL	POLAND	5,672	0.64	60	2368805	158750	619717	12.22%	18.37%	10.16%	94300000	6032271	22200000
PT	PORTUGAL	1,351	0.15	17	3179836	233808	1365071	2.71%	12.34%	3.92%	26400000	1974726	11800000
QA	QATAR	1,222	0.14	23	611145	45424	210790	7.31%	12.18%	6.43%	10900000	812774	3752829
RO	ROMANIA	250	0.03	4	886381	56688	680844	14.92%	9.79%	8.08%	3381664	202319	2430224
RS	SERBIA	168	0.02	3	272240	23975	196896	23.17%	18.38%	19.48%	601691	55795	452004
RU	RUSSIA	1,925	0.22	26	10100000	816962	6098643	16.11%	19.48%	9.72%	147000000	10800000	72600000
SA	SAUDI ARABIA	1,088	0.12	98	2345866	1002530	1190067	-10.47%	8.66%	4.26%	66100000	22600000	43600000
SE	SWEDEN	11,560	1.3	174	228060	74868	703569	7.48%	11.15%	7.68%	17000000	6014555	53200000
SG	SINGAPORE	9,881	1.11	145	864602	122194	1143235	12.55%	18.94%	10.64%	55800000	8285673	74100000
SI	SLOVENIA	220	0.02	3	13270	26995	71210	1.05%	21.79%	5.40%	37469	78045	203048
TH	THAILAND	5,767	0.65	106	2089681	167475	674012	14.69%	23.17%	13.21%	88800000	6770391	31000000
TN	TUNISIA	140	0.02	2	239	235	5106	-6.55%	0.70%	-1.53%	477	469	10212
TR	TURKEY	4,706	0.53	58	1697617	130762	768350	15.98%	18.69%	8.58%	55000000	4237040	23400000
TW	TAIWAN	41,061	4.63	684	530858	134310	531483	10.24%	17.23%	7.74%	135000000	41300000	147000000
UG	UGANDA	88	0.01	1	842	1470	4194	34.73%	71.91%	4.62%	842	1470	4194
US	USA	175,377	19.76	3013	2012926	323727	1733058	7.87%	13.84%	8.24%	2330000000	403000000	2100000000
VN	VIET NAM	820	0.09	15	479322	43086	343905	12.19%	18.35%	14.68%	6087639	552733	4260247
ZA	SOUTH AFRICA	14,883	1.68	148	1074195	444228	423650	10.53%	17.41%	6.08%	95900000	41400000	40100000
ZW	ZIMBABWE	56	0.01	2	15480	14546	138070	-6.75%	1.28%	8.77%	48346	45915	457559
Total		887429	100	14468	1874065	246606	1301047	9.73%	15.35%	8.86%	11813099883	1615895170	7990066031

Table 2: Summary Statistics

This tables reports summary statistics (averages, medians, and standard deviations) for the variables used in regressions. The sample period is 2005-2018. Panels A and B report the emission variables and their pairwise correlations. Panel C reports the control variables. *RET* is the monthly stock return; *LOGSIZE* is the natural logarithm of market capitalization (in $ million); *B/M* is the book value of equity divided by market value of equity; *ROE* is the return on equity; *LEVERAGE* is the book value of leverage defined as the book value of debt divided by the book value of assets; *MOM* is the cumulative stock return over the one-year period; *INVEST/A* is the CAPEX divided by book value of assets; *HHI* is the Herfindahl index of the business segments of a company with weights proportional to revenues; *LOGPPE* is the natural logarithm of plant, property & equipment (in $ million); *VOLAT* is the monthly stock return volatility calculated over the one year period; $MSCI_{i,t}$ is an indicator variable equal to one if a stock *i* is part of MSCI World Index in year *t*, and zero otherwise.

Panel A: Carbon Emissions

Variable	Mean	Median	St. deviation
Log (Carbon Emissions Scope 1 (tons CO2e)) [LOGS1TOT]	10.317	10.135	2.951
Log (Carbon Emissions Scope 2 (tons CO2e)) [LOGS2TOT]	10.173	10.233	2.265
Log (Carbon Emissions Scope 3 (tons CO2e)) [LOGS3TOT]	11.966	12.021	2.219
Growth Rate in Carbon Emissions Scope 1 (winsorized at 2.5%) [S1CHG]	9.73%	3.34%	41.34%
Growth Rate in Carbon Emissions Scope 2 (winsorized at 2.5%) [S2CHG]	15.35%	5.83%	49.01%
Growth Rate in Carbon Emissions Scope 3 (winsorized at 2.5%) [S2CHG]	8.86%	5.44%	25.74%

Panel B: Carbon Emissions: Correlations

	S1CHG	S2CHG	S3CHG	LOGS1TOT	LOGS2TOT	LOGS3TOT
S1CHG	1					
S2CHG	0.485	1				
S3CHG	0.555	0.503	1			
LOGS1TOT	0.040	-0.004	-0.045	1		
LOGS2TOT	-0.020	0.045	-0.061	0.736	1	
LOGS3TOT	-0.047	-0.046	-0.059	0.808	0.824	1

Panel C: Regression Controls

Variable	Mean	Median	St. deviation
RET (%)	1.076	0.054	10.229
LOGSIZE	11.105	9.644	5.212
B/M (winsorized at 2.5%)	0.572	0.440	0.510
LEVERAGE (winsorized at 2.5%)	0.227	0.209	0.175
MOM (winsorized at 0.5%)	0.150	0.089	0.452
INVEST/A (winsorized at 2.5%)	0.049	0.035	0.048
HHI	0.798	0.985	0.252
LOGPPE	7.748	7.684	3.313
ROE (winsorized at 2.5%)	11.094	10.870	16.076
VOLAT (winsorized at 0.5%)	0.092	0.079	0.058
MSCI	0.337	0	0.473

Table 3: Carbon Emissions by Year

The table reports the annual averages across all countries of all emission variables over the period 2005-2018.

year	# firms	S1TOT	S2TOT	S3TOT	S1CHG	S2CHG	S3CHG	TOTS1	TOTS2	TOTS3
2005	3232	2391417	246612	1822093	.	.	.	917000000	106000000	828000000
2006	3532	2367787	264064	1705187	16.18%	18.59%	9.83%	894000000	115000000	749000000
2007	3689	2488889	290500	1800563	18.89%	22.94%	15.94%	934000000	125000000	766000000
2008	3736	2541971	330705	1679148	9.34%	18.13%	-0.16%	955000000	146000000	728000000
2009	3949	2285281	311700	1643489	3.24%	8.47%	10.02%	870000000	136000000	720000000
2010	4098	2407166	308070	1633414	14.26%	18.14%	8.34%	904000000	130000000	689000000
2011	4221	2563380	322518	1825353	9.51%	15.73%	14.51%	937000000	136000000	761000000
2012	4253	2402493	317779	1791769	8.71%	10.60%	3.31%	868000000	133000000	748000000
2013	4912	2211603	297793	1619450	7.06%	8.43%	4.06%	878000000	135000000	743000000
2014	5323	2118666	292460	1432881	6.88%	20.46%	4.90%	895000000	142000000	694000000
2015	5427	2009876	276453	1228497	3.87%	2.48%	-1.76%	860000000	137000000	604000000
2016	11961	1038161	143425	693127	5.95%	11.13%	10.81%	1130000000	183000000	902000000
2017	12817	1046853	167407	759076	13.60%	26.03%	19.03%	1230000000	221000000	1050000000
2018	8781	1136396	148745	729199	10.53%	12.24%	6.21%	1050000000	142000000	663000000

Table 4: Predictors of Carbon Emissions

The sample period is 2005-2018. The dependent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). All variables are defined in Tables 1 and 2. We report the results of the pooled regression with standard errors clustered at the firm and year levels. All regressions include year-month fixed effects and country fixed effects. In columns (4) through (6), we additionally include industry-fixed effects. In columns (7) to (9), we instead include firm fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	LOGS1TOT	LOGS2TOT	LOGS3TOT	LOGS1TOT	LOGS2TOT	LOGS3TOT	LOGS1TOT	LOGS2TOT	LOGS3TOT
LOGSIZE	-0.085**	0.265***	0.210***	0.329***	0.472***	0.453***	0.243***	0.263***	0.297***
	(0.039)	(0.023)	(0.016)	(0.020)	(0.027)	(0.023)	(0.039)	(0.038)	(0.035)
B/M	-0.093	0.108**	-0.007	0.371***	0.451***	0.381***	0.170***	0.188***	0.171***
	(0.061)	(0.040)	(0.037)	(0.044)	(0.051)	(0.047)	(0.054)	(0.053)	(0.044)
ROE	0.010***	0.011***	0.014***	0.008***	0.008***	0.009***	0.001**	0.002***	0.002***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
LEVERAGE	0.533**	0.326	-0.363*	0.669***	0.671***	0.370***	0.460***	0.462***	0.446***
	(0.221)	(0.226)	(0.170)	(0.099)	(0.127)	(0.097)	(0.072)	(0.067)	(0.048)
INVEST/A	5.021***	1.079**	-1.882***	-1.136***	-1.928***	-3.089***	-1.069***	-0.381*	-0.736***
	(0.698)	(0.396)	(0.300)	(0.371)	(0.322)	(0.287)	(0.291)	(0.204)	(0.158)
HHI	-2.038***	-0.763***	-1.232***	-1.216***	-0.660***	-0.722***	-0.591***	-0.587***	-0.399***
	(0.145)	(0.087)	(0.118)	(0.074)	(0.059)	(0.062)	(0.091)	(0.077)	(0.052)
LOGPPE	0.782***	0.469***	0.534***	0.428***	0.336***	0.346***	0.222***	0.165***	0.181***
	(0.026)	(0.014)	(0.014)	(0.015)	(0.016)	(0.016)	(0.024)	(0.021)	(0.017)
MSCI	0.119*	0.226***	0.203***	0.176***	0.256***	0.218***	0.106***	0.134***	0.093***
	(0.059)	(0.045)	(0.041)	(0.040)	(0.049)	(0.042)	(0.019)	(0.022)	(0.016)
Constant	6.359***	3.850***	6.456***	3.902***	2.415***	4.555***	6.203***	6.213***	7.404***
	(0.383)	(0.263)	(0.240)	(0.215)	(0.260)	(0.212)	(0.435)	(0.363)	(0.382)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	886,751	886,895	887,429	874,592	874,736	875,270	886,741	886,885	887,419
R-squared	0.544	0.531	0.621	0.779	0.715	0.793	0.960	0.937	0.977

Panel B: Percentage Changes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	S1CHG	S2CHG	S3CHG	S1CHG	S2CHG	S3CHG	S1CHG	S2CHG	S3CHG
LOGSIZE	0.025***	0.029***	0.025***	0.025***	0.027***	0.025***	0.046***	0.059***	0.050***
	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)	(0.003)	(0.008)	(0.009)	(0.009)
B/M	-0.060***	-0.061***	-0.066***	-0.067***	-0.069***	-0.070***	-0.077***	-0.073***	-0.084***
	(0.009)	(0.009)	(0.006)	(0.009)	(0.009)	(0.007)	(0.013)	(0.013)	(0.013)
ROE	-0.002***	-0.002***	-0.001***	-0.001***	-0.002***	-0.001***	-0.001***	-0.001**	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LEVERAGE	0.060***	0.064***	0.049***	0.060***	0.063***	0.043***	0.023	0.026	0.014
	(0.015)	(0.012)	(0.011)	(0.012)	(0.012)	(0.008)	(0.025)	(0.025)	(0.021)
INVEST/A	0.594***	0.589***	0.372***	0.451***	0.525***	0.317***	0.202	0.252	0.112
	(0.073)	(0.098)	(0.069)	(0.085)	(0.063)	(0.052)	(0.133)	(0.148)	(0.092)
HHI	0.007	-0.022	0.019***	0.011*	-0.017	0.020***	-0.070**	-0.137***	-0.038*
	(0.008)	(0.012)	(0.005)	(0.005)	(0.014)	(0.004)	(0.027)	(0.027)	(0.017)
LOGPPE	-0.021***	-0.021***	-0.020***	-0.023***	-0.022***	-0.021***	-0.039***	-0.035***	-0.033***
	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.005)	(0.006)	(0.004)
MSCI	-0.033***	-0.041***	-0.030***	-0.033***	-0.040***	-0.029***	-0.034***	-0.051***	-0.037***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.007)	(0.004)
Constant	0.004	0.037	-0.025	0.020	0.071	-0.015	-0.002	-0.075	-0.123
	(0.024)	(0.059)	(0.026)	(0.024)	(0.062)	(0.031)	(0.092)	(0.090)	(0.094)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	765,387	765,397	765,949	755,257	755,267	755,819	765,384	765,394	765,946
R-squared	0.036	0.044	0.119	0.047	0.055	0.131	0.256	0.248	0.361

Table 5: Carbon Emissions and Stock Returns: U.S. and China

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regressions include year-month fixed effects, country fixed effects, and industry-fixed effects. Columns (1)-(3) provide the results for firms from the U.S, columns (4)-(6) provide the results for firms from China. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)
		United States			China	
LOGS1TOT	0.083***			0.067**		
	(0.020)			(0.028)		
LOGS2TOT		0.098**			0.149*	
		(0.035)			(0.072)	
LOGS3TOT			0.156***			0.213*
			(0.045)			(0.108)
LOGSIZE	-0.118	-0.146	-0.175	-0.329***	-0.360***	-0.380***
	(0.121)	(0.126)	(0.129)	(0.094)	(0.108)	(0.112)
B/M	0.525	0.507	0.476	0.981**	0.938**	0.919**
	(0.327)	(0.321)	(0.326)	(0.404)	(0.382)	(0.371)
LEVERAGE	-0.482*	-0.491*	-0.503*	-0.107	-0.118	-0.194
	(0.249)	(0.237)	(0.240)	(0.203)	(0.188)	(0.174)
MOM	0.254	0.265	0.266	0.713	0.706	0.696
	(0.312)	(0.311)	(0.311)	(0.417)	(0.411)	(0.401)
INVEST/A	0.434	0.579	0.848	-0.468	-0.217	-0.121
	(2.462)	(2.462)	(2.394)	(0.786)	(0.859)	(0.868)
HHI	0.034	-0.019	0.025	0.611	0.563	0.565
	(0.114)	(0.091)	(0.103)	(0.429)	(0.418)	(0.413)
LOGPPE	0.005	0.005	-0.010	0.058	0.037	0.001
	(0.045)	(0.048)	(0.048)	(0.081)	(0.067)	(0.053)
ROE	0.005	0.005	0.005	0.026*	0.025*	0.024*
	(0.003)	(0.003)	(0.003)	(0.013)	(0.012)	(0.012)
VOLAT	3.521	3.345	3.434	-2.920	-2.962	-2.827
	(4.064)	(4.010)	(4.035)	(1.798)	(1.776)	(1.739)
Constant	0.496	0.639	0.034	2.789	2.621	2.138
	(0.928)	(0.976)	(1.012)	(1.582)	(1.613)	(1.825)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143,399	143,375	143,495	60,218	60,218	60,218
R-squared	0.224	0.224	0.224	0.301	0.301	0.301

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)
		United States			China	
S1CHG	0.736***			0.799**		
	(0.168)			(0.267)		
S2CHG		0.373**			0.616***	
		(0.138)			(0.188)	
S3CHG			1.413***			1.980***
			(0.418)			(0.496)
LOGSIZE	-0.121	-0.107	-0.141	-0.335***	-0.327***	-0.358***
	(0.117)	(0.117)	(0.118)	(0.098)	(0.094)	(0.104)
B/M	0.598*	0.578*	0.653*	1.051**	0.985**	1.111**
	(0.322)	(0.320)	(0.302)	(0.422)	(0.395)	(0.413)
LEVERAGE	-0.482*	-0.456*	-0.489*	-0.059	-0.014	-0.115
	(0.249)	(0.251)	(0.259)	(0.237)	(0.224)	(0.243)
MOM	0.204	0.226	0.142	0.608	0.621	0.479
	(0.306)	(0.309)	(0.301)	(0.423)	(0.409)	(0.372)
INVEST/A	-0.100	0.078	-0.406	-0.766	-1.104	-1.201
	(2.472)	(2.422)	(2.475)	(0.853)	(0.826)	(0.850)
HHI	-0.097	-0.061	-0.109	0.542	0.538	0.421
	(0.097)	(0.100)	(0.098)	(0.418)	(0.405)	(0.387)
LOGPPE	0.069	0.057	0.087	0.108	0.102	0.120
	(0.047)	(0.045)	(0.050)	(0.084)	(0.083)	(0.095)
ROE	0.007**	0.007**	0.008**	0.029*	0.029*	0.029*
	(0.003)	(0.003)	(0.003)	(0.014)	(0.014)	(0.014)
VOLAT	3.191	3.297	3.225	-2.976	-3.167	-3.137
	(4.140)	(4.135)	(4.204)	(1.806)	(1.866)	(1.847)
Constant	1.056	0.984	1.052	3.082*	3.073*	3.241*
	(0.899)	(0.914)	(0.927)	(1.575)	(1.567)	(1.588)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143,423	143,363	143,495	60,218	60,218	60,218
R-squared	0.224	0.224	0.225	0.302	0.301	0.303

Table 6: Carbon Emissions and Stock Returns: Full Sample

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regressions include year-month fixed effects and country fixed effects. In columns (4) through (6), we additionally include industry-fixed effects. In columns (7) to (9), we instead include firm fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LOGS1TOT	0.029			0.066***			0.140***		
	(0.022)			(0.016)			(0.044)		
LOGS2TOT		0.096***			0.118***			0.154**	
		(0.030)			(0.027)			(0.056)	
LOGS3TOT			0.118***			0.174***			0.620***
			(0.032)			(0.037)			(0.180)
LOGSIZE	-0.150***	-0.182***	-0.182***	-0.186***	-0.225***	-0.249***	-2.557***	-2.568***	-2.718***
	(0.040)	(0.042)	(0.042)	(0.041)	(0.042)	(0.045)	(0.341)	(0.345)	(0.391)
B/M	0.501**	0.496**	0.505**	0.610**	0.588**	0.576**	0.458	0.455	0.390
	(0.216)	(0.214)	(0.215)	(0.216)	(0.210)	(0.211)	(0.268)	(0.271)	(0.282)
LEVERAGE	-0.439**	-0.443**	-0.371**	-0.387**	-0.417**	-0.401**	-1.108**	-1.110**	-1.330**
	(0.182)	(0.170)	(0.168)	(0.163)	(0.151)	(0.154)	(0.455)	(0.455)	(0.489)
MOM	0.823**	0.830**	0.828**	0.815**	0.824**	0.825**	0.557	0.561	0.594
	(0.325)	(0.325)	(0.324)	(0.330)	(0.330)	(0.329)	(0.458)	(0.457)	(0.455)
INVEST/A	-0.775	-0.724	-0.409	-0.466	-0.303	-0.003	1.047	0.907	1.295
	(1.115)	(1.176)	(1.236)	(1.065)	(1.093)	(1.111)	(1.789)	(1.812)	(1.806)
HHI	0.014	0.031	0.104	0.059	0.059	0.108	-0.099	-0.087	0.069
	(0.120)	(0.118)	(0.115)	(0.126)	(0.122)	(0.128)	(0.283)	(0.283)	(0.289)
LOGPPE	-0.003	-0.025	-0.042	0.008	-0.003	-0.023	-0.183*	-0.176*	-0.256***
	(0.018)	(0.022)	(0.024)	(0.017)	(0.018)	(0.019)	(0.090)	(0.088)	(0.081)
ROE	0.013***	0.013***	0.012***	0.013***	0.013***	0.012***	0.015**	0.015**	0.014**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
VOLAT	-0.404	-0.560	-0.494	-0.182	-0.231	-0.202	-0.606	-0.633	-0.489
	(3.465)	(3.415)	(3.451)	(3.244)	(3.222)	(3.238)	(3.647)	(3.628)	(3.633)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	746,642	746,797	747,290	736,851	737,006	737,499	746,615	746,770	747,263
R-squared	0.150	0.150	0.150	0.151	0.151	0.151	0.176	0.176	0.177

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
S1CHG	0.500***			0.515***			0.586***		
	(0.089)			(0.091)			(0.086)		
S2CHG		0.301***			0.307***			0.354***	
		(0.062)			(0.065)			(0.071)	
S3CHG			1.342***			1.364***			1.628***
			(0.257)			(0.266)			(0.230)
LOGSIZE	-0.162***	-0.159***	-0.178***	-0.174***	-0.170***	-0.189***	-2.539***	-2.537***	-2.576***
	(0.042)	(0.041)	(0.042)	(0.041)	(0.041)	(0.041)	(0.327)	(0.328)	(0.328)
B/M	0.519**	0.513**	0.557**	0.657**	0.650**	0.696***	0.512*	0.500*	0.580**
	(0.215)	(0.214)	(0.217)	(0.219)	(0.218)	(0.221)	(0.265)	(0.266)	(0.260)
LEVERAGE	-0.455**	-0.441**	-0.492**	-0.372**	-0.357*	-0.403**	-1.051**	-1.048**	-1.060**
	(0.185)	(0.179)	(0.180)	(0.170)	(0.166)	(0.165)	(0.445)	(0.448)	(0.433)
MOM	0.785**	0.800**	0.705**	0.773**	0.789**	0.694*	0.517	0.530	0.452
	(0.321)	(0.321)	(0.314)	(0.327)	(0.327)	(0.320)	(0.452)	(0.454)	(0.449)
INVEST/A	-0.908	-0.768	-1.115	-0.758	-0.661	-0.961	0.732	0.811	0.638
	(1.187)	(1.205)	(1.204)	(1.065)	(1.065)	(1.058)	(1.815)	(1.836)	(1.802)
HHI	-0.050	-0.040	-0.071	-0.028	-0.018	-0.050	-0.145	-0.138	-0.130
	(0.124)	(0.126)	(0.121)	(0.122)	(0.124)	(0.120)	(0.280)	(0.283)	(0.278)
LOGPPE	0.030	0.026	0.045**	0.048**	0.043**	0.063***	-0.133	-0.140	-0.104
	(0.021)	(0.020)	(0.021)	(0.016)	(0.016)	(0.017)	(0.092)	(0.094)	(0.094)
ROE	0.014***	0.014***	0.015***	0.014***	0.014***	0.015***	0.016**	0.016**	0.016**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
VOLAT	-0.500	-0.434	-0.450	-0.289	-0.239	-0.222	-0.593	-0.560	-0.330
	(3.461)	(3.477)	(3.524)	(3.241)	(3.256)	(3.286)	(3.646)	(3.640)	(3.678)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	746,738	746,749	747,290	736,947	736,958	737,499	746,711	746,722	747,263
R-squared	0.150	0.150	0.151	0.152	0.151	0.152	0.177	0.177	0.177

Table 7: Carbon Emissions and Stock Returns: Regional

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in firm-level total emissions (Panel B). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regressions include year-month fixed effects and country fixed effects. All regression models include the controls of Table 6 (unreported for brevity). In columns (3)-(4) and (7)-(8), we additionally include industry-fixed effects. Our sample firms include alternately North America, North America (ex U.S.), Europe, the European Union, Asia, Asia (ex. China), and Others (Africa, Australia, and South America). ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	North America				North America (excl. USA)			
LOGS1TOT	0.042		0.077***		0.013		0.136**	
	(0.024)		(0.018)		(0.034)		(0.046)	
LOGS3TOT		0.116***		0.135***		0.091*		0.196**
		(0.036)		(0.042)		(0.051)		(0.080)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	170,635	170,791	168,452	168,608	25,215	25,275	25,053	25,113
R-squared	0.202	0.202	0.205	0.205	0.158	0.158	0.168	0.168

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Europe				EU			
LOGS1TOT	0.035		0.045**		0.042		0.054*	
	(0.021)		(0.021)		(0.025)		(0.026)	
LOGS3TOT		0.127***		0.158***		0.135***		0.166***
		(0.029)		(0.046)		(0.034)		(0.049)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	170,338	170,518	167,506	167,686	148,080	148,188	145,436	145,544
R-squared	0.189	0.189	0.193	0.193	0.195	0.195	0.199	0.200

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Asia				Asia (excl. China)			
LOGS1TOT	0.023		0.070**		0.025		0.068**	
	(0.024)		(0.025)		(0.023)		(0.024)	
LOGS3TOT		0.116**		0.204***		0.113**		0.197***
		(0.043)		(0.057)		(0.038)		(0.046)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	335,387	335,531	331,338	331,482	274,842	274,986	271,120	271,264
R-squared	0.161	0.161	0.163	0.163	0.159	0.160	0.161	0.162

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)
	Others			
LOGS1TOT	-0.007		0.110***	
	(0.031)		(0.032)	
LOGS3TOT		0.054		0.249***
		(0.050)		(0.065)
Controls	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes
Observations	68,812	68,980	68,085	68,253
R-squared	0.126	0.127	0.131	0.131

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	North America				North America (excl. USA)			
S1CHG	0.722***		0.762***		0.683***		0.771***	
	(0.109)		(0.119)		(0.173)		(0.193)	
S3CHG		1.427***		1.488***		1.513***		1.645***
		(0.317)		(0.354)		(0.414)		(0.406)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	170,659	170,791	168,476	168,608	25,215	25,275	25,053	25,113
R-squared	0.203	0.203	0.206	0.206	0.159	0.159	0.168	0.169

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Europe				EU			
S1CHG	0.290***		0.306***		0.267**		0.286***	
	(0.081)		(0.079)		(0.091)		(0.089)	
S3CHG		1.093***		1.166***		1.108***		1.190***
		(0.277)		(0.276)		(0.319)		(0.324)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	170,362	170,518	167,530	167,686	148,080	148,188	145,436	145,544
R-squared	0.189	0.189	0.193	0.193	0.195	0.195	0.199	0.200

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Asia				Asia (excl. China)			
S1CHG	0.606***		0.613***		0.530***		0.537***	
	(0.140)		(0.135)		(0.114)		(0.107)	
S3CHG		1.623***		1.623***		1.443***		1.450***
		(0.359)		(0.353)		(0.318)		(0.311)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	335,411	335,531	331,362	331,482	274,866	274,986	271,144	271,264
R-squared	0.161	0.162	0.163	0.164	0.160	0.161	0.162	0.163

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)
	Others			
S1CHG	0.162*		0.157	
	(0.084)		(0.105)	
S3CHG		0.573*		0.603*
		(0.296)		(0.298)
Controls	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes
Observations	68,836	68,980	68,109	68,253
R-squared	0.127	0.127	0.131	0.131

Table 8: Carbon Emissions and Stock Returns: Economic Development

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). *GDPPC* measures a country's GDP per capita in current dollars in a given year; *MANUFPERC* is the percentage of a country's GDP that is produced in a given year in manufacturing sector; *HLTHEXPPC* is a country's health expenditures per capita in current dollars in a given year. All other variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regression models include the controls of Table 6 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GDPPC	-108.632**	-108.841**	-104.037**	-103.935**								
	(50.241)	(50.648)	(50.451)	(50.872)								
MANUFPERC					13.870	15.634*	14.703*	16.358*				
					(8.430)	(8.642)	(8.426)	(8.591)				
HLTHEXPPC									-0.053	-0.137	-0.045	-0.114
									(0.196)	(0.202)	(0.193)	(0.196)
LOGS1TOT	0.031		0.067***		0.033		0.077***		0.010		0.050***	
	(0.021)		(0.018)		(0.023)		(0.019)		(0.022)		(0.018)	
LOGS3TOT		0.122***		0.178***		0.143***		0.202***		0.083**		0.139***
		(0.032)		(0.034)		(0.032)		(0.033)		(0.032)		(0.034)
GDPPC*LOGS1TOT	-0.098		-0.087									
	(0.415)		(0.400)									
GDPPC*LOGS3TOT		-0.196		-0.259								
		(0.647)		(0.604)								
MANUFPERC*LOGS1TOT					-0.032		-0.072					
					(0.112)		(0.106)					
MANUFPERC*LOGS3TOT						-0.150		-0.173				
						(0.172)		(0.163)				
HLTHEXPPC*LOGS1TOT									0.003		0.003	
									(0.003)		(0.003)	
HLTHEXPPC*LOGS3TOT										0.008*		0.007
										(0.005)		(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	712,472	713,120	702,886	703,534	679,890	680,514	671,392	672,016	484,683	485,199	478,854	479,370
R-squared	0.150	0.150	0.152	0.152	0.152	0.152	0.153	0.153	0.175	0.175	0.177	0.177

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GDPPC	-110.884**	-113.493**	-105.512**	-107.949**								
	(50.122)	(50.128)	(50.314)	(50.315)								
MANUFPERC					12.517	11.138	12.897	11.568				
					(8.177)	(8.157)	(8.190)	(8.173)				
HLTHEXPPC									-0.039	-0.075	-0.029	-0.067
									(0.193)	(0.194)	(0.191)	(0.193)
S1CHG	0.631***		0.646***		0.169		0.191*		0.763***		0.797***	
	(0.112)		(0.111)		(0.107)		(0.107)		(0.124)		(0.124)	
S3CHG		1.655***		1.678***		0.737***		0.790***		1.711***		1.776***
		(0.260)		(0.263)		(0.270)		(0.266)		(0.285)		(0.289)
GDPPC*S1CHG	-4.004		-4.003									
	(2.608)		(2.592)									
GDPPC*S3CHG		-11.011*		-11.134*								
		(6.287)		(6.277)								
MANUFPERC*S1CHG					2.120***		2.068***					
					(0.660)		(0.666)					
MANUFPERC * S3CHG						3.525**		3.311**				
						(1.502)		(1.501)				
HLTHEXPPC*S1CHG									-0.052**		-0.053**	
									(0.025)		(0.024)	
HLTHEXPPC*S3CHG										-0.099*		-0.104*
										(0.058)		(0.058)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	712,568	713,120	702,982	703,534	679,998	680,514	671,500	672,016	484,767	485,199	478,938	479,370
R-squared	0.150	0.151	0.152	0.152	0.152	0.152	0.153	0.154	0.175	0.176	0.177	0.177

Table 9: Carbon Emissions and Stock Returns: Energy Structure

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). *ELRENEW* measures a country's share of electricity generated by renewable power plants in total electricity generated by all types of plants in a given year; *ENINT* is the ratio between energy supply and gross domestic product measured at purchasing power parity in a given country. Energy intensity is an indication of how much energy is used to produce one unit of economic output in a given year; *ENUSEPC* is a country's energy consumption (in kg of oil equivalent per capita) in a given year. All other variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regression models include the controls of Table 6 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ELRENEW	7.954*	2.655	8.341**	2.397								
	(4.147)	(4.998)	(4.163)	(5.015)								
ENINT					-9.341	0.731	-11.106	3.719				
					(60.820)	(61.283)	(60.793)	(61.388)				
ENUSEPC									-1.403**	-1.452***	-1.459***	-1.435**
									(0.548)	(0.553)	(0.550)	(0.558)
LOGS1TOT	0.008		0.064***		0.031		0.073***		-0.006		0.039*	
	(0.024)		(0.020)		(0.028)		(0.028)		(0.024)		(0.022)	
LOGS3TOT		0.080**		0.140***		0.164***		0.230***		0.082**		0.155***
		(0.031)		(0.035)		(0.053)		(0.054)		(0.040)		(0.042)
ELRENEW*LOGS1TOT	0.016		-0.004									
	(0.175)		(0.176)									
ELRENEW*LOGS3TOT		0.478*		0.516*								
		(0.286)		(0.286)								
ENINT*LOGS1TOT					-0.440		-0.201					
					(0.552)		(0.529)					
ENINT*LOGS3TOT						-1.176		-1.290				
						(0.847)		(0.844)				
ENUSEPC*LOGS1TOT									0.005		0.006	
									(0.005)		(0.005)	
ENUSEPC*LOGS3TOT										0.008		0.003
										(0.007)		(0.007)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	438,536	439,016	433,339	433,819	438,578	439,058	433,381	433,861	423,384	423,864	418,319	418,799
R-squared	0.185	0.185	0.187	0.187	0.185	0.185	0.187	0.187	0.190	0.190	0.192	0.192

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ELRENEW	8.110**	8.064**	8.276**	8.219**								
	(3.345)	(3.344)	(3.359)	(3.358)								
ENINT					-19.894	-23.873	-19.200	-23.389				
					(60.286)	(60.130)	(60.250)	(60.040)				
ENUSEPC									-1.340**	-1.318**	-1.386**	-1.361**
									(0.550)	(0.549)	(0.551)	(0.550)
S1CHG	0.702***		0.750***		0.139		0.153		0.380**		0.381**	
	(0.105)		(0.105)		(0.208)		(0.208)		(0.160)		(0.158)	
S3CHG		1.405***		1.500***		0.370		0.419		0.955**		0.991**
		(0.279)		(0.275)		(0.410)		(0.405)		(0.385)		(0.385)
ELRENEW*S1CHG	-2.207**		-2.463**									
	(1.086)		(1.082)									
ELRENEW*S3CHG		-0.198		-0.699								
		(2.665)		(2.661)								
ENINT*S1CHG					8.584**		8.961**					
					(4.159)		(4.195)					
ENINT*S3CHG						19.559**		19.946**				
						(7.946)		(7.959)				
ENUSEPC*S1CHG									0.038		0.046	
									(0.036)		(0.035)	
ENUSEPC*S3CHG										0.086		0.096
										(0.086)		(0.085)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	438,632	439,016	433,435	433,819	438,674	439,058	433,477	433,861	423,480	423,864	418,415	418,799
R-squared	0.186	0.186	0.188	0.188	0.185	0.186	0.187	0.188	0.190	0.190	0.192	0.192

Table 10: Carbon Emissions and Stock Returns: Socio-political Environment

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). *RULELAW* measures a country's perceptions in a given year of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution; *VOICE* captures perceptions in a given year of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution; *GINI* is a country's GINI index in a given year. All other variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regression models include the controls of Table 6 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RULELAW	-0.679	-0.725	-0.661	-0.710								
	(0.752)	(0.767)	(0.756)	(0.777)								
VOICE					-0.734	-0.712	-0.755	-0.733				
					(0.808)	(0.826)	(0.805)	(0.832)				
GINI									-6.733	-7.363	-6.902	-7.989
									(11.996)	(11.973)	(11.979)	(11.975)
LOGS1TOT	0.027		0.064***		0.033*		0.071***		0.018		0.021	
	(0.017)		(0.014)		(0.017)		(0.014)		(0.082)		(0.082)	
LOGS3TOT		0.113***		0.170***		0.125***		0.182***		0.082		0.080
		(0.026)		(0.029)		(0.025)		(0.028)		(0.115)		(0.116)
RULELAW*LOGS1TOT	0.002		0.002									
	(0.009)		(0.009)									
RULELAW*LOGS3TOT		0.004		0.003								
		(0.015)		(0.015)								
VOICE*LOGS1TOT					-0.005		-0.006					
					(0.011)		(0.011)					
VOICE*LOGS3TOT						-0.009		-0.009				
						(0.018)		(0.017)				
GINI*LOGS1TOT									0.034		0.132	
									(0.220)		(0.221)	
GINI*LOGS3TOT										0.079		0.205
										(0.299)		(0.306)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	746,432	747,080	736,641	737,289	746,432	747,080	736,641	737,289	238,087	238,279	235,066	235,258
R-squared	0.150	0.150	0.151	0.151	0.150	0.150	0.151	0.151	0.195	0.195	0.198	0.198

Panel B: Percentage Changes

DEP. VAR.: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RULELAW	-0.656	-0.629	-0.639	-0.610								
	(0.737)	(0.739)	(0.738)	(0.739)								
VOICE					-0.738	-0.744	-0.771	-0.771				
					(0.807)	(0.812)	(0.807)	(0.813)				
GINI									-6.899	-8.554	-6.069	-7.769
									(12.315)	(12.315)	(12.266)	(12.254)
S1CHG	0.653***		0.669***		0.593***		0.606***		-0.293		-0.234	
	(0.095)		(0.095)		(0.073)		(0.073)		(0.387)		(0.391)	
S3CHG		1.684***		1.700***		1.485***		1.499***		-0.890		-0.680
		(0.225)		(0.226)		(0.176)		(0.177)		(1.028)		(1.023)
RULELAW*S1CHG	-0.137**		-0.138**									
	(0.062)		(0.062)									
RULELAW*S3CHG		-0.319**		-0.315**								
		(0.152)		(0.151)								
VOICE * S1CHG					-0.139**		-0.136**					
					(0.054)		(0.054)					
VOICE * S3CHG						-0.232*		-0.221*				
						(0.130)		(0.130)				
GINI * S1CHG									2.207**		2.078*	
									(1.053)		(1.065)	
GINI * S3CHG										5.957**		5.562**
										(2.675)		(2.672)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Observations	746,528	747,080	736,737	737,289	746,528	747,080	736,737	737,289	238,135	238,279	235,114	235,258
R-squared	0.150	0.151	0.152	0.152	0.150	0.151	0.152	0.152	0.195	0.196	0.198	0.198

Table 11: Carbon Emissions and Stock Returns: Climate Policy Tightness

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). *INTPOLICY* measures the strictness of a country's international climate policy in a given year. *DOMPOLICY* measures the strictness of a country's domestic climate policy in a given year. All other variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regression models include the controls of Table 6 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INTPOLICY	-0.656	-1.106	-0.593	-1.205				
	(0.393)	(1.058)	(0.390)	(1.030)				
DOMPOLICY					-1.058*	-2.555**	-1.061*	-2.637**
					(0.566)	(1.067)	(0.534)	(1.025)
LOGS1TOT	0.047*		0.089***		0.005		0.042	
	(0.022)		(0.022)		(0.023)		(0.025)	
LOGS3TOT		0.132***		0.184***		0.050		0.102***
		(0.040)		(0.041)		(0.028)		(0.031)
INTPOLICY*LOGS1TOT	-0.018		-0.023					
	(0.041)		(0.042)					
INTPOLICY*LOGS3TOT		0.021		0.029				
		(0.091)		(0.088)				
DOMPOLICY*LOGS1TOT					0.062		0.062	
					(0.050)		(0.048)	
DOMPOLICY*LOGS3TOT						0.174*		0.181**
						(0.080)		(0.076)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	551,190	551,766	544,240	544,816	551,190	551,766	544,240	544,816
R-squared	0.153	0.153	0.155	0.155	0.153	0.153	0.154	0.155

Panel B: Percentage Changes

DEP. VAR.: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INTPOLICY	-0.842**	-0.876**	-0.831**	-0.874**				
	(0.307)	(0.303)	(0.309)	(0.307)				
DOMPOLICY					-0.408	-0.431	-0.405	-0.431
					(0.267)	(0.279)	(0.275)	(0.286)
S1CHG	0.652***		0.674***		0.580***		0.596***	
	(0.115)		(0.105)		(0.117)		(0.102)	
S3CHG		1.546**		1.540***		1.342**		1.363**
		(0.504)		(0.475)		(0.572)		(0.537)
INTPOLICY*S1CHG	-0.200		-0.199					
	(0.146)		(0.134)					
INTPOLICY*S3CHG		-0.277		-0.198				
		(0.622)		(0.598)				
DOMPOLICY* S1CHG					-0.067		-0.056	
					(0.184)		(0.172)	
DOMPOLICY* S3CHG						0.069		0.096
						(0.767)		(0.730)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	551,298	551,766	544,348	544,816	551,298	551,766	544,348	544,816
R-squared	0.153	0.154	0.155	0.155	0.153	0.153	0.155	0.155

Table 12: Carbon Emissions and Stock Returns: Reputational Risk

The sample period is 2005-2018. The sample excludes companies in the oil & gas (gic=2), utilities (gic=65-69), and motor (gic=18, 19, 23) industries. The dependent variable is *RET*. The main independent variables are carbon emission levels (columns (1)-(4)) and the percentage changes in emissions (columns (5)-(8)). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regressions include year-month fixed effects and country fixed effects. All regression models include the controls of Table 6 (unreported for brevity). In even-numbered columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.045*		0.072***					
	(0.024)		(0.020)					
LOGS3TOT		0.109**		0.173***				
		(0.036)		(0.041)				
S1CHG					0.524***		0.533***	
					(0.097)		(0.096)	
S3CHG						1.487***		1.500***
						(0.283)		(0.289)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	670,416	671,064	660,781	661,429	670,524	671,064	660,889	661,429
R-squared	0.152	0.153	0.154	0.154	0.153	0.153	0.154	0.155

Table 13: Carbon Emissions and Stock Returns: Physical Risk

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (columns 1-4) and the percentage changes in emissions (columns 5-8). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. Climate Risk Index (CRI) measures the extent to which countries and regions have been affected by impacts of weather-related loss events (storms, floods, heatwaves etc.). All regression models include the controls of Table 6 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CRI	-0.043	-0.044	-0.024	-0.071	-0.281	-0.298	-0.315	-0.331
	(0.476)	(0.708)	(0.490)	(0.726)	(0.379)	(0.386)	(0.384)	(0.391)
LOGS1TOT	0.041		0.080***					
	(0.025)		(0.020)					
LOGS3TOT		0.131***		0.186***				
		(0.037)		(0.042)				
S1CHG					0.428***		0.445***	
					(0.136)		(0.136)	
S3CHG						1.145**		1.169**
						(0.398)		(0.398)
CRI*LOGS1TOT	-0.023		-0.028					
	(0.021)		(0.021)					
CRI*LOGS3TOT		-0.021		-0.021				
		(0.038)		(0.038)				
CRI*S1CHG					0.165		0.164	
					(0.166)		(0.165)	
CRI*S3CHG						0.441		0.439
						(0.399)		(0.382)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	728,383	729,019	718,825	719,461	728,467	729,019	718,909	719,461
R-squared	0.147	0.147	0.149	0.149	0.148	0.148	0.149	0.150

Table 14: Carbon Emissions and Stock Returns: The Role of Investor Awareness

The dependent variable is *RET*. The main independent variables are carbon emission levels (columns 1-4) and the percentage changes in emissions (columns 5-8). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. Panel A reports the results for a sample covering the period January 2014-November 2015 (two years before Paris COP 21 conference). Panel B reports the results for a sample covering the period January 2016-December 2017 (two years after Paris COP 21 conference). All regression models include the controls of Table 7 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Pre Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	-0.032		0.019					
	(0.023)		(0.018)					
LOGS3TOT		0.007		0.096*				
		(0.038)		(0.050)				
S1CHG					0.731***		0.722***	
					(0.119)		(0.119)	
S3CHG						1.924***		1.891***
						(0.338)		(0.345)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	109,394	109,578	108,143	108,327	109,394	109,578	108,143	108,327
R-squared	0.090	0.090	0.098	0.098	0.091	0.092	0.099	0.100

Panel B: Post Paris

DEP. VAR.: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.095***		0.096***					
	(0.031)		(0.025)					
LOGS3TOT		0.209***		0.265***				
		(0.043)		(0.043)				
S1CHG					0.527***		0.509***	
					(0.100)		(0.105)	
S3CHG						1.611***		1.584***
						(0.237)		(0.247)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	192,678	192,810	190,047	190,179	192,678	192,810	190,047	190,179
R-squared	0.048	0.049	0.053	0.053	0.048	0.049	0.053	0.054

Table 15: Carbon Total Firm Emissions and Stock Returns: Awareness (Regional)

Our sample firms include alternately North America, North America (ex U.S.), Europe, the European Union, Asia, Asia (ex. China), and Others (Africa, Australia, and South America). The dependent variable is *RET*. The main independent variable is carbon emission level. All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. Panel A reports the results for a sample covering the period January 2014-November 2015 (two years before Paris COP 21 conference). Panel B reports the results for a sample covering the period January 2016-December 2017 (two years after Paris COP 21 conference). All regression models include the controls of Table 7 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Pre Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	North America				North America (excl. USA)			
LOGS1TOT	-0.014		0.008		-0.038		-0.055	
	(0.049)		(0.040)		(0.065)		(0.094)	
LOGS3TOT		-0.004		0.040		0.163*		0.087
		(0.088)		(0.094)		(0.080)		(0.217)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	26,898	26,955	26,551	26,608	5,357	5,380	5,345	5,368
R-squared	0.150	0.150	0.166	0.165	0.161	0.162	0.184	0.185

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Europe				EU			
LOGS1TOT	0.018		0.068*		0.020		0.106***	
	(0.033)		(0.037)		(0.034)		(0.036)	
LOGS3TOT		0.082		0.215**		0.108		0.281***
		(0.067)		(0.080)		(0.077)		(0.087)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	27,815	27,850	27,349	27,384	23,588	23,612	23,145	23,169
R-squared	0.117	0.117	0.132	0.133	0.127	0.127	0.146	0.146

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Asia				Asia (excl. China)			
LOGS1TOT	-0.058*		-0.044		-0.045		-0.042	
	(0.029)		(0.038)		(0.032)		(0.036)	
LOGS3TOT		-0.026		0.069		0.040		0.121
		(0.057)		(0.084)		(0.072)		(0.080)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	42,151	42,208	41,828	41,885	33,588	33,645	33,288	33,345
R-squared	0.116	0.116	0.124	0.124	0.093	0.093	0.104	0.104

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)
	Others			
LOGS1TOT	-0.100		0.168*	
	(0.065)		(0.098)	
LOGS3TOT		-0.054		0.230*
		(0.090)		(0.122)
Controls	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes
Observations	12,231	12,266	12,115	12,150
R-squared	0.086	0.085	0.112	0.112

Panel B: Post Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	North America				North America (excl. USA)			
LOGS1TOT	0.038		0.069		-0.053		0.071	
	(0.042)		(0.051)		(0.072)		(0.113)	
LOGS3TOT		0.115		0.091		0.028		0.095
		(0.076)		(0.092)		(0.098)		(0.185)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	47,539	47,575	46,918	46,954	7,625	7,649	7,535	7,559
R-squared	0.065	0.066	0.075	0.075	0.068	0.069	0.087	0.088

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Europe				EU			
LOGS1TOT	0.052		0.049		0.074*		0.065	
	(0.038)		(0.036)		(0.043)		(0.044)	
LOGS3TOT		0.201***		0.265***		0.223***		0.317***
		(0.061)		(0.087)		(0.066)		(0.087)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	36,155	36,191	35,567	35,603	29,779	29,779	29,247	29,247
R-squared	0.087	0.088	0.102	0.102	0.096	0.097	0.112	0.113

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Asia				Asia (excl. China)			
LOGS1TOT	0.108**		0.127***		0.105**		0.106**	
	(0.041)		(0.043)		(0.040)		(0.043)	
LOGS3TOT		0.235***		0.331***		0.187***		0.256***
		(0.061)		(0.061)		(0.062)		(0.064)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	92,619	92,643	91,408	91,432	71,817	71,841	70,728	70,752
R-squared	0.062	0.062	0.068	0.069	0.048	0.048	0.056	0.056

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)
	Others			
LOGS1TOT	0.081		0.095	
	(0.056)		(0.077)	
LOGS3TOT		0.142		0.219
		(0.116)		(0.146)
Controls	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes
Observations	16,029	16,065	15,818	15,854
R-squared	0.056	0.057	0.077	0.077

Online Appendix

Table A.1: Industry Representation

The table reports the distribution of unique firms in our sample with regard to GIC 6 industry classification. *#Co.* represents the total number of firms in each industry. The sample period is 2005-2018.

Industry	GICSIX	# Co.
Energy Equipment & Services	1	170
Oil, Gas & Consumable Fuels	2	467
Chemicals	3	530
Construction Materials	4	162
Containers & Packaging	5	102
Metals & Mining	6	506
Paper & Forest Products	7	92
Aerospace & Defense	8	99
Building Products	9	165
Construction & Engineering	10	380
Electrical Equipment	11	282
Industrial Conglomerates	12	144
Machinery	13	580
Trading Companies & Distributors	14	195
Commercial Services & Supplies	15	261
Professional Services	16	150
Air Freight & Logistics	17	70
Airlines	18	75
Marine	19	87
Road & Rail	20	115
Transportation Infrastructure	21	124
Auto Components	22	313
Automobiles	23	75
Household Durables	24	270
Leisure Products	25	73
Textiles, Apparel & Luxury Goods	26	262
Hotels, Restaurants & Leisure	27	359
Diversified Consumer Services	28	105
Media	29	325
Distributors	30	64
Internet & Direct Marketing Retail	31	92
Multiline Retail	32	117
Specialty Retail	33	354
Food & Staples Retailing	34	200
Beverages	35	126
Food Products	36	440
Tobacco	37	25
Household Products	38	41
Personal Products	39	100
Health Care Equipment & Supplies	40	229
Health Care Providers & Services	41	224
Health Care Technology	42	35
Biotechnology	43	273
Pharmaceuticals	44	371
Life Sciences Tools & Services	45	61
Banks	46	679
Thrifts & Mortgage Finance	47	70
Diversified Financial Services	48	180
Consumer Finance	49	116
Capital Markets	50	351
Mortgage Real Estate Investment Trusts (REITs)	51	2
Insurance	52	234
Internet Software & Services	53	180
IT Services	54	301
Software	55	367
Communications Equipment	56	154
Technology Hardware, Storage & Peripherals	57	167
Electronic Equipment, Instruments & Components	58	520
Semiconductors & Semiconductor Equipment	59	398
Diversified Telecommunication Services	60	131
Wireless Telecommunication Services	61	74
Media	62	142
Entertainment	63	114

Interactive Media & Services	64	36
Electric Utilities	65	159
Gas Utilities	66	66
Multi-Utilities	67	57
Water Utilities	68	44
Independent Power and Renewable Electricity Producers	69	152
Equity Real Estate Investment Trusts (REITs)	70	274
Real Estate Management & Development	71	619

Table A2: Carbon Emissions and Stock Returns: Interaction with Foreign Operations

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (Panel A) and the percentage changes in emissions (Panel B). *FORDUM* is an indicator variable equal to one if a firm has any sales generated abroad and zero if all its sales are generated domestically. All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regressions include year-month fixed effects and country fixed effects. In columns (4) through (6), we additionally include industry-fixed effects. In columns (7) to (9), we instead include firm fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LOGS1TOT*FORDUM	0.004			0.002			-0.073		
	(0.012)			(0.010)			(0.042)		
LOGS2TOT*FORDUM		0.008			0.005			-0.037	
		(0.020)			(0.016)			(0.057)	
LOGS3TOT*FORDUM			0.012			0.016			0.026
			(0.023)			(0.020)			(0.061)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	650,522	650,712	651,110	641,794	641,984	642,382	650,495	650,685	651,083
R-squared	0.148	0.148	0.148	0.150	0.150	0.150	0.177	0.177	0.177

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
S1CHG *FORDUM	-0.098			-0.083			0.019		
	(0.097)			(0.098)			(0.130)		
S2CHG *FORDUM		0.025			0.040			0.125*	
		(0.060)			(0.064)			(0.070)	
S3CHG *FORDUM			0.264*			0.301**			0.674***
			(0.131)			(0.131)			(0.207)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	650,594	650,664	651,110	641,866	641,936	642,382	650,567	650,637	651,083
R-squared	0.149	0.149	0.149	0.150	0.150	0.151	0.177	0.177	0.178

Table A.3: Carbon Emissions and Stock Returns: Economic Development

The sample period is 2005-2018. The dependent variable is *RET*. The main independent variables are carbon emission levels (columns 1-4) and the percentage changes in emissions (columns 5-8). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. Panel A reports the results for a sample of firms coming from G-20 and non-G20 countries. Panel B reports the results for a sample of firms from OECD and non-OECD countries. All regression models include the controls of Table 7 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: G20

Developed (G20)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.032		0.072***					
	(0.026)		(0.015)					
LOGS3TOT		0.126***		0.185***				
		(0.036)		(0.037)				
S1CHG					0.517***		0.538***	
					(0.093)		(0.093)	
S3CHG						1.276***		1.308***
						(0.275)		(0.286)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	575,858	576,338	567,704	568,184	575,930	576,338	567,776	568,184
R-squared	0.151	0.151	0.153	0.153	0.151	0.152	0.153	0.153

Developing (non-G20)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.028**		0.060**					
	(0.012)		(0.023)					
LOGS3TOT		0.105***		0.167***				
		(0.032)		(0.052)				
S1CHG					0.427***		0.416***	
					(0.101)		(0.103)	
S3CHG						1.438***		1.461***
						(0.231)		(0.235)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	170,784	170,952	169,147	169,315	170,808	170,952	169,171	169,315
R-squared	0.163	0.163	0.166	0.166	0.164	0.165	0.166	0.167

Panel B: OECD

Developed (OECD)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.038		0.055***					
	(0.022)		(0.013)					
LOGS3TOT		0.124***		0.149***				
		(0.028)		(0.029)				
S1CHG					0.471***		0.495***	
					(0.088)		(0.091)	
S3CHG						1.185***		1.219***
						(0.279)		(0.295)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	524,888	525,512	517,058	517,682	524,984	525,512	517,154	517,682
R-squared	0.158	0.159	0.160	0.161	0.159	0.159	0.161	0.161

Developing (non-OECD)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.011		0.085***					
	(0.024)		(0.023)					
LOGS3TOT		0.105*		0.223***				
		(0.049)		(0.069)				
S1CHG					0.509***		0.514***	
					(0.130)		(0.129)	
S3CHG						1.462***		1.455***
						(0.286)		(0.284)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	221,754	221,778	219,793	219,817	221,754	221,778	219,793	219,817
R-squared	0.174	0.174	0.176	0.177	0.175	0.176	0.177	0.177

Table A.4: Carbon Total Firm Emissions and Stock Returns: Pre/Post Paris (Economic Development)

The dependent variable is *RET*. The main independent variable is carbon emission level. All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. Columns (1)-(4) consider a sample of firms located in developed (G-20) countries, columns (5)-(8) consider a sample from developing (non-G20) countries. Panel A reports the results for a sample covering the period January 2014-November 2015 (two years before Paris COP 21 conference). Panel B reports the results for a sample covering the period January 2016-December 2017 (two years after Paris COP 21 conference). All regression models include the controls of Table 7 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Pre Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Developed Countries (G-20)				Developing Countries			
LOGS1TOT	-0.046		0.012		0.009		-0.000	
	(0.029)		(0.024)		(0.033)		(0.033)	
LOGS3TOT		-0.010		0.088*		0.066		0.086
		(0.041)		(0.051)		(0.053)		(0.092)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	83,578	83,727	82,556	82,705	25,816	25,851	25,587	25,622
R-squared	0.095	0.095	0.104	0.104	0.091	0.091	0.103	0.103

Panel B: Post Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Developed Countries (G-20)				Developing Countries			
LOGS1TOT	0.112***		0.100***		0.055*		0.090**	
	(0.034)		(0.025)		(0.030)		(0.037)	
LOGS3TOT		0.221***		0.259***		0.187***		0.289***
		(0.046)		(0.047)		(0.055)		(0.071)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	148,067	148,151	145,875	145,959	44,611	44,659	44,171	44,219
R-squared	0.051	0.051	0.056	0.057	0.050	0.051	0.062	0.063

Table A.5: Carbon Emissions and Stock Returns: Policy Change and Reputational Risk

The sample excludes companies in the oil & gas (gic=2), utilities (gic=65-69), and motor (gic=18, 19, 23) industries. The dependent variable is *RET*. The main independent variables are carbon emission levels (columns 1-4) and the percentage changes in emissions (columns 5-8). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. Panel A reports the results for a sample covering the period January 2014-November 2015 (two years before Paris COP 21 conference). Panel B reports the results for a sample covering the period January 2016-December 2017 (two years after Paris COP 21 conference). All regression models include the controls of Table 7 (unreported for brevity), year-month fixed effects, and country fixed effects. In selected columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Pre Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	-0.045*		0.005					
	(0.026)		(0.022)					
LOGS3TOT		-0.047		0.052				
		(0.044)		(0.057)				
S1CHG					0.741***		0.746***	
					(0.120)		(0.114)	
S3CHG						2.131***		2.182***
						(0.275)		(0.276)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	96,826	97,010	95,597	95,781	96,826	97,010	95,597	95,781
R-squared	0.088	0.088	0.096	0.096	0.089	0.090	0.096	0.097

Panel B: Post Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.129***		0.122***					
	(0.037)		(0.031)					
LOGS3TOT		0.207***		0.272***				
		(0.045)		(0.049)				
S1CHG					0.559***		0.533***	
					(0.114)		(0.108)	
S3CHG						1.824***		1.787***
						(0.255)		(0.249)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	175,629	175,761	173,034	173,166	175,629	175,761	173,034	173,166
R-squared	0.049	0.049	0.054	0.054	0.048	0.050	0.054	0.055

Table A.6: Carbon Emissions and Stock Returns: Policy Change and Market Uncertainty

The sample period is 2005-2018. The sample are all firms that have presence in the sample any year prior to 2016. The dependent variable is *RET*. The main independent variables are carbon emission levels (columns (1)-(4)) and the percentage changes in emissions (columns (5)-(8)). All variables are defined in Table 1 and Table 2. We report the results of the pooled regression with standard errors clustered at the firm and year level. All regressions include year-month fixed effects and country fixed effects. All regression models include the controls of Table 7 (unreported for brevity). Panel A reports the results for a sample covering the period January 2014-November 2015 (two years before Paris COP 21 conference). Panel B reports the results for a sample covering the period January 2016-December 2017 (two years after Paris COP 21 conference). In even-numbered columns, we additionally include industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Pre Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	-0.032		0.019					
	(0.023)		(0.018)					
LOGS3TOT		0.007		0.096*				
		(0.038)		(0.050)				
S1CHG					0.731***		0.722***	
					(0.119)		(0.119)	
S3CHG						1.924***		1.891***
						(0.338)		(0.345)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	109,394	109,578	108,143	108,327	109,394	109,578	108,143	108,327
R-squared	0.090	0.090	0.098	0.098	0.091	0.092	0.099	0.100

Panel B: Post Paris

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.081**		0.057**					
	(0.030)		(0.026)					
LOGS3TOT		0.217***		0.230***				
		(0.052)		(0.055)				
S1CHG					0.299***		0.288***	
					(0.094)		(0.090)	
S3CHG						1.148***		1.101***
						(0.270)		(0.281)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	125,199	125,331	123,715	123,847	125,199	125,331	123,715	123,847
R-squared	0.071	0.071	0.077	0.078	0.070	0.071	0.078	0.078