The Effect of U.S. Climate Policy on Financial Markets: An Event Study of the Inflation Reduction Act*

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Abstract

The Inflation Reduction Act of 2022 (IRA) represents the largest climate policy action ever undertaken in the United States. Its legislative path was marked by two abrupt shifts as the likelihood of climate policy action fell to near zero and then rose to near certainty. We investigate equity price reactions to these two events, which represent major realizations of climate policy transition risk. Our results highlight the heterogeneous nature of climate policy risk exposure. We find sizable reactions that differ by industry as well as across firm-level measures of greenness such as environmental scores and emission intensities. While the financial market response to the IRA was economically significant, it did not lead to instability or financial stress, suggesting that transition risks posed by climate policies as ambitious as the IRA may be manageable.

Keywords: transition risk, stranded assets, event study, carbon emissions, ESG scores, green stocks, brown stocks
JEL Classifications: G14, G38, Q54, Q58

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1 Introduction

The Inflation Reduction Act of 2022 (IRA) is widely considered to be the most ambitious climate policy action in U.S. history. Over the next decade and beyond, a broad array of new tax credits and direct government expenditures will provide substantial financial support for clean technologies and industries, as well as strong direct incentives for U.S. households and firms to invest in the equipment and capital needed to reduce their carbon emissions. Measured in terms of total fiscal cost, Bistline et al. (2023b) estimate that the cumulative budgetary effect of the climate-related parts of the IRA could be on the order of $1 trillion over the next 10 years.[1] The economic changes induced by the IRA incentives are also expected to result in significant reductions to U.S. greenhouse gas emissions (Bistline et al., 2023a). However, such projections of the economic and climate consequences of the IRA are generally silent about any financial implications. This is true even though the financial sector is integral to supplying the requisite capital for decarbonization and determining climate policy outcomes. The forward-looking responses of financial markets will also be evident much sooner than the economic and emissions effects and can thus provide a useful early reading on policy transmission and success. In this paper, we document the financial market responses to the IRA and provide a new climate finance perspective on this major climate policy action.

One particularly important issue for climate finance is policy transition risk. The substantial investment required for the transformation to a low-carbon economy will rely heavily on financial markets and institutions (e.g., Battiston et al., 2021).[2] However, the uncertain pace and consequences of a decarbonization have become a major policy concern in recent years (Van der Ploeg and Rezai, 2020). If investor expectations were to adjust precipitously to new climate policies, the resulting adverse revaluations of carbon-dependent assets—potentially resulting in stranded assets—could have severe implications for financial solvency and stability along the lines of what former Bank of England governor Mark Carney termed a "climate Minsky moment" (Carney, 2016). Because such abrupt shifts in the prospects for businesses and in asset prices could weaken banks and other financial institutions, central banks and other financial supervisory authorities have started to quantify these risks through climate scenario analyses (Acharya et al., 2023). Therefore, the pricing of transition risks

[1] Many of the IRA tax credits are open-ended without fixed budgets, so the fiscal impact depends on usage and the amount claimed. The official IRA budget score by the Joint Committee on Taxation was under $400 billion, but that likely underestimates likely participation and tax credit take-up.

[2] There are three broad roles that financial markets will play in the green transition (Giglio et al., 2021): allocating funds to sustainable investment, informing climate-related economic and policy decisions, and managing climate risks. As an example, information from financial markets can help pin down the long-run social discount rate used in determining the social cost of carbon (Bauer and Rudebusch, 2023).

in financial markets has become a first-order policy issue. The passage of the IRA—the culmination of decades of attempts to obtain significant U.S. legislation addressing climate change—represents a major realization of climate policy transition risk. By investigating the financial market responses to that climate policy realization, we can illuminate the economic and financial consequences of climate transition risk.

To document stock market responses to the IRA, we use event-study methods to examine equity price movements following key news events leading up to passage of the IRA. Event studies are particularly revealing when relevant new information becomes public via discrete, definitive announcements.[3] The legislative genesis of the IRA in 2022 included two such unambiguous shifts in the likelihood of major policy action, and we leverage these for econometric identification. Two events, in particular, whipsawed the prospects for climate-related legislation: In the first, news reports surfaced late on July 14 of the withdrawal of any support for new climate spending by Senator Joe Manchin of West Virginia—the pivotal vote required for getting legislation through the Senate in the face of unanimous Republican congressional opposition. This episode could be termed a "brown event," as the likelihood of Senate passage of climate legislation plummeted and the probability of any near-term sizable policy action fell to almost zero. The second event occurred in the early evening of July 27, when news broke that Senator Manchin had reached a surprise agreement with Democratic leaders on new legislation to combat climate change. This "green event," which unveiled the IRA for the first time, made it nearly certain that significant climate policy would ultimately become law. Section 2 explains in more detail the provisions of the IRA and the timeline of events preceding its passage. Because these two events represent large discrete shifts in the viability of important climate legislation, they allow for a close-to-ideal event study to investigate the financial market effects of climate policy.

We carry out several complementary event-study exercises to investigate the varying market responses of different industries and different firms. In Section 3, we examine the returns of green and brown industries around the climate policy and IRA announcements. We first employ several commonly used equity indices such as the S&P Global Clean Energy and S&P 500 Integrated Oil & Gas funds. Clean energy indices had sizable negative abnormal returns after the brown event on July 14 but then rebounded strongly after the July 27 IRA debut. By contrast, abnormal returns for brown indices were positive after the brown event and then dropped substantially after the green event. Various brown-minus-green portfolios posted abnormal returns of around 3 to 7 percent after the brown event and -4 to -10 percent

[3]See MacKinlay (1997) for a review of event-study methods. In macroeconomics, a large literature has employed event studies to examine the financial market effects of monetary policy announcements (e.g., Kuttner, 2001; Gürkaynak et al., 2005; Bauer and Rudebusch, 2014).

after the green event. We then consider industry-level returns, using Fama-French industry portfolios to provide insight into what types of sectors investors expected to gain or lose from the shifts in climate policy. Industries that stand to benefit from the provisions in the IRA—those where demand will be boosted or production costs will be subsidized, such as producers of electrical equipment, utilities, and construction companies—exhibited a strong positive response to the green announcement on July 27. By contrast, oil and coal production firms were naturally perceived to be among the biggest losers from the IRA and lost significant market value. The differences in abnormal returns were quite sizable and generally in accord with the specific measures in the IRA.

In Section 4, we conduct a more granular analysis at the level of individual firms. The publicly listed firms in our sample are differentiated using measures of greenness based on their actual carbon emissions data as well as emissions scores and broader Environmental scores (or E scores) calculated by Refinitiv, a global provider of financial market data including firm-level environmental characteristics. The heterogeneous stock market responses across these measures of greenness are statistically and economically significant and support their use in identifying climate policy exposure. Similar to index results, we find that the first event, which signaled that no near-term U.S. climate policy legislation was expected to pass, lowered the stock market values of green firms—those with relatively low emission intensities and superior E and emissions scores—and boosted the values of brown firms. By contrast, with the announcement of a near-certain IRA, green firms benefited and brown firms did not.

Taken together, these event-study results document substantial and rapid financial asset price reactions to climate policy news. In response to these realizations of climate policy transition risk, green and brown stocks within each industry displayed sizable movements in opposite directions. In addition, industry-level returns exhibited pronounced responses in line with the expected effects of subsidies in the IRA. From a theoretical perspective, positive news about the passage of the IRA lifted expected profitability for green firms and disadvantaged brown firms through both demand and cost channels.[4] The IRA subsidies for purchases of low-carbon products should lead to a policy-induced strengthening of customer demand for green goods and services, boosting green firm stocks as their business prospects were improved (a demand channel as in Pástor et al., 2021). Other financial incentives in the IRA include clean energy production and investment tax credits and subsidies, lowering production costs and raising profits (a cost channel). Through these channels, news about the IRA appear to have impacted expected future dividends and, ultimately, stock prices.[5]

[4]As noted by Bistline et al. (2023b), the incidence of IRA tax credits and other provisions—that is, whether they will be captured by producers or consumers—is relevant for assessing the effects of the IRA.

[5]The passage of the IRA could also have shifted the cost of capital and risk premia, by changing percep-

In Section 5, we consider some implications of our event study for calibrating climate policy transition risk. To better understand the risks of climate change and the transition to a low-carbon economy, financial supervisors worldwide are developing climate scenario analyses and climate stress tests to identify potential vulnerabilities in the financial system and assess bank solvency (e.g., Financial Stability Board, 2022; NGFS, 2022a). Such exercises are at an early stage of development, and there are many unknowns about how investors, banks, and other financial institutions will respond as climate policy actions are taken. In terms of transition risk, many climate scenario analyses assume specific asset price responses to a given change in climate policies. Our analysis can help characterize these responses. For example, the declines in brown firm stock prices to the IRA policy action do not appear outsized or disorderly even though this policy transition risk realization was arguably the largest retrospectively or prospectively. Therefore, the transition risks of financial sector bankruptcies, dislocations, and crises to future climate policies may be manageable. Given that the IRA is an extremely large climate policy action but caused manageable financial market responses of brown firms and disadvantaged industries, our evidence suggests limited risk for a climate Minsky moment.

We also take a narrower focus in Section 5 and consider our climate policy events as a case study for using industry classifications to account for carbon transition risk. Specifically, we investigate whether measures of industry-level greenness can account for the cross-industry variation in the equity price responses to the climate policy news. Such metrics have been used for assessing the exposure of commercial banks to different climate policy scenarios (e.g., Jung et al., 2023). But the measured greenness of industries appears to be a poor predictor of the industry-level equity responses to the climate policy announcements we study in this paper. This finding suggests that there is a need for a more granular firm- and asset-level accounting of transition risks—much like earlier work has called for with regard to physical risk (Bressan et al., 2022).

Our paper contributes to a quickly growing literature on the pricing of climate risks in financial markets, and specifically on the pricing of transition risks in green and brown stocks; see Bolton and Kacperczyk (2021), Pástor et al. (2022), and Bauer et al. (2022), among many others. Most prior work on the effects of climate policy on financial markets has studied events with news about *possible future* climate action and shifts in perceived transition risks, often with mixed results. Ramelli et al. (2021) investigate the stock market reaction to the 2016 and 2020 U.S. Presidential elections, finding better stock market performance of carbon-intensive firms in response to the Trump election but also higher stock returns for firms with higher climate responsibility around *both* the Trump and Biden election wins.

tions of future climate risks, but such shifts are much less clear.

Monasterolo and De Angelis (2020) document shifts in the risk characteristics of green and brown stock indices before and after the announcement of the 2015 Paris Agreement, but they find no appreciable penalty on the returns or valuations of high-carbon assets and firms. Other related empirical work considers larger and more heterogeneous sets of climate policy news. Barnett (2023) identifies a number of climate policy events and shows that industries with a larger exposure to changes in oil prices exhibit a more negative stock market response to events that increase the likelihood of future climate policy action. Ardia et al. (2022) show that unexpected increases in a news-based index of climate change concerns benefit green stocks over brown stocks. Cassidy (2023) constructs a dataset of climate policy announcements and documents that brown stocks perform better than green stocks around events with a large amount of climate policy news. Other studies of the effects of climate policies on financial performance more broadly include Kumar and Purnanandam (2022), Bartram et al. (2022), and Jung et al. (2021).

While most earlier studies have focused on news about possible future climate action and shifts in perceived transition risk, we examine clearly identified events with major news about immediate climate policy action. That is, we focus on realizations of transition risk, and there are only very few other studies in this vein. Carattini and Sen (2019) document which stocks benefited from news that two carbon tax initiatives in Washington State were rejected by voters. Ivanov et al. (2023) study the passage of California's cap-and-trade legislation and the failed version at the federal level (the Waxman-Markey bil)l and document more constrained bank lending to high-emission firms. Hengge et al. (2023) study carbon policy news related to the European Union Emission Trading System (EU-ETS). They examine events with exogenous changes in the price of emission permits following Känzig (2023) and show that a surprise increase in the carbon price leads to negative abnormal returns of brown stocks compared with green stocks, measured using emission intensities. Our paper provides novel evidence on the financial market response to realizations of transition risk, using the stock market response to news about the IRA—the most important climate policy in U.S. history.

2 The Inflation Reduction Act

To set the stage for the empirical analysis, we provide a description of the timeline of events leading up to passage of the IRA and then summarize the key climate policy ingredients of this legislation.

Table 1: Timeline of key legislative events for Inflation Reduction Act (IRA)

Date	Time	Event
19-Nov-21, Fri.	9:49 am	House passes Build Back Better climate legislation
19-Dec-21, Sun.	9:12 am	Manchin announces decision to vote against Build Back Better
14-Jul-22, Thu.	9:29 pm	Press reports Manchin will not support new climate spending
27-Jul-22, Wed.	5:03 pm	Manchin and Schumer announce new climate legislation: IRA
03-Aug-22, Wed.	3:31 pm	CBO/JCT publish cost estimates of IRA
07-Aug-22, Sun.	2:45 pm	Senate passes IRA
12-Aug-22, Fri.	5:42 pm	House passes IRA
16-Aug-22, Tue.		President Biden signs the IRA into law

A timeline for major legislative events during passage of the IRA, which was a smaller, climate-focused version of the earlier Build Back Better Act. Event times (in ET) reflect initial news accounts according to Dow Jones Newswires, which is a financial news source used by investors worldwide.

Table 1 highlights some of the key events in the legislative history of the IRA. The IRA resulted from negotiations in the Senate to rework the Build Back Better Act, which was an expansive package of climate change, health care, tax reform, and social safety net proposals. While the Build Back Better Act passed the House, it faced an evenly divided Senate and would need every Democratic vote for passage. Senator Joe Manchin became the key holdout, which resulted in months of challenging negotiations and swings of sentiment regarding passage. On the evening of July 14—after U.S. equity markets[6] had closed—press reports surfaced that Senator Manchin had decided to oppose any further attempts to pass the Build Back Better Act and, in particular, had rejected any further climate legislation. One such report, Romm and Stein (2022), noted "Sen. Joe Manchin III (D-W.Va.) told Democratic leaders Thursday he would not support an economic package this month that contains new spending on climate change or new tax increases targeting wealthy individuals and corporations, marking a massive setback for party lawmakers who had hoped to advance a central element of their agenda before the midterm elections this fall." However, two weeks later on July 27, Senator Manchin and Senate Majority Leader Charles Schumer announced that they had reached a new agreement to pass climate legislation, and they unveiled the complete text of the "Inflation Reduction Act of 2022".[7] This announcement was also made

[6]The New York Stock Exchange is usually open from Monday through Friday from 9:30 am to 4:00 pm.

[7]As described in Romm et al. (2022): "Sen. Joe Manchin III (D-W.Va.) on Wednesday reached a deal with Democratic leaders on a spending package that aims to lower health-care costs, combat climate change and reduce the federal deficit.... Under the deal, Schumer secured Manchin's support for roughly $433 billion in new spending, most of which is focused on climate change and clean energy production. It is the largest such investment in U.S. history, and a marked departure from Manchin's position only days earlier. ... It came as a surprise to many Democratic lawmakers, illustrating the tumultuous and secretive negotiations between Schumer and Manchin, which have spanned months."

after equity markets closed and was generally viewed as essentially guaranteeing passage of climate legislation. Indeed, the IRA sped through the Senate and House within two weeks and was signed into law a few days later.

The dramatic demise and rebirth of climate legislation represented by these July events—with the probability of climate policy action first falling to near zero and then jumping to close to one—are ideal for assessing the impact of the IRA on financial markets. The other events in Table 1 are arguably of much less interest for our purposes. The two events that preceded July 2022 pertained to the more expansive Build Back Better legislation and were part of yearlong intermittent negotiations with shifting legislative priorities that included health care, education, immigration, and tax reform. Accordingly, the extent and timing of any climate news content of these earlier events is much less clear. There were also three notable IRA events after July 2022 that included the release of cost estimates and actual IRA passage by the Senate and House. However, once Senators Manchin and Schumer had reached agreement, the August 2022 events were widely anticipated, and, according to contemporaneous press accounts, any residual uncertainty was effectively resolved before the actual votes were recorded in Congress. With climate concerns front and center for the July 2022 events and with the information arrival so clearly delineated, our analysis focuses on these dates to give the cleanest read on climate policy news.

In terms of legislative initiatives to limit climate change, the IRA provides funding for clean energy through a mix of tax incentives, grants, and loan guarantees.[8] It supports investments in clean electricity and transmission, carbon capture and storage, green hydrogen, and electric transportation and energy infrastructure. There are home energy rebates to help make homes more energy efficient and new tax credits to induce consumers to buy new and used electric vehicles. The IRA also introduces a program to increase the costs of methane emissions. Relative to past initiatives, the cost of the climate actions in the IRA is enormous—accrued both by expanding existing programs and introducing new ones. The Congressional Budget Office (CBO) and Joint Committee on Taxation (JCT) estimated that U.S. federal budgetary costs through 2031 would be \$271 billion in climate-related tax credits and \$121 billion for direct expenditures (Bistline et al., 2023b). However, as stressed by Bistline et al. (2023b), many of the tax credits are uncapped, so their take-up and cost depend on corporate investment decisions and household consumption decisions. Based on a detailed energy systems modeling of the U.S. economy, Bistline et al. (2023b) project the budgetary cost of the climate-related provisions to be several times larger than the CBO/JCT

[8] Besides curtailing climate change, the IRA has two other goals: restraining health-care costs and reducing the federal budget deficit. The first of these is notably aided by allowing Medicare to begin negotiating the price of select prescription drugs. Federal deficit reduction is largely achieved via a new 15 percent minimum tax on corporations with earnings of at least \$1 billion a year.

estimate—perhaps as high as $1 trillion.

In terms of climate policy effectiveness, the IRA is estimated to significantly reduce carbon emissions, with projected reductions by 2030 of around 37% below 2005 levels (Bistline et al., 2023a).[9] This would seem to put the United States within reach of its 50% reduction target by 2030 under the Paris Agreement. To calibrate the magnitude of the IRA policy action, it is possible in theory to provide a rough estimate of the equivalent carbon price that would be needed to achieve the same emissions reduction. That is, a non-carbon price climate policy can be be translated into an emissions-equivalent shadow carbon price, as described in Hänsel et al. (2022). Bistline et al. (2023b) estimate that the power sector policies, which account for about 70% of the IRA emissions reductions, may have similar emissions reductions to a U.S. carbon tax of around $12 to $15 per ton of carbon dioxide (CO_2). Scaled up, this suggests that the total IRA would represent an approximate equivalent shadow carbon price of roughly on the order of $20 per ton of CO_2. By this measure, the IRA clearly represents a sizable climate policy initiative with significant effects comparable to those contemplated in the usual climate scenario analyses associated with central bank climate stress tests (NGFS, 2022a).

By using an emissions-equivalent shadow carbon price that summarizes various climate policy actions such as subsidies, taxes, and regulation (e.g., Hänsel et al., 2022; NGFS, 2022a), it is possible to provide a broad-brush account of the two key climate policy events. With the election of President Biden and Democratic majorities in both houses of Congress in 2020, there were three broad plausible paths for U.S. climate policy: (1) further minimal incremental action, which would continue a more than decade-long trend of little progress on national climate policy; (2) a break from the past in the form of a moderately significant climate policy initiative; or (3) a very ambitious, wide-ranging policy action along the lines of a "Green New Deal" or the Build Back Better climate legislation. These three potential paths could be roughly approximated in terms of the future shadow carbon price path as (1) no change to the path, (2) a level shift upward in the path of about $20, and (3) a level shift upward of $50 or more. Before July 2022, there was sizable transition risk associated with the uncertainty around which path would be taken. The July 14 event appeared to adopt the first option with no policy action. However, the IRA announced on July 27 locked in the middle path and represented a substantial climate policy transition realization.

Before turning to the empirical analysis, it is helpful to outline how these climate policy events might be expected to affect the stock market from a conceptual asset pricing perspective. A company's equity price depends on its expected stream of future profits and dividends and on the discount rate used to calculate their (risk-adjusted) present value.

[9] Baseline projections without the IRA had reductions by 2030 of about 28% below 2005.

The legislative events in July 2022 likely affected stock prices predominantly by changing expected dividends. The shifts in the expected path for the shadow carbon price directly impacted expected profitability of green and brown firms. Higher carbon price paths translate into higher profits for green firms, which will face less competition from carbon-dependent competitors, and lower profits for brown firms. For example, a higher carbon price will raise the production costs and lower sales and revenues of firms that are more dependent on fossil fuels in their operations. Meanwhile, lower carbon price paths benefit brown firms more than green firms. After the July 14 brown event—which established a low expected shadow carbon price path—the expected profits of brown firms would likely rise and those of green firms would fall. Conversely, the jump in the future carbon price trajectory following the July 27 green event would push up expected profits of green firms and depress those of brown firms. Furthermore, these shifts in the expected paths for profits would have corresponding differential effects on the prices of green and brown stocks.

Considering the specifics of the IRA, there are both supply- and demand-side subsidies that favor green firms. On the supply side, the IRA includes production and investment tax credits for clean energy, which can boost green firm profits by lowering costs. The effects on stock prices might be best understood through the lens of a *cost channel*: Firms that benefit from such subsidies see their marginal cost decline and their profits, dividends, and stock prices rise. The IRA also contains demand-side subsidies to business and consumers to increase demand for green products. Via this *demand channel*, profits and dividends of green firms are boosted as well, again raising their stock prices.[10] Brown firms, which are relatively disadvantaged by the production and demand subsidies, would see their profits and dividends—and thus stock prices—decline. Therefore, we anticipate that the two sharp movements in the mean shadow carbon price path will have effects on profitability and equity prices that vary with the overall greenness of a firm, which, following a growing carbon finance literature, can be measured by the firm's CO_2 emissions or environmental score.

Another potential channel through which a change in climate policy could affect stock prices is via the cost of capital. An increase in transition uncertainty would raise the expected returns of firms that are exposed to this type of risk and thus lower their stock prices.[11] The signing of the 2015 Paris Agreement and, more generally, increasing concerns about climate change, raise the likelihood of future climate policy action and therefore transition

[10]This demand channel is similar to the *customer channel* of Pástor et al. (2021) where firms benefit from additional demand in accordance with their greenness.

[11]Effects on the cost of capital could also result from a shift in investor preferences for green investments, perhaps from a bandwagon effect in which IRA news increases investor interest in green assets, according to the *investor channel* of Pástor et al. (2021). While it is conceivable that new climate legislation could raise public awareness in a way that drives investors towards green investments—lowering expected returns and raising prices of green stocks—evidence of such a shift is not apparent.

risk—particularly for carbon-dependent firms. However, unlike many previous analyses of climate-related events and risks (e.g. Ramelli et al., 2021; Jung et al., 2021; Barnett, 2023), we do not interpret our event study results as operating primarily through *changes* in climate policy transition uncertainty and risk. Although some IRA implementation details are still being worked out, we view passage of the IRA as a *realization* of transition risk, because it implements specific new climate policies.

Finally, there are, of course, complications resulting from the specific non-carbon price nature of the U.S. climate legislation. In contrast to a broad, uniform carbon tax, the effects on cost and demand of the IRA subsidies will depend on their particular specification, the relevant market structure and segmentation, and the incidence across firms and industries. For example, subsidies in support of clean electricity may benefit utility firms and energy companies that are in industries with relatively high overall emissions footprints. As a result, the stock market effects of the IRA may depend not only on emissions/greenness of individual firms, but also on whether their industries are specifically favored and subsidized by the IRA—regardless of the greenness of that industry. This is a point that we will return to in Section 5.

3 Climate policy responses at an industry level

The first part of our analysis focuses on the response of different sectors and industries to the IRA announcements. We consider both stock market indices commonly used to represent the green and brown energy sectors, and then turn to industry portfolios using methods from empirical asset pricing. The goal of this aggregate analysis is to provide some indication of financial market participants' views about whether the IRA represents meaningful climate legislation that will be sustained going forward.

We investigate the returns of various reported stock market indices that are self-classified either as clean or green energy funds or as fossil energy funds, including about a dozen of the more well-known low-carbon and fossil energy equity indices listed in Table 2. Our selection of indices is informed in part by Monasterolo and De Angelis (2020), who studied the reaction of various equity market indices to the 2015 announcement of the Paris Agreement.[12] Table 2 reports abnormal returns for the 11 indices we use in this event study—six green and five brown indices—with raw S&P500 market returns shown on the bottom line for comparison.

[12] We omit one index that was labeled green in Monasterolo and De Angelis (2020), the STOXX Global ESG Environmental Leaders index. They find that this index is just as well correlated with the brown oil and gas funds. Most tellingly, this index is heavily weighted with bank stocks, which fared poorly with the announcement of the IRA. We also omit a European oil and gas index listed as a brown index in Monasterolo and De Angelis (2020).

Table 2: Abnormal green and brown equity index returns

		Brown event (July 14)		Green event (July 27)	
	Std. dev.	1 day	3 days	1 day	3 days
Green					
Nasdaq Clean Edge Green Energy	1.4	**-3.4**	-0.9	**6.9**	**7.5**
Wilderhill Clean Energy	1.5	-2.6	-0.8	**6.4**	**5.6**
S&P Global Clean Energy	1.2	**-3.4**	-1.3	**6.5**	**7.3**
World Renewable Energy (Renixx)	1.6	**-4.0**	-2.6	**7.3**	**7.8**
ISE Global Wind Energy	1.0	-0.5	0.6	**3.3**	**3.9**
MAC Global Solar Energy	1.7	**-4.1**	-2.6	**6.2**	**6.9**
Brown					
S&P 500 Integrated Oil & Gas	1.4	-0.3	2.5	-0.3	2.6
FTSE Local USA Oil & Gas & Coal	1.8	-0.1	2.4	-1.6	-2.5
FTSE All World Oil & Gas & Coal	1.2	0.3	3.3	-0.4	1.0
Dow Jones Select Oil Expl. & Prod.	1.9	-0.2	3.2	-1.6	-2.6
Dynamic Energy Expl. & Prod. Intellindex	2.1	-0.3	3.7	-1.1	-1.8
Market					
S&P 500 (raw returns)	1.2	1.9	3.9	1.2	2.4

Equity index returns around IRA events, in percent. Abnormal returns are calculated from raw returns using estimated alphas and betas from a market model using daily value-weighted CRSP market returns from January 2016 to May 2022. Returns larger than two times the daily standard deviation are shown in bold.

All returns are based on Bloomberg price quotes from the close of the trading day. Appendix Table A.1 reports the corresponding raw returns for comparison. Abnormal returns are calculated from the differences between observed raw returns and predicted returns from an estimated model of market returns (e.g., MacKinlay, 1997). To estimate the market model, we regress daily raw returns of each asset on the return of the CRSP value-weighted stock market index, a proxy for the market portfolio, from January 2016 to May 2022 to avoid overlap with the event days. For each of the two policy events, we report one-day and three-day returns, with the latter calculated by accumulating daily abnormal returns. As noted above, the events took place in the evenings after trading hours on July 14 and July 27, 2022. The event windows therefore start when the stock market closed on those dates and end at market close on the next day (for one-day returns) or three days later (for three-day returns).[13]

Table 2 shows that the IRA events had substantially different impacts on green and brown indices. The direction of the differences is intuitive and their magnitudes are sizable. After

[13] We obtained similar results using just the overnight close-to-open returns but judged that a slightly longer window better captured the market pricing of news during business hours.

the July 14 media reports that lowered the probability that any climate policy action would pass the Senate, green indices performed worse than brown indices, both for one-day and three-day abnormal returns. For one-day returns, the median green index fell 3.4% while all of the brown indices were little changed. The relative outperformance of brown indices justifies the "brown event" label. The pattern is reversed and even more stark for the July 27 "green event," when news of Senator Manchin's support for the IRA assured its passage. The median green fund had a 6.5% abnormal return, and the median brown index fell 1.1%.

To provide further insight on broad market moves around the policy events, Figure 1 plots the cumulative returns for eight market indices from market close on July 14 to market close on August 15. These cumulative returns illustrate the persistence of the equity index reactions to climate legislation during the crucial month when climate policy was declared dead and the IRA was announced and later signed by President Biden. The July 14 and July 27 events are indicated with vertical dashed lines.[14] The clean-energy and fossil-fuel-energy stock indices are shown as green and brown lines, respectively. For the cumulative raw returns shown in Panel A, the green indices underperformed the brown ones during the two weeks following the July 14 announcement, ending about 6 percent lower on July 26. Similarly, the outperformance of green indices on the day after the July 27 announcement also persisted. The performance differences in green versus brown stocks are even more pronounced for the abnormal returns shown in Panel B. During the month, the gains in the green indices following the green event significantly outweighed their losses after the brown event, resulting in a cumulative outperformance ranging from 8 to 24 percentage points. The differences between green and brown equities are far less affected by the passage of the law in the House and Senate later in August 2022, which were both widely anticipated. While fossil-fuel stocks did post sizable declines on August 3 and 4, this reflected a plunge in benchmark crude oil prices, which were down about 6% over those two days on concerns about rising oil supplies and a deteriorating economic outlook.[15]

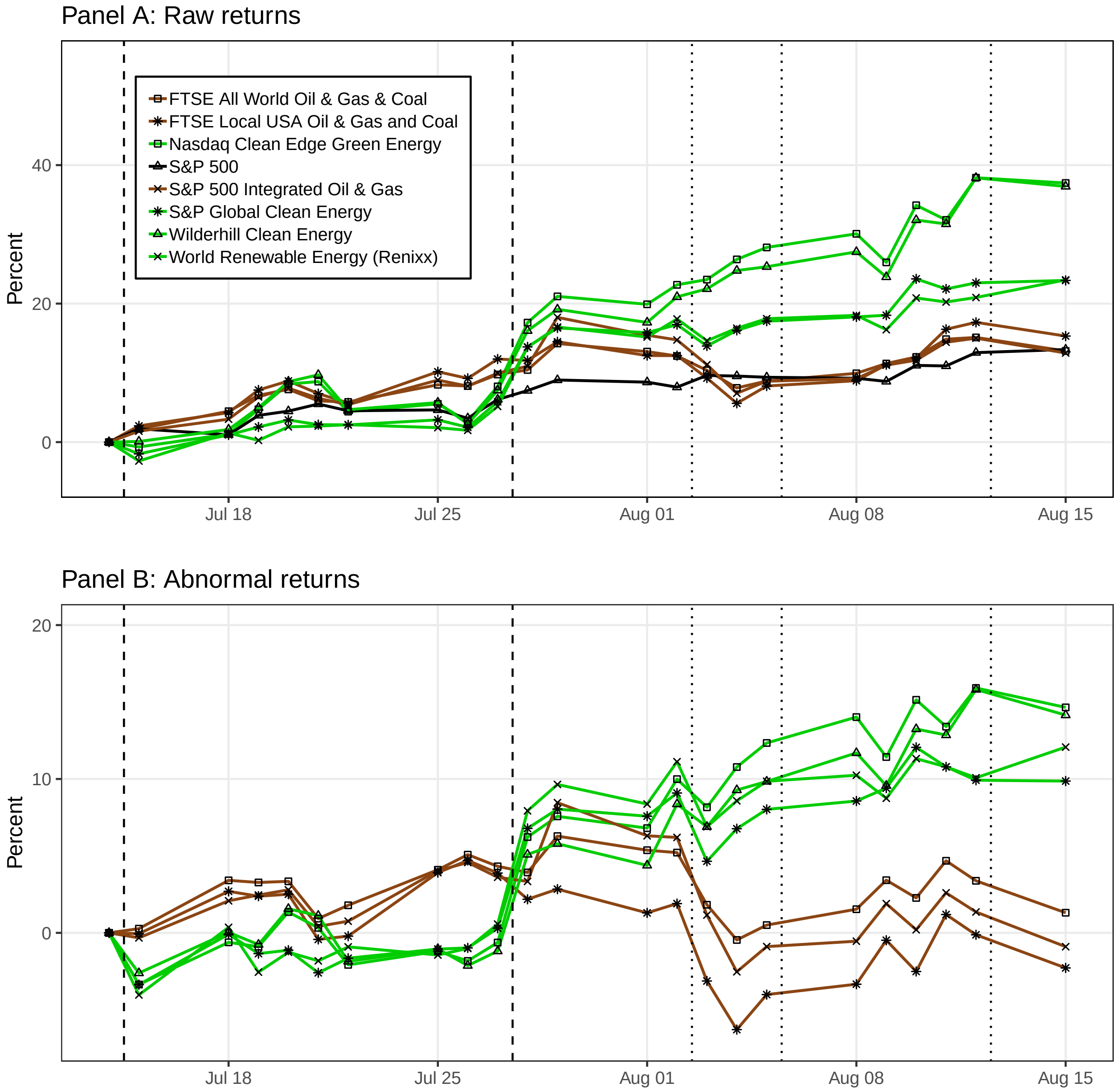
This index-level analysis yields a consistent picture of the financial performance of energy-related equity holdings. Indeed, the response of equity markets to major news about the likelihood of the passage of the IRA suggests that markets expected clean/renewable energy companies to benefit and oil/gas/coal firms to be disadvantaged by its policies.

We now turn to the analysis of the heterogeneous response of equity returns across major industries. Various industry classifications are available, and here we use the 17 Fama-French industry portfolios, which are widely used in empirical asset pricing. These industry

[14] Again, the news on these days was released after markets had closed, so these news releases are shown as occurring between the market close quotes on these event days and the subsequent days.

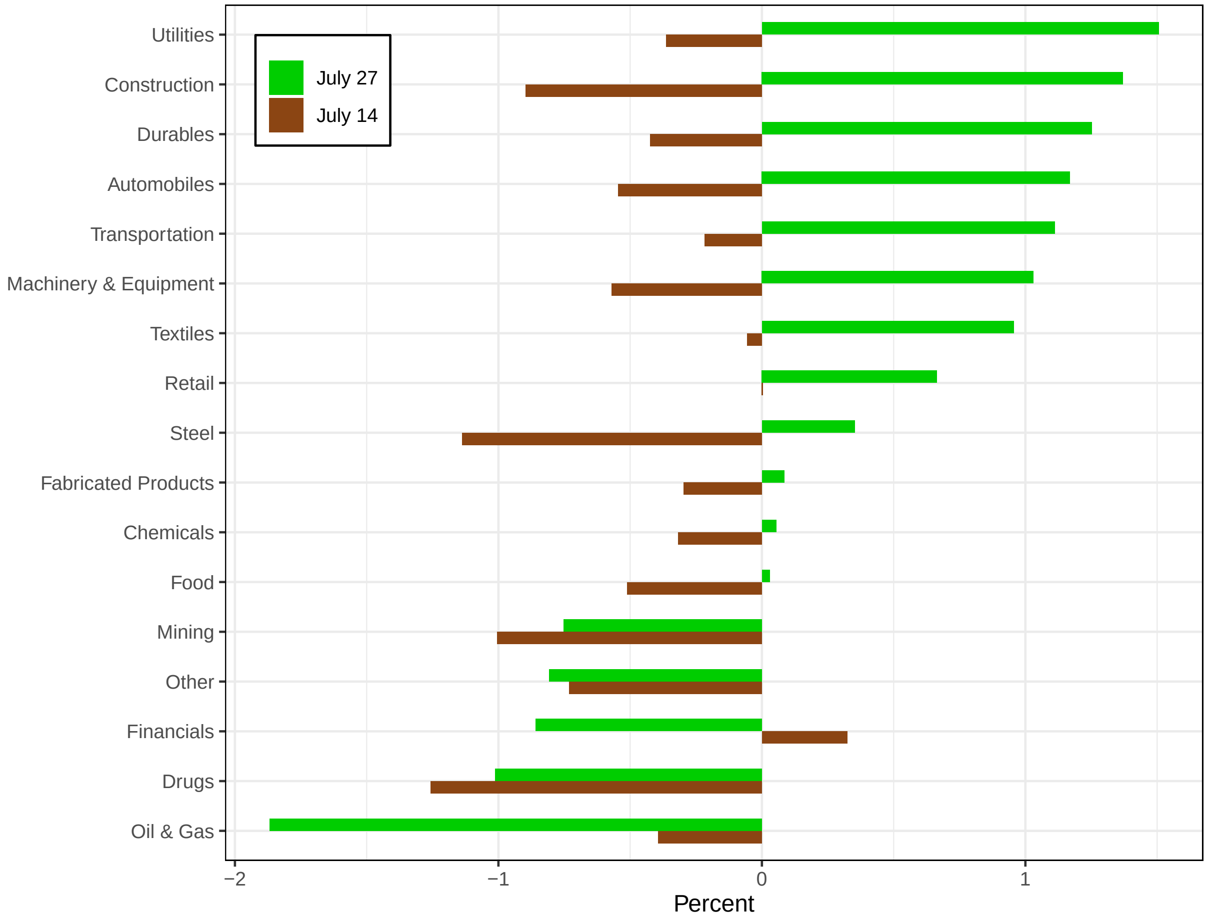
[15] Oil prices posted much smaller movements around the July 14 and 27 events—up 1.8 percent and down 1.0 percent, respectively.

Figure 1: Performance of green and brown indices after climate policy events



Daily cumulative returns for green and brown indices from market close on July 14 to August 15. Panel A (B) shows raw (abnormal) returns—see notes for Table 2. The brown and green events on July 14 and July 27, respectively, are denoted by vertical dashed lines. Three later events—described in Table 1—are denoted by vertical dotted lines. Each vertical line denotes the start of the event window, so the immediate observation to the right of each line shows the market response.

Figure 2: Abnormal industry returns around green and brown events



Daily abnormal returns for 17 Fama-French industry portfolios (equal-weighted). Abnormal returns are calculated using the market model, estimated with daily returns and the CRSP equal-weighted market index return over the period from January 2016 to May 2022. Brown bars show returns using closing prices from July 14 to July 15 (brown event) and green bars show the returns from July 27 to July 28 (green event).

portfolios are based on Compustat/CRSP four-digit Standard Industrial Classification (SIC) codes. We use the daily, equal-weighted portfolio returns, which are available on Ken French's website.[16] For each of the 17 industry portfolios, we calculate abnormal returns in the same way as for the index returns, and report the one-day abnormal returns across industries for the brown event on July 14/15 and the green event on July 27/28.

The abnormal portfolio returns for the 17 Fama-French industries around the brown and green IRA events are shown in Figure 2. The raw event returns are plotted in Appendix

[16] See https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_17_ind_port.html (accessed 04/13/2023) for data and details on the industry definitions and return calculations. We use equal-weighted returns for consistency with our firm-level analysis in Section 4, but the use of value-weighted portfolios leads to qualitatively similar results.

Figure A.1. The brown event led to industry-level responses that are quite mixed and less clear-cut. But the green event produced industry winners and losers generally in line with what would be expected based on the IRA legislation.

In response to the green event, those industries performed best that are likely to benefit substantially from IRA subsidies and related measures. The utilities industry, which showed the most positive response, contains electric services and natural gas transmission/distribution/services. It stands to gain from the tax credits for renewable natural gas and construction of renewable electricity plants more generally, as well as from additional demand for electricity as it becomes an ever more important energy source in the U.S. economy. The construction industry will likely get a big boost from the tax incentives for homeowners to invest in energy-efficient home improvements. This industry notably includes clean energy companies and contractors that focus on solar installations and power generation. Tax credits for electric vehicles and charging infrastructure will help the automobile and transportation industries (for an in-depth analysis, see Slowik et al., 2023). The machinery and equipment industry includes electrical equipment/machinery/distribution/components and batteries, which will play an integral part in the green transition.

At the other end, the oil & gas and mining industries stand to lose substantially from the IRA legislation and the intended decarbonization of the U.S. economy. Consequently, stocks in these industries exhibited large negative abnormal returns around the green event. Two other industries performed poorly around this event but due to measures in the IRA unrelated to climate change. The drug industry is expected to be adversely impacted by IRA changes to Medicare that try to lower prescription drug prices. And financial institutions are likely to be particularly affected by the 15 percent minimum corporate tax on large corporations, as many large banks and insurance companies pay little or no federal taxes.[17]

The cross-industry heterogeneity in the equity market response conforms quite well with the incidence of the subsidies and credits contained in the IRA. The effects can be understood through the lens of the model of Pástor et al. (2021) as working via the customer channel, as well as the cost channel defined in Section 2 whereby production subsidies lower costs and increase profits and stock returns. But it is important to note that the IRA did not necessarily benefit green industries and hurt brown industries, as commonly defined. For example, two industries with generally high levels of emissions—oil & gas and utilities—had entirely opposite responses to the green event, according to Figure 2. In Section 5, we will revisit the question of whether the observed cross-industry heterogeneity in the equity

[17] For example, among the 19 Fortune 100 companies that the Center for American Progress identified in a recent report as paying an effective federal tax rate below 10 percent, four belong to the financial sector (Koronowski et al., 2022).

response is related to emissions or other measures of industry exposure to carbon policy.

Overall, the response of both stock market indices and industry portfolios to IRA announcements show that market participants quickly differentiated between expected winners and losers of the policies in the IRA. Cross-industry differences in abnormal returns were sizable, on the order of several percentage points, after news that the IRA passage had become a near certainty.

4 Climate policy responses of individual firms

So far, we have established that the two climate policy events had substantial impacts on broad equity valuations—especially for the clean and fossil fuel energy sectors, which appeared particularly sensitive to the news about climate policy. Here, we examine the effects of these events on individual firms. The extent to which individual companies face the prospect of greater or lesser profits resulting from the policy initiatives should be reflected in changes in their equity prices. Specifically, firms will perform better if they are well-positioned to benefit—in relative terms—from clean-economy production and consumer subsidies, or more generally, from a higher (implicit) price of carbon. Earlier research—such as Hengge et al. (2023), Bauer et al. (2022), Barnett (2023), and many others—identify green and brown firms by using specific firm-level measures of environmental characteristics such as firm-level CO_2 emissions. Using such detailed company measures, including environmental scores and emissions, we can elucidate the firm-level equity responses to climate policy news.

We obtain firm-level accounting, equity return, and environmental data from Refinitiv.[18] We use all available U.S. stocks after imposing some commonly used filters. Initially, our raw data set consists of the 3,601 U.S. firms. We filter out firms without emissions scores for the year 2021, reducing the number of firms to 3,165. Following common practice in the empirical asset pricing literature, we apply a variety of standard filters to avoid unreliable returns data, which reduces our sample to 2,537 stocks.[19] Some firms released their earnings data during our event windows, which can lead to large price movements unrelated to the IRA news and thus create noise for our estimates. To mitigate this problem, we exclude firms with an earnings announcement on the event day or the following day. As a result of this additional restriction, our regression samples contain 2,520 firms for the July 14 event

[18] Refinitiv—soon to be rebranded LSEG Data & Analytics—provides accounting data from the Worldscope database, stock market returns from Datastream, and environmental data from the ESG database.

[19] Specifically, we filter out stocks that are not common equity, primary equity quotations, or listed in NYSE, AMEX, or NASDAQ. We also remove securities with prices lower than $1 during our estimation and event windows, and securities whose name fields indicate non-common equity affiliation (see, e.g., Ince and Porter, 2006; Griffin et al., 2010; Bauer et al., 2022).

and 2,122 firms for the July 27 event. Given the occurrence of both IRA announcements in July 2022, we use firms' 2021 environmental and accounting data in order to best match the information set that investors likely had available when trading in response to the policy news.

For individual firms, our analysis employs several different measures of carbon dependence or greenness. Two of these are proprietary estimated measures.[20] The first is an "emissions score" that aggregates various firm-level metrics of how effective and committed a company is to reducing its emissions. This measure depends heavily on the estimated emissions data but also, for example, on assessments of the quality of a firm's "environmental management systems." The second measure is a broader environmental (E) score, which combines almost 70 metrics in three categories: emissions, innovation, and resource use. Note that the emissions score is one of the three components of the E score. Importantly, in the calculation of both of these scores, each underlying indicator is evaluated relative to peer companies in the same industry. That is, firms are categorized among 60 different industries, and green firms—those with high emissions scores or E scores—perform well within their own industry.

Finally, we also employ a very tangible, narrow measure of greenness: a firm's CO_2 emissions. This metric is widely used in economic research to measure a firm's sensitivity to climate risk and climate policy news. Similiar to Ilhan et al. (2021), Ramelli et al. (2021), and many others, we use emission intensity, defined as the ratio of a firm's emissions to its market capitalization, which accounts for the effect on emission levels of firm size. In calculating emission intensity, it is also useful to differentiate between emissions as reported by firms and estimated emissions (Bauer et al., 2022). Many firms—even those in an ESG database—do not report emissions. For such firms, ESG data vendors provide estimates of emission levels that are largely based on a firm's sales or scale. These estimates have measurement error, and some have argued that using such imputed instead of reported emissions can lead to bias in some empirical analyses (Aswani et al., 2023), although event studies have not been implicated. Accordingly, our analysis using emission intensity is limited to firms with disclosed/reported emissions, which reduces our sample size by about two-thirds but arguably increases the reliability of the results.[21] However, in unreported analysis, we obtained very similar results for the much larger sample of firms available using emission intensity calculated

[20] Refinitiv offers a large ESG database that covers about 85% of the global market cap and draws on more than 630 different ESG metrics. For details about the proprietary methodology, see https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf (accessed 03/16/2023).

[21] Specifically, we use each firm's reported total 2021 scope 1 and scope 2 emissions (in kilotons of CO_2 equivalents) relative to its market capitalization (in million USD at the end of 2021). We do not include scope 3 emissions because they are hard to monitor and attribute.

with estimated emissions. In addition, our other two greenness metrics—E and emissions scores—incorporate the estimated emission levels, and we use the full sample of available firms for these.

In our event-study regressions, we control for various firm-level characteristics. These include size (log total assets), market leverage (earnings before interest and taxes divided by interest expenses), revenue growth (annual growth rate in total revenues), and profitability (return on assets). Additionally, we follow Ramelli et al. (2021) and Wagner et al. (2018) and include a measure of cash effective tax rate (ETR), given that the tax burden of a firm can be an important determinant of its exposure to policy changes.[22] For the emission intensity measure of greenness, we also include the standard industry fixed effects using 17 Fama-French industries based on their SIC codes. As noted above, industry effects are already accounted for with E and emissions scores, which are constructed relative to peer companies in the same industry.[23]

Table 3 reports summary statistics for our firm-level data. The emissions and E scores range from 0 to 1 (as we divide the raw scores by 100). High scores indicate good environmental and emissions performance—i.e., low-carbon firms—but the median firm gets a relatively low score of around 0.2. These scores also display substantial dispersion across firms but little skewness. Emission intensity, which is available for fewer firms, ranges from 0 to 3.7 (kilotons of CO_2 per million USD market cap), with higher values indicating higher-carbon firms. As others have noted (Bolton and Kacperczyk, 2021; Bauer et al., 2022), there is a large degree of skewness in emission intensity. A small number of firms have very high emission intensities, so the mean firm has an intensity about 20 times as large as the median firm (0.2 vs. 0.01). This effect is mitigated for E and emissions scores by their within-industry construction. The bottom panel characterizes daily returns around the two IRA events. The raw returns have means roughly similar to the S&P 500 returns shown in Table A.1, and average abnormal returns are close to zero. These returns display little skewness but substantial dispersion across firms.

To investigate the role of environmental performance measures for modulating the stock market response to IRA news, we regress event returns on E scores, emissions scores, and emission intensities, controlling for firm characteristics and industry fixed effects (for intensities). Table 4 shows regression estimates for raw event returns, and Appendix Table A.2 reports results for abnormal returns, which differ minimally from those for raw returns.

The results in the first three columns of Table 4 pertain to the brown event returns

[22]ETR is missing for a fairly large number of firms, and like Ramelli et al. (2021) we replace the missing values with zero and add an indicator variable identifying missing observations.

[23]In any case, omitting industry fixed effects completely or including them everywhere did not significantly change our results reported below.

Table 3: Summary Statistics

	Mean	SD	Min	q25	Median	q75	Max	Obs.
Environmental performance								
E score	0.28	0.28	0.00	0.01	0.19	0.50	0.98	2,537
Emissions score	0.31	0.32	0.00	0.00	0.21	0.58	1.00	2,537
Emission intensity	0.20	0.58	0.00	0.00	0.01	0.08	3.70	900
Firm-level controls								
Size	21.70	1.84	17.40	20.44	21.61	22.87	26.37	2,528
Leverage	0.15	0.56	-2.20	0.01	0.09	0.24	3.51	2,133
Rev. growth	0.34	1.13	-1.00	0.04	0.14	0.30	10.39	2,428
Profitability	-0.01	0.18	-1.02	-0.02	0.02	0.07	0.37	2,503
ETR	0.11	0.31	-1.73	0.00	0.15	0.23	1.23	2,537
Daily returns								
Brown event (July 14), raw	1.92	2.60	-44.74	0.86	1.94	3.05	24.35	2,520
Brown event (July 14), abn.	-0.18	2.60	-47.54	-1.06	-0.11	0.91	22.39	2,520
Green event (July 27), raw	1.04	2.99	-26.61	-0.31	0.96	2.33	29.97	2,122
Green event (July 27), abn.	-0.25	2.97	-27.87	-1.60	-0.31	1.07	27.87	2,122

Summary statistics for firm-level environmental measures, controls and accounting variables, and event returns. Environmental measures are described in the text. Size is log of total assets in millions USD, market leverage is EBIT divided by interest expenses, revenue growth is annual growth in total sales, profitability is return on assets, ETR is the cash effective tax rate (total income taxes paid divided by pretax income). Returns are from market close of July 14 (27) to market close of July 15 (28), and abnormal (abn.) returns are the residuals from an estimated market model.

Table 4: Event return regressions

	Brown event (July 14)			Green event (July 27)		
	(1)	(2)	(3)	(4)	(5)	(6)
E score	-0.77^{***}			1.98^{***}		
	(0.19)			(0.27)		
Emission score		-0.44^{**}			1.47^{***}	
		(0.17)			(0.24)	
Emission intensity			0.31^{**}			-0.43^{**}
			(0.15)			(0.21)
Size	0.16^{***}	0.13^{***}	0.05	-0.15^{***}	-0.13^{***}	-0.21^{***}
	(0.03)	(0.04)	(0.06)	(0.05)	(0.05)	(0.07)
Market leverage	0.30^{***}	0.30^{***}	0.37	0.02	0.03	−0.02
	(0.10)	(0.10)	(0.25)	(0.11)	(0.11)	(0.33)
Revenue growth	0.15^{*}	0.15^{**}	−0.20	−0.04	−0.05	0.28^{*}
	(0.08)	(0.08)	(0.21)	(0.07)	(0.07)	(0.16)
Profitability	0.01	−0.04	0.89	0.45	0.50	−3.94
	(0.58)	(0.58)	(2.24)	(0.87)	(0.87)	(4.20)
ETR	0.12	0.13	−0.01	−0.04	−0.04	−0.38
	(0.19)	(0.18)	(0.16)	(0.17)	(0.17)	(0.31)
ETR missing dummy	-1.21^{***}	-1.20^{***}	−0.32	−0.73	-0.77^{*}	-1.32^{**}
	(0.43)	(0.43)	(0.72)	(0.46)	(0.46)	(0.52)
Constant	−1.23	−0.85		3.94^{***}	3.60^{***}	
	(0.75)	(0.77)		(1.04)	(1.06)	
Observations	2,043	2,043	824	1,693	1,693	669
R^2	0.04	0.03	0.10	0.04	0.03	0.12
Industry fixed effects	No	No	Yes	No	No	Yes

Regression results for event returns. The dependent variable is the one-day raw return from market close on July 14 to July 15 (the brown event) in the first three columns, and the return from July 27 to 28 (the green event) in the last three columns. The key regressors are the environmental pillar score (E score), the emission category score, and emission intensity, calculated as the reported level of scope 1+2 emissions divided by market cap (at the end of 2021). Controls include size, market leverage, revenue growth, profitability, and effective tax rate (ETR), which are described in the text and the notes to Table 3. The third and sixth columns include industry fixed effects using the 17 Fama-French industries. Clustered standard errors (by industry) are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

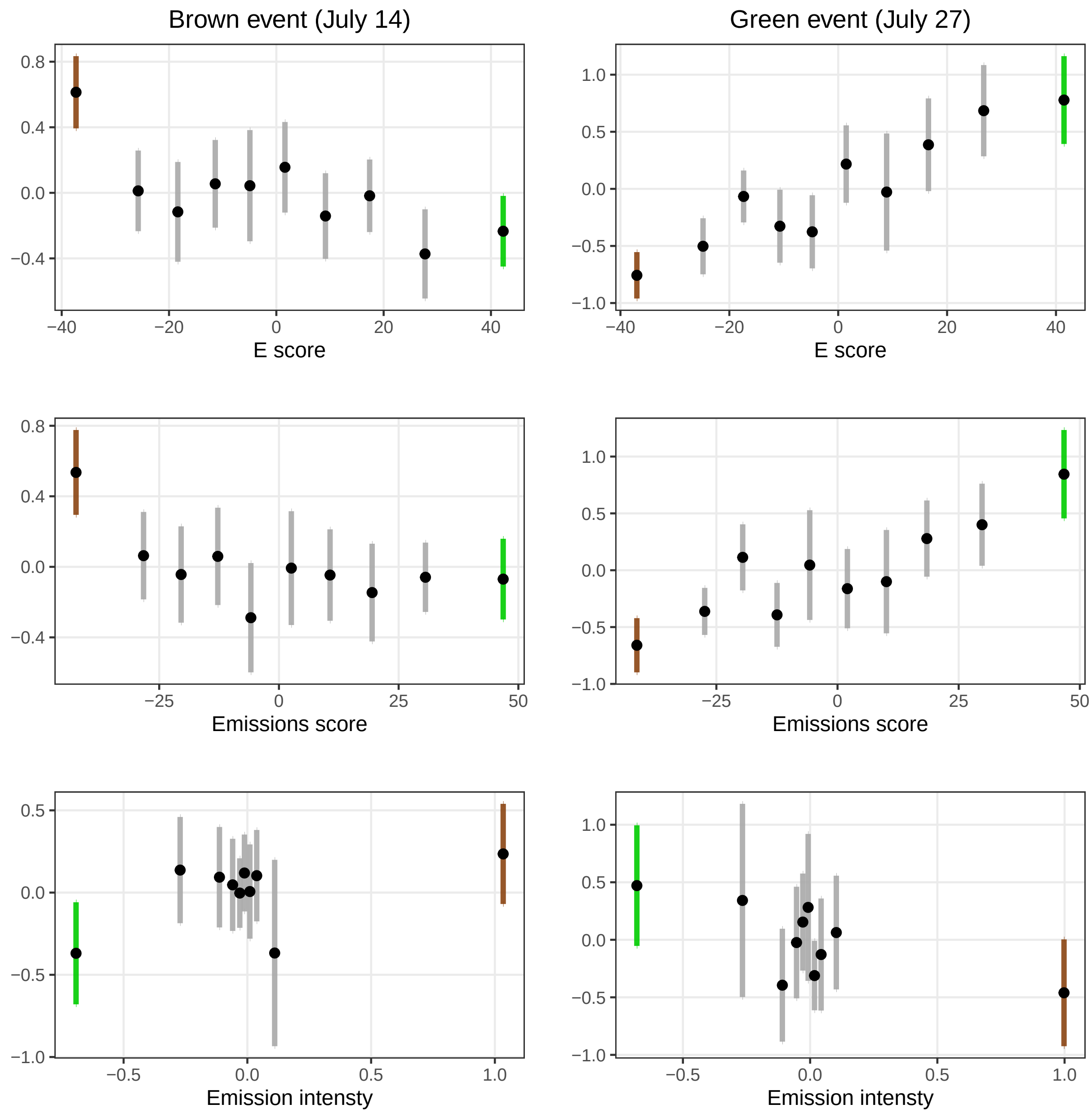
on July 14-15. They show that firms with high E and emissions scores or low emission intensities had a significantly worse daily stock market performance around this event. This is consistent with a deterioration in the outlook for future profits of green firms by the diminished prospects for comprehensive climate policy. By contrast, the differential stock market responses of green and brown firms to the green event on July 27-28 have the opposite sign. The coefficients on the E and emission scores are positive, while the coefficient on emission intensity is negative. These responses are also stronger and statistically more significant than for the earlier event. With the astonishing news of near-certain passage of comprehensive climate policy in the form of the IRA, green firms exhibited a substantially better stock market performance than brown ones. Specifically, in terms of E scores, a greener firm at the upper 75 percentile (with an E score of 0.58) had almost a full percentage point higher daily equity return after July 27 than a browner firm at the lower 25 percentile (with an E score of 0.01).

Overall, our results using E and emissions scores are completely consistent with those using emission intensity. All three metrics show that high-carbon firms were expected to have better prospects in the absence of climate policy and that low-carbon firms performed better when the IRA climate policy was announced. This consistency is notable because the environmental scores calculated by ESG data providers are based on relatively subjective collections of indicators using proprietary methodologies. As such, at the firm level, the information in these metrics can differ substantially across providers (Berg et al., 2022; Ehlers et al., 2022). Similarly, we find a modest connection between E and emissions scores and the direct measure of emission intensity: E and emissions scores have a correlation of only -0.11 and -0.08, respectively, with emission intensity. In light of the apparent noise in distinguishing green and brown firms, the consistency of our results points to the strength of the underlying effect of the climate policy news that we identify.[24]

To more finely judge the economic significance of the firm-level results, Figure 3 displays the cross section of firm-level returns using portfolio sorts. We first orthogonalize event returns and greenness measures with respect to our regression control variables (size, market leverage, revenue growth, profitability, and effective tax rate—as well as industry fixed effects for emission intensity). Then, a univariate regression of the orthogonalized event return on the orthogonalized greenness measure would recover exactly the coefficient of interest reported in Table 4 (according to the Frisch-Waugh-Lovell theorem). We form decile portfolios and plot mean portfolio returns against greenness (similar to a bin scatter plot of

[24] As noted earlier, Ramelli et al. (2021) find conflicting results for the stock market response to the Trump election depending on whether E scores and emission variables were used, but for that event, the timing of any news about the prospects for climate action was less clear-cut.

Figure 3: Event returns of decile portfolio



The dots measure event returns of decile portfolios formed using E scores (top row), emission scores (middle row) or emission intensities (bottom row), for either the brown event on July 14 (left column) or the green event on July 27 (right column). Returns and greenness measures are orthogonalized with respect to the control variables in Table 4 (size, market leverage, revenue growth, profitability, and effective tax rate). Vertical bars indicate 90% confidence intervals with greenest (brownest) deciles denoted by green (brown).

returns on greenness). The resulting Figure 3 shows the cross-sectional relationship between event returns and our three measures of greenness. The left-hand column illustrates brown event returns and shows clear negative relationships between returns and E/emissions scores and a positive relationship between returns and emission intensity. These correlations are completely consistent with the associated coefficient estimates in Table 4 but allow a finely sliced reading of the firm-level results. For example, much of the response is driven by the greenest and brownest deciles of firms. These extremes are denoted by green and brown colored confidence intervals. For the brown event, the greenest firms had returns that were around 3/4 percentage point lower than brownest firms for *all* of the carbon metrics. For the green event shown in the right-hand panels, the reverse correlations between returns and greenness metrics are evident, with the high-carbon firms performing much worse across all three metrics. The announcement of the new IRA climate policy clearly led to a quantitatively significant green outperformance. Specifically, after the IRA announcement, the returns of green firms were 1.5 percentage points higher than those of brown ones using E and emissions scores and almost 1 percentage point higher using emission intensity. Furthermore, given the considerable lack of overlap of the green and brown confidence intervals in all of the panels of Figure 3, the statistical significance of our results across both events is confirmed.

Our analysis provides clear and consistent evidence of the stock market impact of the two climate policy events. When negotiations for further U.S. climate policy action publicly collapsed on July 14, investors bid up shares of brown, carbon-dependent firms while green, low-emissions firms lost value. Conversely, unveiling the IRA climate policy package benefited green stocks and hurt brown stocks. These results hold up whether environmental performance is measured using scores from ESG providers or actual emissions disclosed by the stock market companies. Again, these results are consistent with, for example, the asset pricing model of Pástor et al. (2021) in which green stocks can benefit from a policy-induced greater demand for goods and services of greener providers. In addition, clean-energy investment subsidies and similar policies appeared likely to reduce costs for green firms.

5 Industry greenness as a measure of transition risk

So far, we have shown that surprising realizations of U.S. climate policy had substantial effects on equity prices and that these effects differed significantly across firms. Such estimates of policy sensitivities are critical to a rapidly growing literature on the potential adverse implications of climate policy changes for the financial system. Specifically, central banks and financial supervisors are investigating the exposure and resilience of financial institutions to the transition risks posed by imperfectly anticipated efforts to facilitate and force a shift to a low-carbon economy (NGFS, 2022a; Acharya et al., 2023).

Central banks and supervisors are particularly interested in financial transition risk assessments of commercial banks—notably, in how loan portfolios and other bank assets may be revalued under a range of climate policy scenarios (Jung et al., 2023). The various climate scenarios differ in terms of the scope and pace of the policy-induced economic transformations taken to lower carbon emissions. The associated decarbonization risks include possible declines in asset prices, income, and profitability, and these risks are most material for companies with business models that rely on high carbon emissions—exactly as suggested by our firm-level analysis in the previous section. To the extent that such declines are also reflected in collateral values, loan repayments, and credit claims, the associated financial institution lenders may also face losses. However, as noted above, firm-level emission metrics and data are only available for a subset of firms. Given the inadequate coverage of the available firm-level data, it is difficult to estimate such potential transition-related losses at a granular firm or asset level. Thus, for many climate-related risk assessments, potential losses have been calculated based on sectoral or industry classifications, which are available for all of a financial institution's loans and assets. For example, Jung et al. (2023) examines the exposure of commercial banks to different climate policy scenarios by employing estimates of the effects of different carbon taxes on the output and profits of various industries as estimated from the general equilibrium models of Jorgenson et al. (2018), Goulder and Hafstead (2017), and NGFS (2022b). In effect, banks' exposures to climate policy shifts depend on the industry composition of their loan portfolio and the estimated industry-level effects of the climate policies that drive decarbonization. Similarly, Choi et al. (2020) identify high-emission firms based on their industry classification.

The climate policy events that we identified can provide a useful case study to assess the appropriateness of using industry classifications to account for climate transition risk. To recap, Section 3 showed that the equity responses of some industries—notably, utilities and construction—accord well with the shifting probabilities of passage of significant climate policy legislation. Then, Section 4 documented that within-industry variation in the equity response to the climate policy events was correlated with the greenness of individual firms. Now we consider whether industry-level greenness metrics can account for the cross-industry variation of the equity price response to climate policy news.

This analysis employs three different measures of industry-level greenness. The first two are constructed directly from our firm-level data, which we aggregate up to the 17 Fama-French industries. Industry-level emissions are the sum of all disclosed scope 1 and scope 2 emissions (in tons of CO_2 equivalents) of the firms in each industry. For these industry-level greenness metrics, we use total industry emissions and emission intensity, which divides total emissions by industry market cap (in million USD at the end of 2021).

Our final measure of industry-level greenness is based on the transition risk exposure for each industry as proxied by estimates of the differing loss in output in each sector that would be caused by a carbon tax. Jung et al. (2023) use such carbon tax sensitivities in their study of the transition risk exposures of U.S. banks. Like them, we use the Jorgenson et al. (2018) estimates of carbon tax sensitivities, which are based on an intertemporal general equilibrium model calibrated to U.S. industries.[25] Jorgenson et al. (2018) use the IGEM industry classification. We assign the firms in each of the 60 Refinitiv industries to one of the IGEM industries, which results in 29 IGEM industries for our sample.

To calculate industry-level event returns, we aggregate firm-level abnormal returns—constructed as explained in Section 3—into equal-weighted industry portfolios. Table 5 relates the industry-level event returns to the three measures of industry greenness. Note that, for all three measures, high values indicate brown industries with high transition risk. Thus, if these measures accurately captured the transition risk of the IRA policies, then we would expect to see positive coefficients in the regressions for the brown event (first three columns), and negative coefficients for the green event (last three columns). Instead, the coefficients on the emissions level variable have the wrong sign in both regressions, although they are not statistically significant. For emission intensity, the coefficients have the expected sign only for the brown event, but that is marginally statistically significant (at the 10-percent level). Finally, the coefficients on the carbon tax sensitivity variable only have the expected sign for the green event, but again, neither are statistically significant.

To illustrate the weak relationships between greenness measures and returns, Figure 4 provides the underlying scatter plot corresponding to column 5 in Table 5. The emission intensities of the 17 industries are measured on the horizontal axis, and the equity responses of firms in those industries are measured on the vertical axis.[26] The regression line is effectively flat indicating very poor fit and weak predictive ability. Two industries illustrate the difficulty of using measures of greenness at an industry level: oil & gas and utilities have similar emission intensities, but they had diametrically opposed IRA equity price responses because clean power subsidies supported the utility sector.

[25]Specifically, we employ the estimated output sensitivities to an introduction of a $25 tax per metric ton of CO_2 equivalents, with a 1% tax growth rate.

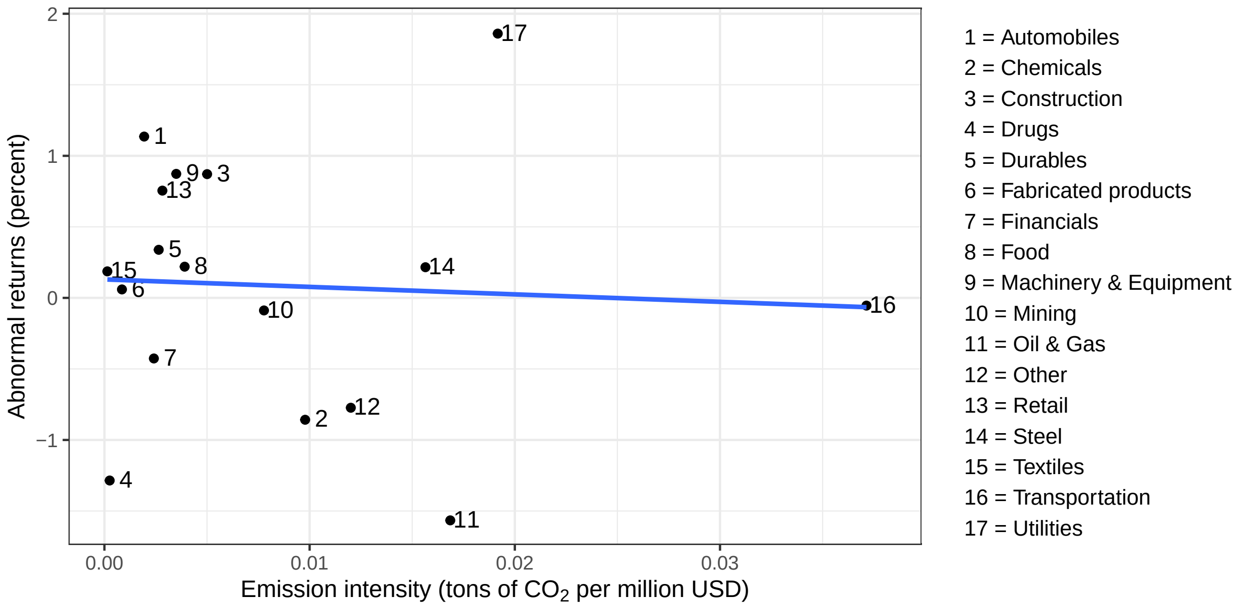
[26]There are small differences in industry returns between Figures 2 and 4. The former are estimated using all registered firms, and the latter are estimated using only our ESG firm-level dataset. However, the same conclusion is obtained with either measure: on average across all industries, returns and greenness appear uncorrelated.

Table 5: Event returns and industry-level green metrics

	Brown event (July 14)			Green event (July 27)		
	(1)	(2)	(3)	(4)	(5)	(6)
Emissions	−0.17			1.05		
	(0.31)			(2.56)		
Emission intensity		8.96*			−5.26	
		(4.64)			(19.38)	
Carbon tax sensitivity			−1.31			−7.06
			(3.29)			(8.83)
Constant	−0.38***	−0.49***	−0.05	−0.02	0.13	0.22
	(0.12)	(0.14)	(0.14)	(0.23)	(0.22)	(0.21)
Observations	17	17	29	17	17	29
R^2	0.004	0.067	0.004	0.024	0.003	0.047

The table shows regressions of abnormal returns on emissions, emissions intensity, and a measure of industry sensitivity to carbon taxes. Abnormal returns are calculated from raw returns using a market model estimated with daily value-weighted CRSP market returns from January 2016 to May 2022. Emissions and emission intensity are aggregated to 17 Fama and French industries using our firm-level dataset. Total emissions is the sum of total disclosed scope 1 and scope 2 emissions, in tons of CO_2 equivalents. Emission intensity is total emissions divided by market cap in million USD at the end of 2021. Carbon tax sensitivity is a measure of industry output sensitivity to the introduction of a $25 per metric ton CO_2 equivalent tax rate with a 1% growth rate from Jorgenson et al. (2018). ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Figure 4: IRA announcement: industry abnormal returns and emission intensity



This figure shows a scatter plot of emission intensity and abnormal returns from July 27 to July 28 (green event) for the 17 Fama and French industries. Firm-level data are aggregated to industry level. Abnormal returns are calculated from raw returns using a market model estimated with daily value-weighted CRSP market returns from January 2016 to May 2022. Emission intensity is constructed as the total emissions (scope 1 and 2) divided by market cap. The best fitting regression is shown as the blue line.

Overall, measured greenness of industries appears to be essentially unrelated to the equity response to the climate policy announcements. In other words, the cross-industry heterogeneity in the response is not captured well by industry-level measures of greenness, in contrast to the within-industry heterogeneity documented in Section 4, which was significantly correlated with firm-level greenness. One important implication of the poor performance of the industry-level greenness measures is that, based on the climate policy transition realizations that we examined, they are likely a weak foundation for capturing and assessing transition risk. We believe that our event study considers some of the cleanest, most clearly demarcated U.S. climate policy announcements in terms of timing. Of course, the announced policy shifts were much more complicated than the simple carbon tax changes envisioned in many climate stress tests and model simulations. However, policy complexity seems unavoidable—perhaps especially in the United States given the politicization of views on climate change (see, e.g., DiLeo et al., 2023) —and practical, real-world stress testing should take this into account.

6 Conclusion

Our event study used the econometric identification of clearly delineated policy news to investigate how financial markets value firms' climate-related prospects. We show that the equity market responses to announcements of climate policy actions were quick, substantial, and distinctly heterogeneous with wide variation across firms and industries. Green stocks—equities of firms with lower carbon emission intensities and better environmental and emission scores—benefited from news that the IRA would become law, while brown stocks—those of more carbon-intensive and more polluting firms—lost value. This heterogeneity of stock price responses is both statistically and quantitatively significant. We find equity movements in the opposite direction—with brown stocks outperforming green stocks—for the earlier event when the prospects for climate action shifted to negligible. These heterogeneities—particularly the increased investor demand for the stocks of low-carbon firms—are in line with the IRA's goal of fostering a transition away from fossil fuels. These results also appear consistent with several mechanisms that lead to different expected profits for green and brown firms. In particular, the heterogeneities likely reflect the varying effects of IRA tax credits and subsidies on green and brown product demand, revenues, and investment and production costs.

We also provide a cautionary note regarding the use of industry or sectoral measures of greenness for financial risk assessments and climate scenario analyses. Industries likely to benefit from the new policies—in particular, the utilities, construction, and automobile/transportation sectors—saw their stocks appreciate. However, across all industries, there was little correlation between industry-level greenness and stock market response. This finding suggests that a more granular, firm-level level approach may often be necessary to reliably capture exposure to transition risk.

Our examination of the reactions of equity prices to two major climate policy transition realizations can help policymakers, regulators, and investors better understand such transition risks and the likely financial effects of new climate policies. The results of our event study have some reassuring implications for financial transition risk assessments. The highly ambitious IRA climate policy legislation was a significant climate policy transition realization that could have increased the likelihood of stranded assets. Nevertheless, it did not result in any dramatic or disorderly repricing akin to a "climate Minsky moment." That is, the most consequential climate policy action ever in U.S. history did not lead to firm-level equity price responses that were overwhelming or destabilizing. Of course, there are caveats to this conclusion. Financial investors may have naively underreacted to these actions or even put sizable odds on a future policy rollback. Alternatively, other types of climate policies—such as a precipitous and largely unexpected carbon pricing scheme—could have different implications and potentially lead to financial stress and instabilities. But given the significant scope and clear-cut timing of the climate policy news during the passage of the IRA, it is difficult to envisage another set of events that would serve as a more definitive realization for assessing climate transition risk.

Appendix

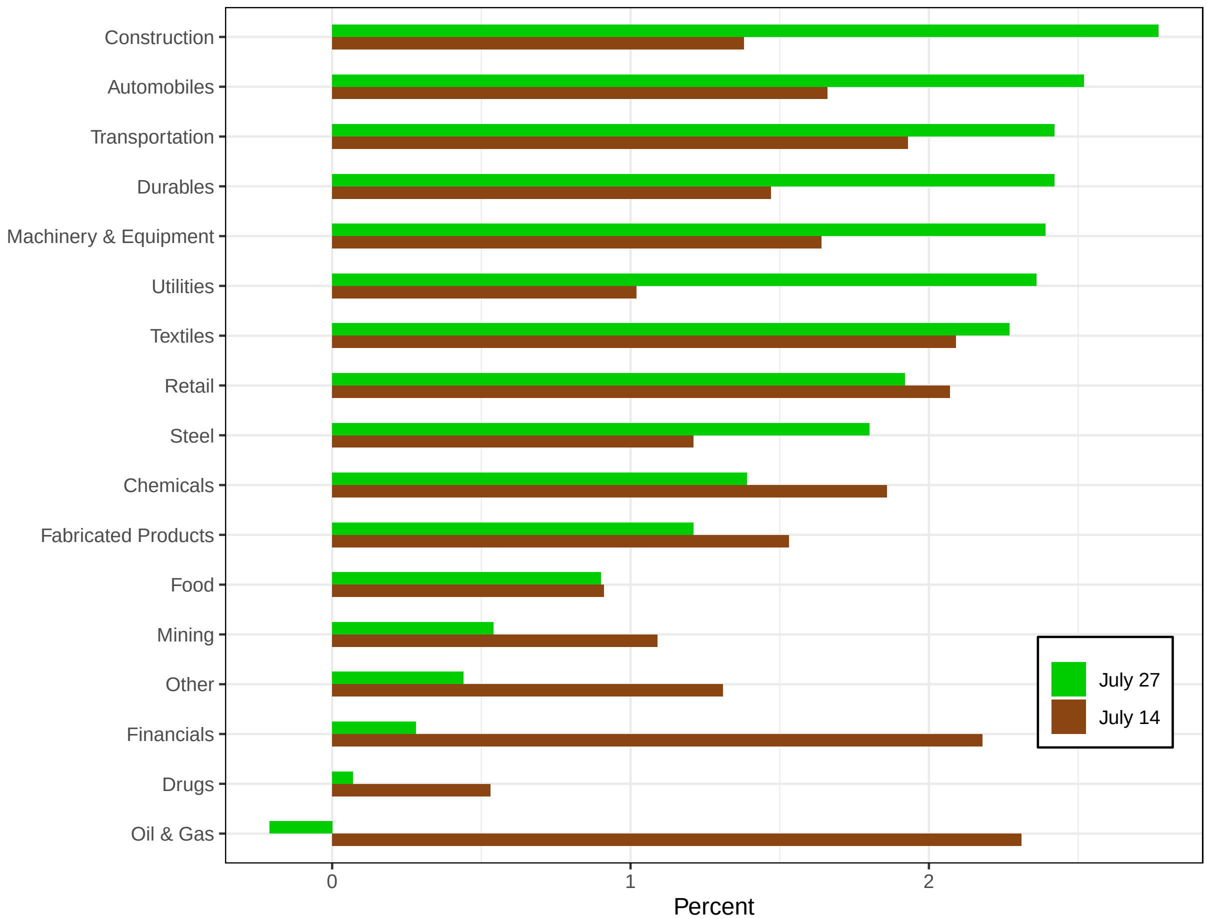
A Additional results

Table A.1: Green vs. Brown Stock Raw Returns - Index Level

		14 July 2022		27 July 2022	
	Std. dev.	1 day	3 days	1 day	3 days
Green					
Nasdaq Clean Edge Green Energy	2.2	-0.7	4.7	**8.5**	**11.0**
Wilderhill Clean Energy	2.3	0.1	5.0	**8.0**	**9.1**
S&P Global Clean Energy	1.6	-1.7	2.2	**7.5**	**9.4**
World Renewable Energy (Renixx)	1.8	-2.7	0.3	**8.1**	**9.5**
ISE Global Wind Energy	1.2	0.5	2.9	3.9	5.3
MAC Global Solar Energy	2.1	-2.0	1.8	**7.5**	**9.6**
Brown					
S&P 500 Integrated Oil & Gas	1.9	1.6	**6.5**	0.9	5.0
FTSE Local USA Oil & Gas & Coal	2.3	2.3	7.5	-0.2	0.4
FTSE All World Oil & Gas & Coal	1.6	1.9	**6.8**	0.6	3.0
Dow Jones Select Oil Exploration and Production	2.5	2.3	8.6	-0.0	0.5
Dynamic Energy Exploration & Production Intellindex	2.6	2.3	**9.3**	0.4	1.4
Market					
S&P 500	1.2	1.9	3.9	1.2	2.4

Equity index returns around IRA events, in percent. Raw returns are calculated using end-of-day index prices from the day of the event to one or three days after the event. Returns larger than 2 times the standard deviation are shown in bold.

Figure A.1: Returns of 17 Fama-French industry portfolios around green and brown events



Daily returns for 17 Fama-French industry portfolios (equal-weighted). Brown bars show returns using closing prices from July 14 to July 15 (brown event) and green bars show the returns from July 27 to July 28 (green event).

Table A.2: Event-study regressions: abnormal returns

	15 July 2022			28 July 2022		
	(1)	(2)	(3)	(4)	(5)	(6)
E score	-0.86^{***}			1.93^{***}		
	(0.19)			(0.27)		
Emission score		-0.54^{***}			1.41^{***}	
		(0.17)			(0.24)	
Emission intensity			0.31^{**}			-0.42^{**}
			(0.14)			(0.21)
Size	0.15^{***}	0.13^{***}	0.07^{*}	-0.16^{***}	-0.13^{***}	-0.19^{**}
	(0.03)	(0.03)	(0.04)	(0.05)	(0.05)	(0.09)
Market leverage	0.37^{***}	0.36^{***}	0.43^{*}	0.06	0.06	0.02
	(0.10)	(0.10)	(0.25)	(0.11)	(0.11)	(0.33)
Revenue growth	0.10	0.11	-0.38^{***}	-0.07	-0.08	0.17
	(0.08)	(0.08)	(0.14)	(0.07)	(0.07)	(0.14)
Profitability	0.61	0.56	2.17	0.79	0.84	-3.22
	(0.60)	(0.60)	(2.21)	(0.88)	(0.88)	(4.22)
ETR	0.31^{*}	0.31^{*}	0.12	0.08	0.08	-0.27
	(0.18)	(0.18)	(0.13)	(0.16)	(0.17)	(0.32)
ETR missing dummy	-1.19^{***}	-1.18^{***}	-0.16	-0.72	-0.76^{*}	-1.21^{**}
	(0.44)	(0.44)	(0.70)	(0.45)	(0.45)	(0.52)
Constant	-3.26^{***}	-2.93^{***}		2.77^{***}	2.39^{**}	
	(0.73)	(0.75)		(1.03)	(1.06)	
Observations	2,043	2,043	824	1,693	1,693	669
R^2	0.05	0.04	0.09	0.04	0.03	0.12
Fixed Effects	NO	NO	YES	NO	NO	YES

The figure shows the industry fixed-effects regression of one-day abnormal returns on environmental pillar score (E score), emission score, and emission intensity. Emission intensity is constructed as total emissions (scope 1 and 2) divided by market cap. Controls include size, market leverage, revenue growth, profitability, and effective tax rate. Fixed effects account for the Fama and French 17 industries. Clustered standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

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