The Effects of Climate Policies on U.S. listed Energy Firm Returns: Evidence from IIJA, CHIPS, and IRA

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Abstract

We investigate the energy industry reaction to three key climate policies following the Paris Agreement. Our findings show that information conveyed in the CHIPS announcement, which supported semiconductor industries, had a significant negative impact on the energy sector. Conversely, news from the IRA announcement resulted in a significant positive stock return. The IRA response is consistent with the regulatory goal to reduce transition risk by encouraging traditional energy companies to replace equipment and invest in renewable clean technologies. However, contrary to our expectation, the IIJA announcement had no significant impact on the stock returns of energy companies. The lack of market response is attributed to: (i) IIJA support for the use of natural gas as a transition fuel, with a relatively slow transition speed. A gradual transition that relies heavily on natural gas as a transition fuel may have limited impact on large publicly traded oil and gas companies with strong reserve life ratios; (ii) during the second half of 2021 the U.S. was still grappling with COVID-19 and the spread of the Delta variant, the economic climate was unfavourable, and many investors were more focused on the healthcare sector. As a result, the impact of climate related policies was overlooked by the market; (iii) the IIJA was the first significant environmental policy following the U.S. rejoining the Paris Agreement. Therefore, the market remained in a wait-and-see mode. Overall, our research shows that investors consider current policies when assessing climate risks.

Keywords: IIJA, CHIPS, IRA, U.S. climate policy reforms, Energy firm returns

1. **Introduction**

In response to global warming climate risks, the Paris Agreement, as an international legal agreement to address climate change risk, was adopted by 196 parties at the United Nations Climate Change Conference (COP21) in Paris, France on December 12, 2015. The agreement took effect on November 4, 2016. The overall goal of the agreement is to limit the increase in global average temperature to within 2°C above pre-industrial levels, while encouraging efforts to limit the temperature increase to 1.5°C (*The Paris Agreement*, 2015). In recent years, leaders have stressed the need to limit global warming to 1.5°C. This call stems from the findings of the United Nations Intergovernmental Panel on Climate Change (IPCC), which warns that exceeding the 1.5°C threshold will lead to more severe climate impacts, including increased frequency and intensity of droughts, heat waves and extreme rainfall. To achieve this 1.5°C goal, greenhouse gas emissions must peak by 2025 and decrease by 43% by 2030 (IPCC, 2022).

Given that fossil fuels contribute to higher net greenhouse gas emissions compared to renewable energy sources (IPCC, 2020) reducing GHG emissions across the entire energy sector requires major transitions, including a significant reduction in fossil fuel use, the adoption of low-emission energy sources, a shift to alternative energy carriers, and improvements in energy efficiency and conservation (IPCC, 2022). Investing in clean energy is crucial for moving from traditional carbon-intensive energy to low-carbon, clean energy, which is necessary to achieve net-zero emissions and address climate change (Saeed et al., 2021), and will significantly impact the future use of oil, gas, and coal.

In 2021 and 2022, to achieve 1.5°C goal, the United States enacted three important laws aimed at reducing greenhouse gas (GHG) emissions to address climate change: the Infrastructure Investment and Jobs Acts (IIJA), also known as the Bipartisan Infrastructure Law), the Inflation Reduction Act of 2022 (IRA), and the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act. IIJA allocates approximately $23 billion per year for energy transition initiatives. It provides funding to improve infrastructure resilience to disasters and address historical pollution (*H.R.3684-Infrastructure Investment and Jobs Act, 2021*, 2021). Meanwhile, CHIPS designed to strengthen supply chains and enhance research and development in high-tech sectors, allocates approximately $13 billion per year to fund carbon-free energy initiatives (*H.R.4346 - Chips and Science Act, 2022*, 2022). IRA allocates an estimated $43 billion per year for energy transition initiatives, including tax credits and subsidies designed to encourage household adoption of electric vehicles, heat pumps, and rooftop solar systems, and to support large-scale wind, solar, and battery deployment (*H.R.5376 - Inflation Reduction Act, 2022*, 2022).These investment levels represent significant opportunities for investors. However, as the impacts of climate change become increasingly evident, it is also clear that climate change presents risks to investors and respective financial system (Diaz-Rainey et al., 2021). With the emergence of new technologies and shifts in consumer behaviours, global investors are increasingly focused on the implications of climate change for the pricing of financial assets and the allocation of their investment portfolios (Krueger et al., 2020). Moreover, US investors' sensitivity to climate transition risk has significantly increased following the 2020 presidential election (Fang & Parida, 2024). The research reveals that firms' stock-price movements in response to Trump's election showed that the 2016 election led to a boost in carbon-intensive stocks, while the 2020 election favoured low-carbon stocks (Ramelli et al., 2021). As climate change becomes a critical global issue, the urgency for an energy transition is fundamentally reshaping the relationship between carbon and energy markets (Ding et al., 2022).

Based on a distinction made by Mark Carney (Carney, 2015), climate change risk can influence financial stability through three main channels. First, physical risks, which include extreme weather, hydrological, and other climatic events, are impacting the value of financial assets globally. Second, liability risks arise from the heightened compensation awarded to economic agents affected by climate change. Lastly, transition risks may occur due to the adjustment of asset prices as the economy shifts towards to low-carbon future. The transition to a low-carbon economy may require significant changes in policy, law, technology, and markets to accommodate the mitigation and adaptation demands of climate change. The financial and reputational risks posed to organizations by transition risks can vary depending on the nature, pace, and focus of the changes (FSB, 2017). Within the oil and gas sector, transition risks are from several associated elements: rising costs related to finding and extracting new oil and gas reserves, low oil prices, the decreasing costs of renewable energy production, the transition to electric vehicles propelled by advancements in battery technology and reduced costs for vehicles and batteries, the consumer-led "war on plastics" that affects demand for petrochemicals, higher fuel efficiency standards for vehicles, and the establishment of carbon pricing and taxation schemes (Diaz-Rainey et al., 2021). Current research suggests that the restructuring of the energy sector, combined with iterative technological advancements and shifts in market preferences driven by low-carbon transition policies in response to climate change, will significantly affect carbon-intensive industries (Ma et al., 2024). This transformation may result in stranded assets and increased financial strain on traditional fossil fuel companies, presenting long-term transition risks (Bolton & Kacperczyk, 2021; Semieniuk et al., 2022).

The speed and nature of transition will have significant implications for the evaluation of energy companies. A gradual transition that heavily relies on gas as a "transition" fuel may have a limited impact on large publicly traded oil and gas firms with reserve life ratios (Griffin et al., 2015). Conversely, a rapid transition could result in stranded reserves of gas, oil and coal, leading to substantial shareholder losses (McGlade & Ekins, 2015). Ultimately, policy is expected to play a significant role in moderating the speed and nature of the transition (Diaz-Rainey et al., 2021). Therefore, the contents of the policy are crucial, as they will have a significant impact on investors. Uncertainty in climate policy creates a risk premium for investments in power generation, which affects investor preferences and shapes investment decisions (Blyth et al., 2007; Bouri et al., 2022; Yang et al., 2008). Additionally, climate policy uncertainty influences investor preferences for green energy stocks, carrying significant implications for asset pricing strategies and portfolio allocation (Bouri et al., 2022). Climate policy uncertainty has a profound impact on a range of firm-level outcomes, including stock performance, share price volatility, R&D investments, patenting activity, and employment trends among publicly listed companies in the United States (Basaglia et al., 2021).

The U.S has recently enacted three significant laws designed to reduce GHG emissions to combat climate change: the IIJA, CHIPS, and IRA. Each of these policies involves substantial investments aimed at decreasing GHG emission as outlined in Figure 1a. Policy analysts project that these three legislative measures could significantly lower U.S. GHG emission, paving the way for a comprehensive energy transition as shown in Figures 1b and 1c. These policies encourage the development of new energy sources, which will expose the traditional energy sector —oil, gas, and coal and consumable fuels —to transition risks. Therefore, we explore whether the enactment of the IIJA, CHIPS, and IRA policies will impact stock returns in the U.S energy industry.

[Insert Figure 1 here]

The event study analysis documents evidence that the enactment of the IIJA is not associated with significant CAARs, although the CAARs are generally negative. The exceptions are the Oil and Gas Equipment and Services sector, which shows significance at the 10% level with a CAAR of -8.32% in the event window [-5, 5], and the Coal & Consumable Fuels sector, which is significant at the 10% level on the IIJA issuance date, with a CAAR of -4.60%. We attribute the insignificance of the energy sector reaction to the IIJA announcement to three factors. First, the IIJA supports the use of natural gas as a transition fuel, with a relatively slow transition speed. The speed and nature of this transition will have significant implications for the evaluation of energy companies. A gradual transition that relies heavily on natural gas as a transition fuel may have limited impact on large publicly traded oil and gas companies with strong reserve life ratios (Griffin et al., 2015). Second, during the second half of 2021, the United States was still dealing with the Delta variant of the COVID-19 pandemic, that caused a resurgence in cases. The unfavourable economic conditions led many investors to concentrate on the healthcare sector, causing the market to overlook the effects of environmentally related policies. Third, the IIJA represents the first significant environmental policy implemented after the U.S. rejoined the Paris Agreement, with a primary focus on infrastructure that resulted in a market that has adopted a wait-and-see approach.

However, the CHIPS announcement had a significant negative impact on the energy sector (CAAR -9.11%), with the most pronounced effects observed in Oil and Gas Drilling (CAAR -20.05%), Oil and Gas Equipment and Services (CAAR -10.48%), Integrated Oil and Gas (CAAR -6.50%), and Oil and Gas Exploration and Production (CAAR -12.21%). The reason is that CHIPS emphasizes conducting research and development programs in basic energy sciences to understand, model, and control matter and energy at the electronic, atomic, and molecular levels, thereby laying the foundation for new energy technologies. In carrying out chemistry-related research and development activities, the Office of Science will prioritize the development of sustainable chemistry to support clean, safe, and economical alternatives to traditional chemical products and processes (*H.R.4346 - Chips and Science Act, 2022*, 2022). Since CHIPS does not use natural gas as a transitional energy source but instead directly supports the development of new technologies, its policy content reflects a clear government intention to accelerate the transition. By comparison, the first policy, the IIJA, supports using natural gas as a transition fuel. However, a rapid transition could result in stranded reserves of gas, oil, and coal, leading to substantial shareholder losses (McGlade & Ekins, 2015).

In contrast, IRA had a significant positive impact on the energy sector (CAAR 8.29%), with the most notable effects in the integrated oil and gas industry (CAAR 9.42%), Oil and Gas Exploration and Production (CAAR 11.69%), and Oil and Gas Storage and Transportation (CAAR 7.49%). Through the interpretation of the IRA, we attribute the positive impact to its focus on the tax reduction measure. It encourages the traditional energy sector to upgrade equipment and develop clean energy sources, significantly reducing the transition risks faced by the traditional energy industry. Aligned with the Biden-Harris Administration's focus on supporting working families, promoting equity, and advancing environmental justice, IRA emphasizes fostering shared prosperity, enhancing the nation's resilience to increasing health and well-being challenges, and directing crucial economic investments to historically underserved communities, particularly those affected by long-standing pollution. For several clean energy tax incentives, the law provides bonus credits for projects located in economically distressed or traditional energy communities and for those that comply with prevailing wage standards and hire registered apprentices, additionally, the act supports the President's Justice40 initiative, which aims to ensure that 40 percent of the overall benefits from climate, clean energy, and related federal investments are delivered to marginalized communities that are overburdened by pollution and lack adequate infrastructure and services ("Inflation-Reduction-Act-Guidebook," 2023).

Our analysis makes a valuable contribution to the literature on the valuation of energy companies (Badia et al., 2020; Ewing & Thompson, 2016; Howard & Harp Jr, 2009; Kaiser, 2013; Osmundsen et al., 2006). The findings demonstrate how climate risks impact energy companies (Bebbington et al., 2020; Diaz-Rainey et al., 2021; Griffin et al., 2015; Heede & Oreskes, 2016; Meinshausen et al., 2009; Monasterolo & De Angelis, 2020; Mukanjari & Sterner, 2018). In recent years, many papers have studied how the Paris Agreement and Trump's election have affected stock market (Diaz-Rainey et al., 2021; Monasterolo & De

Angelis, 2020). Our study examines the impact of subsequent policies following the Paris Agreement on the energy company stock returns. The results show that a gradual transition has a limited impact on the oil and gas industry (Griffin et al., 2015), while a rapid transition leads to substantial volatility in energy sector stock returns (McGlade & Ekins, 2015). Our analysis highlights how specific climate policy contents that reduces energy transition risk can significantly influence investors. Overall, we find that investors evaluate relevant policies when conducting climate risk assessment. Therefore, differences in climate policies will directly impact stock market response.

The remainder of the paper is organized as follows: Section 2 is the hypotheses development. Section 3 discusses the methodology and data. The study ends with the conclusion in Section 4.

2. Hypotheses Development

The paper mainly explores the short-term impact of policies on energy companies, investors assess climate risks based on the transition risks triggered by these policies, which in turn affect stock returns. We focus on the impact of the three most significant climate policies issued by the U.S. following Paris Agreement on the stock value of energy companies. The first policy, the IIJA, was issued on November 15, 2021. The second policy, CHIPS, was issued on August 9, 2022. The third one, IRA, was issued on August 16, 2022. These are the three main regulations passed by the U.S. aimed at reducing GHG emissions. These laws could reduce GHG emissions by more than 40% below 2005 levels by 2030, prompting a full-scale energy transition (Burgess et al., 2024). Therefore, these laws may lead to a reduction in the production and consumption of traditional energy. This has raised concerns about the possibility of oil, gas and coal reserves becoming "stranded assets" potentially resulting in a dangerous "carbon bubble" with significant impacts on global financial markets (Heede & Oreskes, 2016). We use event study methodology to examine the significance of the impact of the three events on energy companies' stock returns by calculating the difference between each company' actual and expected returns.

Based on the interpretation of the three events, we found that the three policies differ in the scale and approach of their investments in reducing GHG emissions. The IIJA mainly focuses on investments in infrastructure, such as electric vehicle (EV) charging stations, electricity transmission infrastructure, and upgrading rail and port infrastructure. Significant investments in electricity infrastructure will reduce the reliance on traditional energy, which may negatively impact the energy sector. Moreover, The CHIPS Act focuses on supporting the semiconductor industry and promoting technological research and development, with the Office of Science tasked with implementing a research and development program in basic energy science. The development and subsequent application of new technologies pose a significant threat to the traditional energy sector and increase the transition risks. Therefore, this may also negatively impact energy industry stock returns. In addition, the IRA emphasizes tax incentives and subsidies to encourage households and businesses to invest in clean energy, electric vehicles, and energy efficiency. While the policy primarily aims to promote the adoption of clean energy technologies across multiple sectors, certain provisions allow traditional energy companies to benefit from tax cuts, thereby reducing their transition risks. Due to the policy's support for the energy sector's transition, this could be positive news for energy company stock returns. Therefore, we propose three hypotheses:

H1: The IIJA announcement is negatively correlated with energy company stock returns.

H2: The CHIPS announcement is negatively correlated with energy company stock returns.

H3: The IRA announcement is positively correlated with energy company stock returns.

3. Data and Methodology

3.1. Data selection

Our sample consists of U.S. oil, gas, and coal & consumable fuels companies. The daily stock return data is sourced from the CRSP database, covering the period from January 1, 2017, to December 29, 2023. Initially, our sample included 443 energy companies. After removing companies with insufficient data, 235 companies remained, including 7 Oil and Gas Drilling companies, 48 Oli and Gas Equipment and Services companies, 12 integrated Oil and Gas companies, 72 Oil and Gas Exploration and Production companies, 17 Oil and Gas Refining and Marketing companies, 64 Oil and Gas Storage and Transportation companies, and 15 Coal & Consumable Fuels companies. The list of companies is determined by combining the CRSP U.S. listed companies with the energy companies from the Capital IQ database. In line with the study by Diaz-Rainey, Gehricke, Roberts, and Zhang (2021), we excluded companies with missing returns in the estimation window. Additionally, we excluded companies with missing returns in the 30 days prior to the last day of the event window (Kolari & Pynnönen, 2010), which in our sample is (-24 to +5). The expected stock returns are estimated using the Fama-French five-factor model(Fama & French, 2015), with data sourced from the WRDS database.

3.2. Methodology

To test the impact of these three events on stock returns, we apply a portfolio event study methodology that accounts for cross-sectional correlation of abnormal returns, as outlined by Kolari and Pynnönen (2010). The typical process of conducting an event study follows a structured sequence of steps. First, the event window is defined. Next, normal returns are calculated, which involves defining the estimation window and selecting the appropriate estimation model from which the abnormal returns (ARs) are calculated. Finally, statistical tests are conducted to determine the significance of the ARs (MacKinlay, 1997). Variable definitions are reported in Table A3 in the Appendix. The event window consists of one or more days and includes the event day itself. A common approach is to also include the days before and after the event to account for possible news leaks prior to the event or delayed market reactions (Pacicco et al., 2018). Based on this approach a relatively long event window consisting of five days either side of the event, [-5, +5] (Diaz-Rainey et al., 2021) is used to account for the uncertainty of the actual timing of news leakage and the possibility of market under-reaction. To further guard against potential information leakage, we also use a shorter event window of [-3, +3] (Ahmed et al., 2023) as a robustness check. The estimation window, used to determine expected returns prior to the event, is set from t=-280 to t=-30, covering 250 trading days (Ahmed et al., 2023). To avoid including information leaked well before the events in the estimation window, we allow a gap of 26 trading days between the end of the estimation period and the beginning of the event window.

Various models are used to estimate ARs. The single index (SIM) is the most common. To enhance the explained variance of the SIM (and improve the detection of ARs), the expected return is sometimes estimated using multiple factors, leading to the use of multifactor models (MFMs), including the five-factor model introduced by Fama-French (2015). This study applies the Fama-French five-factor (Fama & French, 2015) model to calculate abnormal returns based on Equation (1):

$$AR_{i,t} = R_{i,t} - [R_{f,t} + \hat{\alpha}_i + \hat{\beta}_{1,i}(R_{m,t} - R_{f,t}) + \hat{\beta}_{2,i}SMB_t + \hat{\beta}_{3,i}HML_t + \hat{\beta}_{4,i}RWM_t + \hat{\beta}_{5,i}CMA_t] \quad (1)$$

where $(R_{m,t} - R_{f,t})$ represents the excess market return on day t. The risk-free (R_f) is estimated using the one-month Treasury bill rate. SMB (Small minus Big) is the second Fama-French factor, defined as the average return of the nine small-cap portfolios minus the average return of the nine large-cap portfolios. HML (High minus Low) is the third Fama-French factor, calculates as the difference between the average return of the two value portfolios and the average return of the two growth portfolios. RMW (Robust minus Weak) is the fourth Fama-French factor, measured as the difference in average returns between two portfolios with robust operating profitability and two portfolios with weak operating profitability. CMA

(Conservative minus Aggressive) is the fifth Fama-French factor, defined as the average return of the two conservative investment portfolios minus the average return of the two aggressive investment portfolios.

Examining the impact of the event over a multi-day period is done by aggregating the ARs over the time series to generate cumulative abnormal returns (CARs). The CARs for each company are subsequently calculated as Eq. (2):

$$CAR_{i,t} = \sum_{t=-\tau}^{t=\tau} AR_i \tag{2}$$

Finally, to obtain the average effect over multiple days, we need to calculate the cumulative average abnormal returns (CAARs) by summing the CARs for each day. The CAARs for all sample companies are then calculated as Eq. (3):

$$CAAR_t = \frac{1}{N} \sum_{i=1}^{N} CAR_{i,t} \tag{3}$$

[Insert Table 1 here]

4. Empirical results

From Table 1, it is evident that for the IIJA policy, most of the uncertainty occurs prior to the announcement, as reflected in a standard deviation of 0.0667. Following the announcement, the standard deviation drops significantly to 0.0251, indicating a marked reduction in market uncertainty. Furthermore, the post-announcement standard deviation (0.0517) remains lower than the pre-announcement value (0.0667). Similarly, for the CHIPS policy, most of the uncertainty is concentrated before the event, with a higher pre-announcement standard deviation. On the announcement date, the standard deviation is relatively low, suggesting that the market's reaction to the disclosure is more stable. The post-announcement uncertainty

(0.0598) is also lower than the pre-announcement standard deviation (0.0909), further supporting the trend of reduced volatility after the announcement. In contrast, as shown in Table 1, the IRA policy exhibits higher volatility in the post-announcement period. While the volatility during the [-5, 5] window is notably elevated, this is largely driven by post-announcement uncertainty, in the pre-announcement period exhibits lower volatility. This indicates that, while market expectations were relatively stable before the IRA announcement, the market's reaction became more sensitive once the policy was revealed. In comparison, the post-announcement volatility for IIJA and CHIPS is lower, pointing to a more stable market response to these policies.

[Insert Table 2 here]

Table 2 presents the CAARs for the three policies and includes the impact of each policy announcement on stock returns across different event windows and various sub-industries. Consistent with our expectations, the CHIPS announcement is negatively correlated with stock returns for the entire energy sector, while the announcement of IRA is positively correlated. However, contrary to our expectations, the IIJA announcement had no significant impact on stock returns. Figure 2 shows the CAAR for the whole energy sector and seven energy sub-industries within the event window [-5, +5] following the announcement of the three policies. Overall, considering IIJA and CHIPS, the CAARs are mostly negative across sub-industries, with few exceptions, while under the IRA policy, the CAARs are predominantly positive. Figures 3, 4 and 5 respectively display changes in the impact of the IIJA, CHIPS and IRA announcements on the CAAR of the entire energy sector and seven energy sub-industries across the three sub-windows: [-5, -1], [0, 0], and [1, 5]. From Figure 3, it can be observed that under the IIJA policy, the CAAR show a gradual downward trend within the event window of [-5, +5], with negative CAAR primarily concentrated on the day of the policy announcement and the following five days. From the data in Table 2, there is no significant correlation between

CAARs and the IIJA announcement, except for the Oil and Gas Equipment and Services and Coal & Consumable Fuels sectors. Therefore, the negative impact on CAAR observed in the five days following the IIJA announcement can be viewed as the result of other factors' influence in some sub-industries.

[Insert Figure 2 here]

[Insert Figure 3 here]

[Insert Figure 4 here]

In Figure 4, under the CHIPS policy, the CAAR exhibits a trend of initially rising and then declining within the whole event window; however, the CAAR is predominantly negative. This change indicates that the CHIPS policy had a negative impact on stock returns even before its announcement. The reason is that, based on the experience with IIJA, the market anticipated and reacted to CHIPS announcement in advance. As information was gradually digested, the negative impact diminished until the policy's release date. However, following the announcement, as investors interpreted the policy, the negative response continued to rise. This reflects the market's concerns about the potential implications of the policy. In Figure 5, for the IRA policy, the CAAR demonstrates an upward trend within the event window of [-5, +5], with the CAAR generally remaining positive during the five days following the policy announcement. This suggests that the market's reaction to the IRA was somewhat delayed, occurring after a period of interpreting the policy. This highlights the critical importance of the content of subsequent policies in shaping market responses. The next section analyses the results of each event individually and explains the reasons for the sector and sub-industries.

[Insert Figure 5 here]

4.1. Stock impact of the IIJA

The first significant climate change policy event we examine is the signing of the IIJA on November 15, 2021. The event study results are presented in Event A of Table 2. As mentioned, we perform event studies for the entire sample as well as for each of the seven sub-sectors. As shown in Figure 3, over the 11 days before and after the issuance of the IIJA, the CAAR for the entire energy sector is gradually declining, and during the five days following the policy announcement, the CAAR for most sub-industries is negative. However, from Table 2, the enactment of IIJA does not show a significant association with CAAR, even though the overall CAAR is negative. However, there are exceptions: the Oil and Gas Equipment and Services sector exhibits significance at the 10% level, with a CAAR of -8.32% in the event window [-5, 5]. The reason is that the IIJA tackles climate change by creating a grant program to support the installation of publicly accessible electric vehicle charging infrastructure, hydrogen fuelling stations, propane fuelling stations, and natural gas fuelling stations along designated alternative fuel corridors. This initiative aims to reduce carbon emissions and promote the use of cleaner energy sources for transportation (H.R.3684-Infrastructure Investment and Jobs Act, 2021, 2021). The increase in government-supported alternative energy infrastructure is likely to impact the demand for oil and gas equipment and services. The speed and nature of the transition will have significant implications for the evaluation of energy companies. A gradual transition that depends heavily on gas as a "transition" fuel may have limited impact on large publicly traded oil and gas companies with strong reserve life ratios (Griffin et al., 2015). This is why other sectors of the oil and gas industry have not had a major response to the IIJA announcement.

Additionally, the Coal & Consumable Fuels sector is significant at the 10% level on the IIJA issuance date, with a CAAR of -4.60%. Through an analysis of the IIJA, we find that it aims for a gradual transition using transitional energy sources like natural gas. This approach has limited impact on oil and gas companies but reduces the demand for coal due to increased reliance on natural gas. This is also why the Coal & Consumable Fuels sector had a significant response on the day the IIJA was released. In addition, the United States was still grappling with the COVID-19 pandemic, and many investors were more focused on the healthcare sector. As a result, the impact of environmentally related policies was overlooked by the market. Furthermore, the IIJA is the first significant environmental-related policy following the U.S. rejoining the Paris Agreement, which has led to a market that remains in a wait-and-see mode. Therefore, there is no significant correlation between the IIJA announcement and the CAARs of the entire energy sector.

4.2. Stock impact of the CHIPS

The second key climate change policy event we investigate is the signing of CHIPS on August 9, 2022. The results from the event study are outlined in Event B of Table 2. From Table 2, throughout the entire 11-day event window, the CHIPS announcement shows a significant negative impact on the energy sector, with a CAAR of -9.11%. Among different sub-industries, Oil and Gas Drilling, Oil and Gas Equipment and Services, Integrated Oil and Gas, and Oil and Gas Exploration and Production companies show significant effects at the 1% level, with CAARS of -20.05%, -10.48%, -6.50% and -12.21%, respectively. Additionally, Oil and Gas Refining and Marketing and Coal & Consumable Fuels companies are significant at the 5% level, with CAARs of -5.91%and -14.74%, respectively. Oil and Gas Storage and Transportation companies show significant effects at the 10% level, with CAARS of -3.59%. This is consistent with our expectations.

Table 2 shows that the impact of the CHIPS announcement on energy company stock returns is primarily concentrated in the five days leading up to the announcement. This indicates that the market responded strongly in anticipation of the CHIPS release. From Table A4 in the Appendix, he correlation between CAAR and the CHIPS announcement is significantly lower in the 7-day event window compared to the 11-day event window, suggesting that the market took a relatively long time to react to the CHIPS announcement prior to its release. Additionally, Figure 4 illustrates that from the five days before the policy announcement to the announcement day itself, the negative impact of the CHIPS policy on CAARs is diminishing. This further suggests that the market did not respond to the IIJA policy for various reasons; however, the implementation of the IIJA has increased market sensitivity to climate-related policies, leading to a proactive response to the second most important climate policy, CHIPS. CHIPS primarily targets the development of new technologies to replace traditional energy sources, such as oil, gas, and coal, thereby accelerating the energy transition. A rapid transition could lead to gas, oil, and coal reserves becoming stranded assets, potentially causing significant losses for shareholders (McGlade & Ekins, 2015). Table 2 shows that sub-industries directly related to oil, gas, and coal, such as Oil and Gas Drilling, Coal & Consumable Fuels, Oil and Gas Exploration and Production, and Oil and Gas Equipment and Services, exhibited the most significant responses to the CHIPS announcement. This was followed by Integrated Oil and Gas, which, due to its diversified business structure, demonstrates relatively higher resilience compared to the sub-industries. Next are the Oil and Gas Refining and Marketing and Oil and Gas Storage and Transportation sub-industries, where the impact is relatively smaller, as the development of new technologies will require time, resulting in a less immediate effect on the products and sales within the current oil and gas sector.

4.3. Stock impact of the IRA

The third significant climate change policy event we examine is the signing of the IRA on August 16, 2022. The findings from the event study are presented in Event C of Table 2. We find that during the 11-day event window, the release of the IRA has a significant positive impact on the entire energy sector, with a CAAR of 8.29%. Regarding the sub-industries, Integrated Oil and Gas, Oil and Gas Exploration and Production, and Oil and Gas Storage and Transportation companies are significant at the 1% level, with CAARs of 9.42%, 11.69%, and

7.49%, respectively. Oil and Gas Equipment and Services companies are significant at the 10% level, with CAARs of 7.67%. This is consistent with hypothesis H3. For Oil and Gas Drilling and Oil and Gas Refining and Marketing companies, there is no significant relationship during the event window [-5, 5]. However, in the event window of [1, 5], there is a significant correlation, with CAARs of 13.51% and 6.82%, respectively. From Table 2, we can see that in the five days following the policy announcement, these sub-industries also experience a significant positive impact on stock returns. These sub-industries are slower to react to the IRA policy, which affected the overall significance of the event window. Unlike the previous policies, IIJA and CHIPS, the IRA may be beneficial to the energy industry. However, due to initial scepticism about the policy details, the market did not respond strongly in the days leading up to or on the day of the IRA announcement, adopting a wait-and-see approach. Over the five days following the IRA announcement, as the market analysed the IRA specifics, it became clear that the IRA provides an additional bonus credit for facilities that meet domestic content requirements, particularly for those located in energy communities—areas defined by significant employment tied to oil, gas, or coal industries (*H.R.5376 - Inflation Reduction Act, 2022*, 2022). Within the oil and gas sector, transition risks stem from various related factors, such as the establishment of taxation schemes (Diaz-Rainey et al., 2021). Tax reduction measures significantly reduce the transition risk faced by oil and gas industry. This confirmation of the IRA's favourable impact on the oil and gas industry led to a significant market reaction. Therefore, during the event window [1, 5], all oil and gas sectors showed a significant positive response to the IRA announcement. Notably, the sectors most closely related to facilities, such as Oil and Gas Drilling and Oil, Gas Exploration and Production, Oil and Gas Equipment and Services, and Integrated Oil and Gas had the most pronounced reactions.

Across all the different event windows, Coal & Consumable Fuels companies reported no significant response to the IRA announcement, which contrasts with other sub-industries. Although the IRA offers some tax incentives for Coal & Consumable Fuels companies, coal remains the most carbon-intensive fossil fuel, with significant negative externalities on the environment, and is easier to replace than oil and gas (Luderer et al., 2018). As a result, phasing out coal has become a priority for many countries, and political debates are increasingly focused on how to manage coal exits in the coming decades (Garg et al., 2017). Therefore, despite the tax incentives provided by the IRA, they are unlikely to alter the broader trend of coal's gradual phase-out, making it difficult for Coal & Consumable Fuels sub-industries have a significant positive response to the IRA announcement. From the IRA analysis, we find that, particularly in the five days following the policy announcement, the market starts to react significantly. This indicates that investors begin to respond to the policy based on their interpretation of IRA. Given the industry response to the previous policy, CHIPS, the firms affected by the announcement began to interpret and react to the IRA. As shown in Appendix Table A4, within the 7-day event window, the market had a stronger impact on stock returns during the three days following the IRA announcement, consistent with the 11-day event window. Furthermore, by comparing the 11-day event window with the 7-day event window, we find that the impact of the IRA announcement on stock returns is more pronounced in the 11-day window. Similar to the CHIPS policy, the market took a relatively long time to respond to the IRA announcement.

Overall, using the 11-day event window, we report that CHIPS had a significant negative impact on the entire sample, while IRA had a significant positive impact on the whole sample. However, due to the use of natural gas as a transitional energy under the IIJA, which slowed the pace of the transition, and the impact of the COVID-19 pandemic, along with the fact that the IIJA was the first significant climate policy (leading the market to adopt a wait-and-see approach), there is no evidence of a significant market response to the IIJA announcement. We also used a 7-day event window as a robustness check to verify the impact of IIJA, CHIPS, and IRA announcements on the entire energy sector and its sub-sectors. By comparing the 11-day event window with the 7-day event window, we also found that the market requires a relatively long time to respond to climate policies. For the eleven-day event window, the event windows for CHIPS and IRA overlap, which could lead to dual effects. Compared to 7-day event window, The significant positive response of the market to the IRA announcement may offset the significant negative response to the CHIPS announcement. Nevertheless, as shown in Table 2, the negative response of the market to the CHIPS announcement is not weakened. This is because investors' reactions to IRA announcement are primarily concentrated in the five days following the event, so the overlap of the event windows did not weaken the market response to the IRA announcement.

5. Conclusion

This study analyses the stock market reaction of three major climate change policies, issued by the U.S. following the Paris Agreement, for listed firms in the U.S. energy sector. We use an event study methodology to measure how each of the climate policy announcements impact abnormal stock market returns during the pre- and post-announcement period. Changes related to climate policy provide critical information about transition risks for the energy industry. The IIJA, CHIPS and IRA announcements each signal a growing focus by the U.S. on energy transition. Our results show that this heightened attention has significantly impacted the value of the U.S. energy sector and companies working within specific sub-industries. Given that the consequences of climate change pose potential risks to investors and the financial system this analysis also points to potential portfolio return risks as companies transition away from carbon into non-carbon fuel sources. Our research adds to the growing body of literature on how climate risk may influence the valuation of energy companies (Bebbington et al., 2020; Diaz-Rainey et al., 2021; Griffin et al., 2015; Monasterolo & De Angelis, 2020; Mukanjari & Sterner, 2018). Relative to previous literature, our study uses three specific climate regulations to examine their impact on the energy sector. The findings indicate a significant negative response around the CHIPS announcement for firms in the Oil and Gas Drilling, Coal & Consumable Fuels, Oil and Gas Exploration and Production, and Oil and Gas Equipment and Services sectors within the energy industry. This contrasts starkly with the positive response recorded for the IRA policy announcement. The difference in the abnormal stock returns for the energy sector following these two policy changes clearly demonstrates that investors evaluate climate risk based on the climate policies. However, the lack of impact from the IIJA on energy companies' stock returns suggests that investors may also delay their response to climate policies due to factors such as the economic environment. The effect of climate risk on the financial system should not be underestimated. Prior research on IIJA, CHIPS and IRA has primarily focused on climate aspects. Our paper is the first to examine the energy sector market response to these three policies. By using two event windows — eleven days and seven days— we find investors exhibit both anticipatory behaviour and lagged responses to the policy announcement. The analysis also confirms that investors indeed express their concerns about climate risk through their responses to climate policies.

Regardless of whether the stricter climate policies are implemented gradually or suddenly in response to a climate "shock", they can have profound implications for the market (Diaz-Rainey et al., 2021). Given that U.S. banks are heavily exposed to the oil and gas sector (Nguyen et al., 2023) such shocks could lead to dramatic declines in stock prices as well as an increase in bad debts within these banks. This exposure suggests that policymakers should pursue a more rapid and incremental tightening of regulations rather than waiting until a sudden and dramatic policy shock is necessary, which could potentially trigger a financial crisis (Diaz-

Rainey et al., 2021). The financial and reputational risks that organizations face due to transition risks can differ based on the type, speed, and focus of the changes(FSB, 2017). Our analysis indicates that a gradual transition has a limited impact on the oil and gas industry. However, a rapid transition leads to substantial volatility in energy sector stock returns. Moreover, the establishment of related tax incentives will impact the stock returns of oil and gas companies. Therefore, policymakers should carefully consider the transition speed and specific measures when developing climate policies to avoid triggering a financial crisis. Our findings focus on the impact of U.S. climate policy announcements for the American listed energy sector. Given the variations in policies and national contexts in other countries, further research with additional data may be necessary to understand the effects in regions outside the U.S.

Appendix:

Table A3

Variable name	Label	Description
Daily stock return	Ret	A return is the change in the total value of an investment in a common stock one da dollar of initial investment. (CRSP)
Fama-French five factors model	MFM	The Fama-French factors is used to estimate the expected stock returns: $R_{i,t} = R_{f,t} + \hat{\alpha}_i + \hat{\beta}_{1,i}(R_{m,t} - R_{f,t}) + \hat{\beta}_{2,i}SMB_t + \hat{\beta}_{3,i}HML_t + \hat{\beta}_{4,i}RWM_t + \hat{\beta}_{5,i}$
Abnormal return	AR	The daily abnormal return is calculated by subtracting the predicted normal return f actual return for each day in the event window. $AR_{i,t} = R_{i,t} - [R_{f,t} + \hat{\alpha}_i + \hat{\beta}_{1,i}(R_{m,t} - R_{f,t}) + \hat{\beta}_{2,i}SMB_t + \hat{\beta}_{3,i}HML_t + \hat{\beta}_{4,i}RWM_t +$
Cumulative abnormal return	CAR	The cumulative abnormal returns are the sum of the abnormal returns from the even $CAR_{i,t} = \sum_{t=-\tau}^{t=\tau} AR_i$
Cumulative average abnormal return	CAAR	The average cumulative abnormal returns for all sample companies is $CAAR_t = \frac{1}{N}\sum_{i=1}^{N} CAR_{i,t}$
Event date	EVDate	The date when the event occurred. We choose three regulations. The first one is IIJ occurred on 15 November 2021. The next one is CHIPS which occurred on 09 Aug The last one is IRA occurred on 16 August 2022.
Event window	Event window	We adopt a [-3, +3] event window and a relatively long [-5, +5] event window.
Estimation window	ESW	The estimation window is t = -280 to t = -30.
Excess Return on the Market	Mkt-RF	The excess return on the market. It is calculated as the value-weight return on all N AMEX, and NASDAQ stocks (from CRSP) minus the one-month Treasury bill rate Ibbotson Associates). (WRDS)
Small-Minus-Big Return	SMB	The average return on the nine small portfolios minus the average return on the nine big portfolios. (WRDS)
High-Minus-Low Return	HML	The average return on the two value portfolios (that is, with high BE/ME ratios) mi average return on the two growth portfolios (low BE/ME ratios). (WRDS)
Robust Minus Weak Return	RMW	The average return on the two robust operating profitability portfolios minus the av return on the two weak operating profitability portfolios. (WRDS)
Conservative Minus Aggressive Return	CMA	The average return on the two conservative investment portfolios minus the average the two aggressive investment portfolios. (WRDS)

Table A4

	CAAR [-3, 3]	CAAR [-3, -1]	CAAR [0, 0]	CAAR [1, 3]
Event A: IIJA (15nov2021)				
Whole Energy Industry	-2.25%	-1.10%	-0.94%	-0.21%
Oil and Gas Drilling	-12.62%*	-5.78%	-2.69%	-4.15%
Oil and Gas Equipment and Services	-6.28%	-3.91%*	-1.54%	-0.84%
Integrated Oil and Gas	0.33%	-1.10%	-0.04%	1.47%
Oil and Gas Exploration and Production	-0.88%	-1.63%	-0.04%	0.79%
Oil and Gas Refining and Marketing	0.13%	1.61%	-0.85%	-0.64%
Oil and Gas Storage and Transportation	-0.17%	0.72%	-0.66%	-0.23%
Coal & Consumable Fuels	-5.11%	1.55%	-4.60%*	-2.07%
Event B: CHIPS (09aug2022)				
Whole Energy Industry	-1.55%	-2.52%**	-0.11%	1.08%
Oil and Gas Drilling	-9.44%**	-8.57%***	-1.99%	1.12%
Oil and Gas Equipment and Services	-1.65%	-2.27%	-0.60%	1.22%
Integrated Oil and Gas	0.75%	-0.80%	-0.60%	2.15%
Oil and Gas Exploration and Production	-1.03%	-3.15%	-0.95%	3.06%
Oil and Gas Refining and Marketing	-0.19%	-0.94%	1.99%*	-1.23%
Oil and Gas Storage and Transportation	-1.07%	-2.04%*	0.92%	0.04%
Coal & Consumable Fuels	-5.84%	-2.90%	-0.13%	-2.80%
Event C: IRA (16aug2022)				
Whole Energy Industry	3.25%	3.25%	-0.20%	4.60%***
Oil and Gas Drilling	1.11%	-3.29%	-1.77%	6.18%*
Oil and Gas Equipment and Services	3.17%	-1.17%	-1.00%	5.34%**
Integrated Oil and Gas	3.39%	0.63%	-0.81%	3.57%**
Oil and Gas Exploration and Production	4.87%	-0.80%	-0.47%	6.14%***
Oil and Gas Refining and Marketing	1.60%	-2.34%	-0.19%	4.13%**
Oil and Gas Storage and Transportation	3.58%	-0.45%	0.93%	3.10%**
Coal & Consumable Fuels	-3.40%	-5.08%	0.01%	1.67%

Notes: The table presents the cumulative average abnormal returns calculated using Equations (1), (2), and (3) for three policy announcements: IIJA, CHIPS and IRA. The abnormal returns are measured using the Fama-French five-factor (FF5F) model. The results encompass the full sample across all energy industries; ***, **, * indicate statical significance at 1%, 5%, and 10% levels, respectively.

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Table 1

Descriptive statistics (n = 235)

	Variable	Mean	Standard Deviation	Minimum	Maximum
IIJA					
	CAAR [-5,5]	-0. 0292	0. 0824	-0. 2693	0. 2530
	CAAR [-5,-1]	-0. 0007	0. 0667	-0. 1721	0. 3853
	CAAR [0,0]	-0. 0097	0. 0251	-0. 1208	0. 0533
	CAAR [1,5]	-0. 0188	0. 0517	-0. 2091	0. 1290
CHIPS					
	CAAR [-5,5]	-0. 0961	0. 1100	-0. 6496	0. 1969
	CAAR [-5,-1]	-0. 0761	0. 0909	-0. 6325	0. 2132
	CAAR [0,0]	-0. 0015	0. 0295	-0. 1451	0. 0926
	CAAR [1,5]	0. 0185	0. 0598	-0. 2845	0. 2580
IRA					
	CAAR [-5,5]	0.0774	0.0956	-0.1886	0.6971
	CAAR [-5,-1]	-0.0167	0.0559	-0.2284	0.1764
	CAAR [0,0]	-0.0024	0.0269	-0.0985	0.1298
	CAAR [1,5]	0.0965	0.0795	-0.1982	0.7558

Notes: This table presents the Mean, Median, Standard Deviation, Minimum, and Maximum values of CAAR for the entire energy sector, calculated across different event windows for three events based on Equations (1), (2) and (3).

Table 2

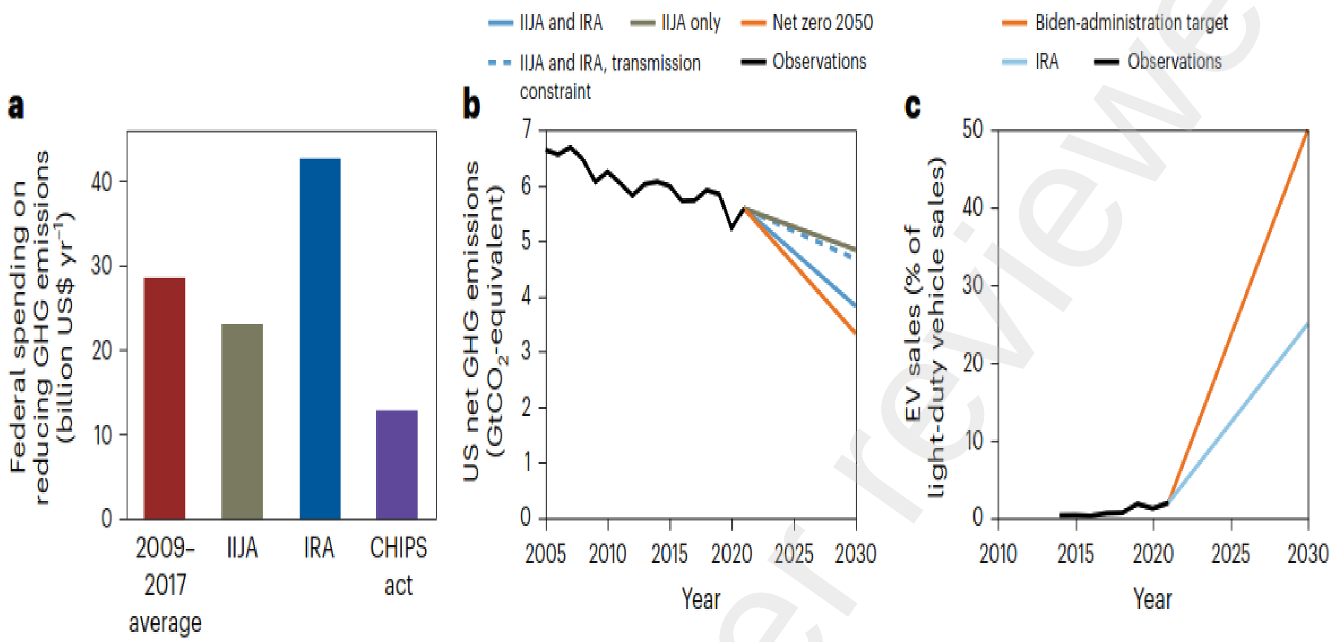
Event study results for three policies

	CAAR [-5, 5]	**CAAR [-5, -1]**	**CAAR [0,0]**	**CAAR [1,5]**
Event A: IIJA (15nov2021)				
Whole Energy Industry	-2.50%	0.14%	-0.94%	-1.70%
Oil and Gas Drilling	-12.36%	-4.19%	-2.69%	-5.48%
Oil and Gas Equipment and Services	-8.32%*	-3.43%	-1.54%	-3.35%
Integrated Oil and Gas	0.07%	0.78%	-0.04%	-0.67%
Oil and Gas Exploration and Production	-1.09%	-1.18%	-0.04%	0.14%
Oil and Gas Refining and Marketing	1.46%	3.32%	-0.85%	-1.01%
Oil and Gas Storage and Transportation	-0.43%	1.95%	-0.66%	-1.72%
Coal & Consumable Fuels	-2.25%	7.66%	-4.60%*	-5.30%
Event B: CHIPS (09aug2022)				
Whole Energy Industry	-9.11%***	-7.34%***	-0.11%	-1.66%
Oil and Gas Drilling	-20.05%***	-12.46%***	-1.99%	-5.60%*
Oil and Gas Equipment and Services	-10.48%***	-7.13%***	-0.60%	-2.75%
Integrated Oil and Gas	-6.50%***	-5.50%***	-0.60%	-0.41%
Oil and Gas Exploration and Production	-12.21%***	-10.58%***	-0.95%	-0.69%
Oil and Gas Refining and Marketing	-5.91%**	-3.74%**	1.99%*	-4.16%*
Oil and Gas Storage and Transportation	-3.59%*	-4.48%***	0.92%	-0.03%
Coal & Consumable Fuels	-14.74%**	-8.26%*	-0.13%	-6.34%
Event C: IRA (16aug2022)				
Whole Energy Industry	8.29%***	-1.48%	-0.20%	9.97%***
Oil and Gas Drilling	6.21%	-5.53%	-1.77%	13.51%***
Oil and Gas Equipment and Services	7.67%*	-2.24%	-1.00%	10.91%***
Integrated Oil and Gas	9.42%***	-0.17%	-0.81%	10.40%***
Oil and Gas Exploration and Production	11.69%***	-1.06%	-0.47%	13.22%***
Oil and Gas Refining and Marketing	4.67%	-1.96%	-0.19%	6.82%***
Oil and Gas Storage and Transportation	7.49%***	0.06%	0.93%	6.51%***
Coal & Consumable Fuels	0.83%	-6.47%	0.01%	7.29%

Notes: The table presents the cumulative average abnormal returns calculated using Equations (1), (2), and (3) for three policy announcements: IIJA, CHIPS and IRA. The abnormal returns are measured using the Fama-French five-factor (FF5F) model. The results encompass the full sample across all energy industries; ***, **, * indicate statical significance at 1%, 5%, and 10% levels, respectively.

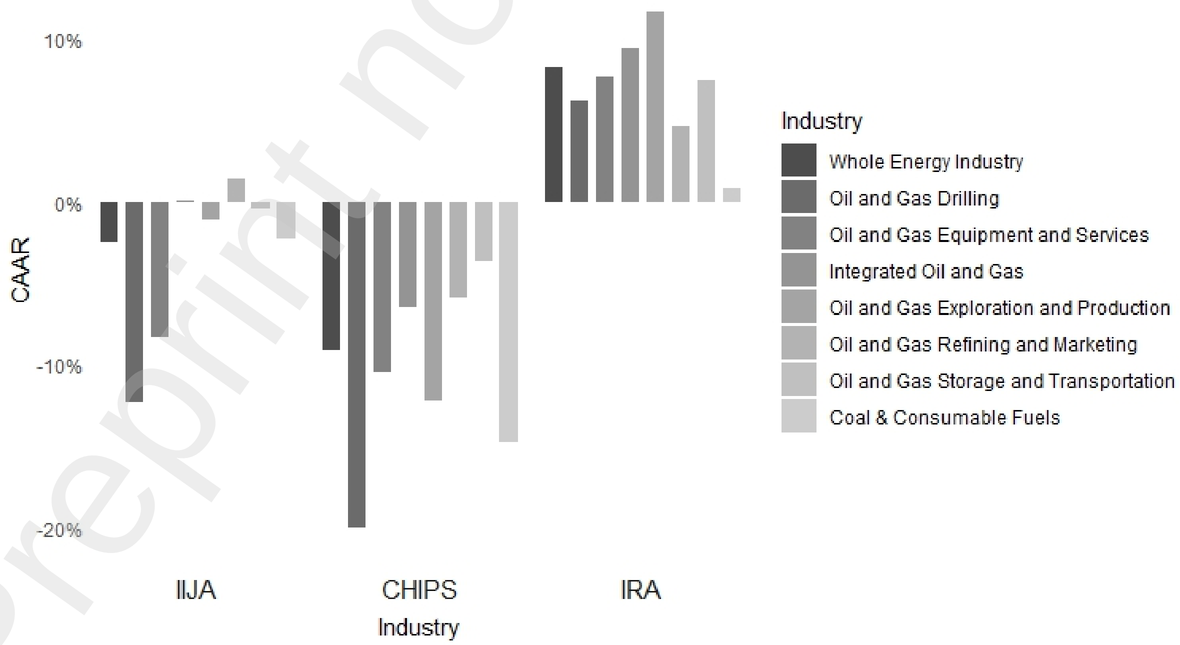
Figure 1

a: Source: (Burgess et al., 2024) b: Source: (Burgess et al., 2024) c: Source: (Burgess et al., 2024)



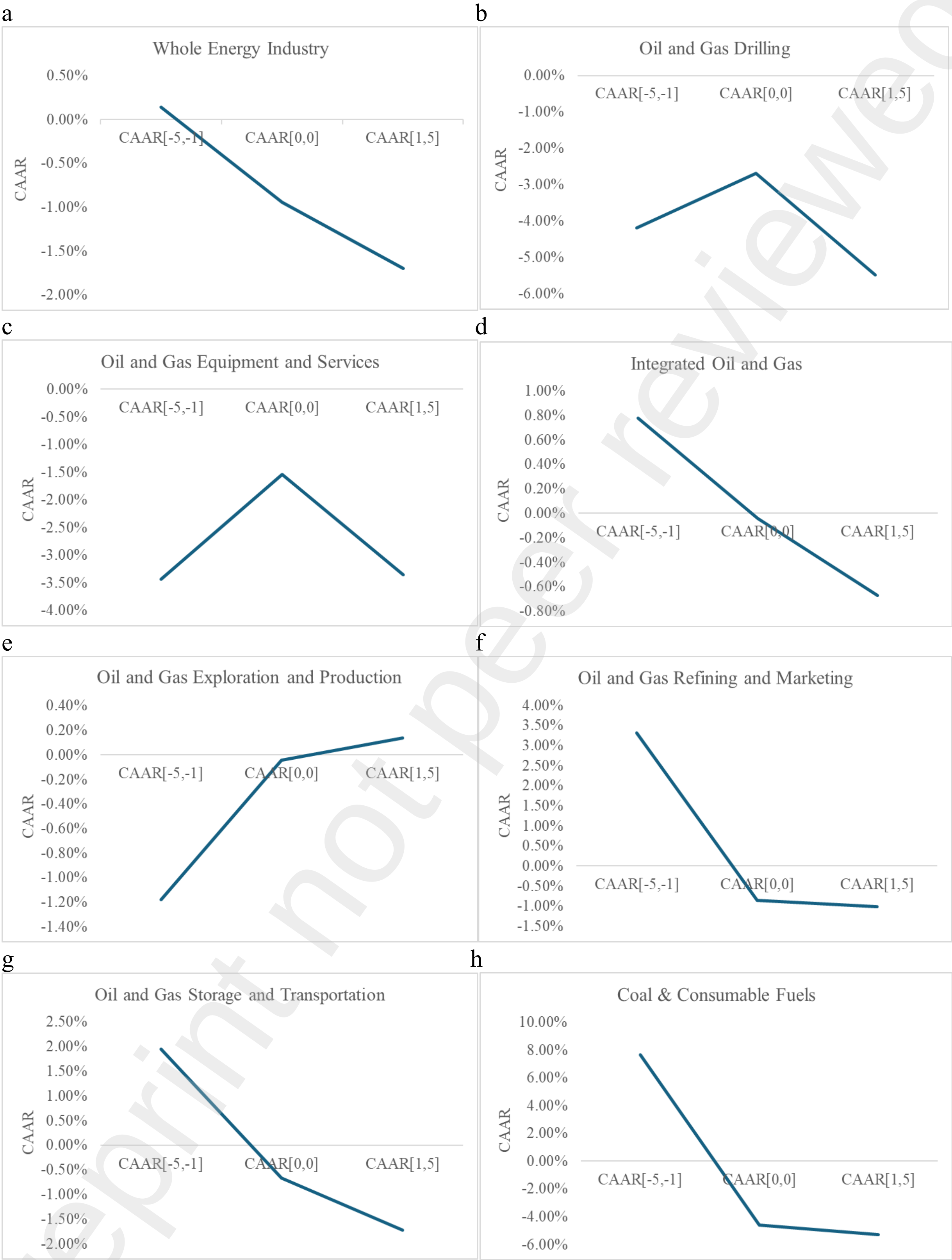
Notes: Fig. 1 reports spending and objectives of recent U.S. climate policies. a. Expenditure aimed at reducing GHG emissions (excluding adaptation measures) from the IIJA, CHIPS, and IRA, compared to the baseline from 2009-2017. b. Historical net GHG emissions (including land-based carbon sinks), in comparison to net-zero targets and projections for 2030 based on policy scenarios. For simplicity, lines connect observed values from 2021 to projected 2030 outcomes. c. Historical electric vehicle (EV) sales as a percentage of light-duty vehicles, compared to the Biden administration's target and a simulated scenario under the IRA.

Figure 2



Notes: Fig. 2 shows the impact of the announcement of the IIJA, CHIPS and IRA on the CAAR of the entire energy sector, as well as on seven energy sub-industries, within the event window [-5, +5].

Figure 3



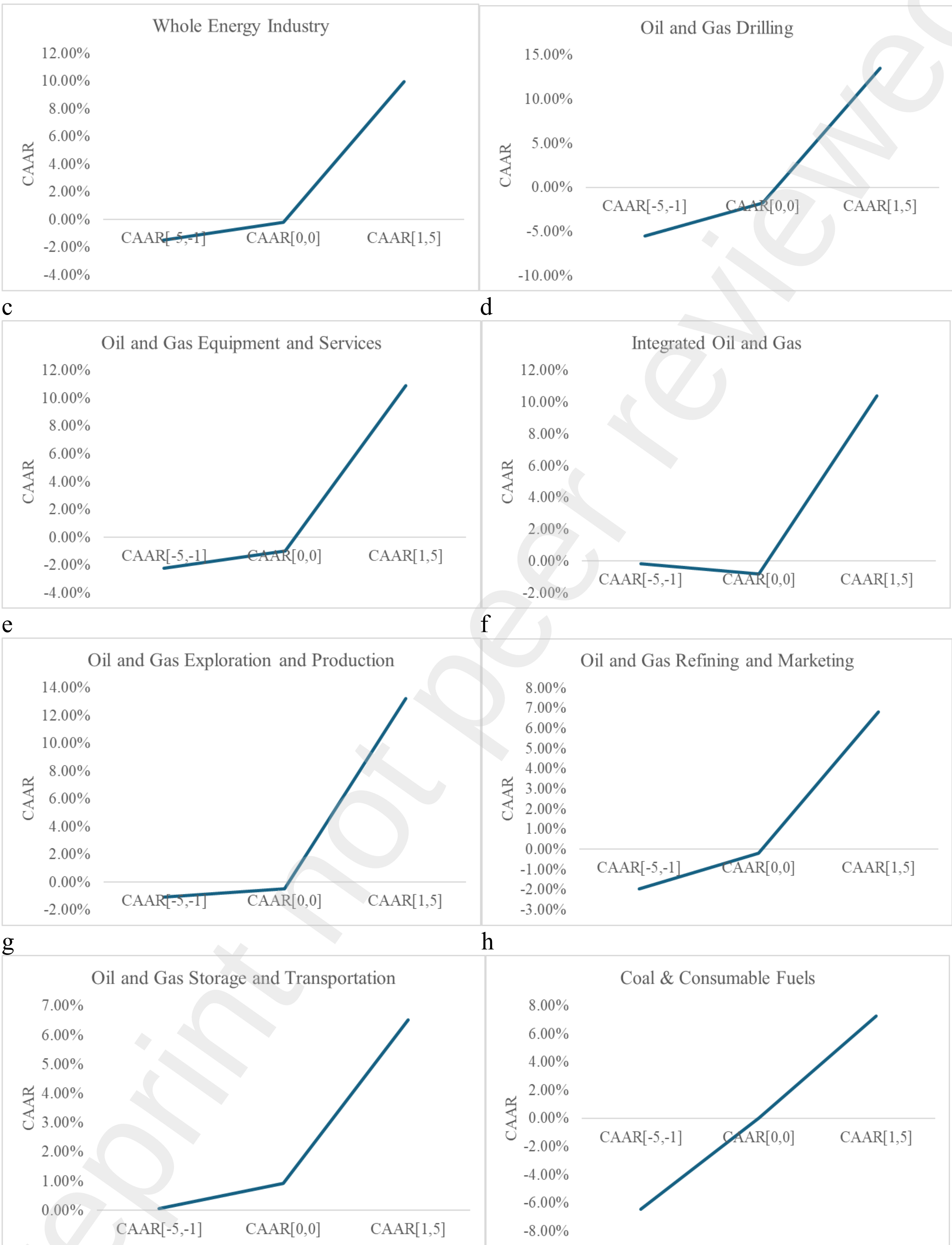
Notes: Fig. 3 illustrates the changes in the impact of the IIJA announcement on CAAR of the entire energy sector and seven energy sub-industries across the three sub-windows: [-5, -1], [0, 0], and [1, 5].

Figures 4

Notes: Fig. 4 illustrates the changes in the impact of the CHIPS announcement on CAAR of the entire energy sector and seven energy sub-industries across the three sub-windows: [-5, -1], [0, 0], and [1, 5].

Figures 5

a



Notes: Fig. 5 illustrates the changes in the impact of the IRA announcement on CAAR of the entire energy sector and seven energy sub-industries across the three sub-windows: [-5, -1], [0, 0], and [1, 5].